NIGERIAN ELECTRIFICATION PROJECT

RURAL ELECTRIFICATION AGENCY

ENERGY = EMPOWERMENT = EFFICIENCY

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

OF THE PROPOSED

2 MW SOLAR-HYBRID POWER PLANT AND ASSOCIATED INFRASTRUCTURE

At

FEDERAL UNIVERSITY OF EDUCATION (FUE) ZARIA, KADUNA STATE (LOT 1 – NORTHWEST) UNDER THE NIGERIA ELECTRIFICATION PROJECT (DESERT TO POWER) PHASE II

SUBMITTED TO:

FEDERAL MINISTRY OF ENVIRONMENT, ABUJA

FINAL-DRAFT REPORT **September 2026**

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

OF THE PROPOSED

2 MW SOLAR-HYBRID POWER PLANT AND ASSOCIATED INFRASTRUCTURE AT FEDERAL UNIVERSITY OF EDUCATION (FUE) ZARIA, KADUNA STATE

Report No.: REA-NEP/FUE-ZARIA/09-2026/001

Client: **RURAL ELECTRIFICATION AGNECY**

Date of Report: **September 2026**

Project Consultant: **BOLBEN ENERGY AND ENVIRONMENTAL SERVICES LIMITED**

Bolben Quality Assurance/Quality Control:

	Name	**Function**	**Signature**	**Date**
Reviewed & approved by	Mariam Mopelola .M	QA/QC Expert		09/2026
Compiled by	Nurudeen O. Ahmed	Environmental Analyst		09/2026
Version	Status			
1	**Draft ESIA Report**		**September 2026**	

Table Of Content

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

LIST OF ACRONYMS, UNITS AND ABBREVIATIONS

Cubic metres	(m^3)
Decibel	(dB)
Hectare	(Ha)
Hertz	(Hz)
Kelvin	(K)
Kilometres	(Km)
Kilovolt-ampere	(kVA)
Kilovolts	(Kv)
Kilowatts	(Kw)
Megawatt	(MW)
Meter per second	(m/s)
Metres	(M)
Volt	(V or E)
Watt per square meter	(W/m^2)
Watt	(W)
AfDB	African Development Bank
AIDS	Acquired Immunodeficiency Syndrome
APPI	Area of Potential Project Influence
ARAP	Abbreviated Resettlement Action Plan
ASUU	Academic Staff Union of Universities
BMP	Biodiversity Management Plan

BOD	Biochemical Oxygen Demand
COPE	Care of the People
CWD	Coarse woody debris
DISCOs	Distribution Companies
DRG	Debt Relief Gains
EA	Environmental Assessment, and Modification Reports
ECN	Energy Commission of Nigeria
EEP	Energizing Education Programme
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMF	Electromagnetic Field
EMS	Environmental Management System
EMP	Environmental Management Plan
ESC	Erosion and sediment control
ESCP	Erosion and Sediment Control Plan
ESIA	Environmental and Social Impact Assessment
ESMF	Environmental and Social Management Framework
ESMP	Environmental and Social Management Plan
FEED	Front End Engineering Design
FEC	Federal Executive Council
FEPA	Federal Environmental Protection Agency
FGN	Federal Government of Nigeria
FMEnv	Federal Ministry of Environment

GPS	Global Positioning System
HIV	Human Immunodeficiency Virus
HSE	Health, Safety, and Environment
HT	High Tension
ICREEE	Inter-ministerial Committee on Renewable Energy and Energy Efficiency
IPP	Independent Power Project
LGA	Local Government Area
LT	Low Tension
NACOP	National Council on Power
NASU	Non Academic Staff Union
NEEAP	National Energy Efficiency Action Plan
NEP	Nigeria Electrification Project
NEPP	National Electric Power Policy
NERC	Nigerian Electricity Regulatory Commission
NESREA	National Environmental Standards and Regulations Enforcement Agency
NiMET	Nigerian Meteorological Agency
NML	Noise Management Level
NOx	Nitrogen oxides
NSIFT	National Social Insurance Trust Fund
NUC	National University Commission
O&M	Operations and maintenance
PAPs	Project Affected Persons

PCT	Plant Community Type
PESCP	Progressive Erosion and Sediment Control Plan (aka ESCP)
PMP	Project Management Plan
POCR	Pre-operation Compliance Report
RAP	Resettlement Action Plan
RAV	restricted access vehicles
RBL	Rating Background Level
REA	Rural Electrification Agency
SEforAll	Sustainable Energy for All
Sp./spp.	Species/species (plural)
STEL	Short Term Exposure Limit
SWMP	Soil and Water Management Plan
TCN	Transmission Company of Nigeria
TCP	Traffic Control Plans
TMP	Traffic Management Plan
TWA	Time Weighted Average
VEZ	Vegetation exclusion zone (different to Asset protection zone surrounding infrastructure)
VLMP	Vegetation and Land Management Plan
WMP	Waste Management Plan
WTCs	Workshop Training Centres

EXECUTIVE SUMMARY

ES 1 Introduction

This report presents the Environmental and Social Impact Assessment (ESIA) for the proposed 2-megawatt (MW) Solar-Hybrid Power Plant and its associated infrastructure to be located within the premises of the Federal University of Education (FUE) Zaria, Kaduna State, Nigeria.

The proposed project forms part of the Federal Government of Nigeria's (FGN) Nigeria Electrification Project (NEP) Phase II (Desert-to-Power Programme), being implemented through the Rural Electrification Agency (REA). The project is currently under consideration for financing by the African Development Bank (AfDB), and this ESIA has been prepared as part of the environmental and social due diligence requirements for project appraisal and decision-making.

The project is part of the Federal Government's Energizing Education Programme (EEP), aimed at providing reliable and sustainable 24-hour uninterrupted electricity to Federal Universities.

The scope of the EEP includes provision of an off-grid, dedicated and independent power plant, rehabilitation of existing electricity distribution infrastructure, and provision of street lighting (for illumination and improved security) as well as a world class renewable energy training centre for each of the beneficiary universities. FUE Zaria is one of the beneficiary universities under the EEP Phase II.

In compliance with the relevant requirements of the Federal Ministry of Environment (FMEnv.) and other relevant regulatory agencies in Nigeria, as well as the applicable requirements of the African Development Bank's updated Integrated Safeguards System (ISS, 2023), the ESIA of the proposed Project in FUE. Zaria has been conducted.

The ESIA has therefore established the environmental and social baseline conditions within the Project Area of Influence, identified and evaluated the potential impacts associated with each phase of the Project, assessed project alternatives, and developed appropriate mitigation measures and an Environmental and Social Management Plan (ESMP). The findings of the assessment provide the basis for informed regulatory decision-making and demonstrate that the Project can be implemented in an environmentally and socially responsible manner, provided the recommended mitigation and management measures are fully implemented.

Policy, Legal and Administrative Framework

The principal legal, regulatory, and policy instruments applicable to the proposed 2 MW Solar-Hybrid Power Plant and associated infrastructure at FUE Zaria are presented below. The framework has been limited to instruments that have direct relevance to environmental assessment, renewable-energy development, electricity infrastructure, land access, climate change, occupational health and safety, and environmental management of the Project.

Legal Framework

The principal national legislation applicable to the Project includes:

- **Environmental Impact Assessment (EIA) Act, Cap E12 LFN 2004** – provides the statutory basis for environmental impact assessment of projects that are likely to have significant environmental effects and establishes requirements for environmental assessment and approval prior to project implementation.

- **Electric Power Sector Reform Act (EPSRA), 2005** – provides the legal framework for the generation, transmission, distribution and supply of electricity in Nigeria. It is relevant to the proposed captive/off-grid power generation and associated electricity infrastructure.
- **Climate Change Act, 2021** – establishes Nigeria's legal framework for addressing climate change and promoting measures for climate mitigation and adaptation. It is particularly relevant to the Project because of its renewable-energy component and potential contribution to reducing greenhouse-gas emissions.
- **Land Use Act, Cap L5 LFN 2004** – governs the administration, control and use of land in Nigeria and is relevant to the acquisition, allocation, occupation and development of land required for the Project.
- **National Environmental Standards and Regulations Enforcement Agency (NESREA) Act, 2007** – establishes NESREA and provides the statutory basis for enforcement of environmental standards and regulations applicable to environmental protection and pollution control.
- **Energy Commission of Nigeria Act, No. 62 of 1979 (as amended)** – provides the statutory basis for the functions of the Energy Commission of Nigeria in relation to national energy planning and coordination, including renewable and alternative energy development.
- **Employees' Compensation Act, 2010** – provides for compensation and protection of employees in respect of work-related injuries, occupational diseases, disabilities and death and is relevant to occupational health and safety during Project implementation.

Regulatory Framework

The principal regulatory instruments and guidelines relevant to the Project include:

- **Federal Ministry of Environment (FMEnv) EIA Procedural Guidelines** – provide the procedural framework for undertaking and processing environmental impact assessments in Nigeria. The ESIA has been prepared in accordance with the applicable requirements of these guidelines.
- **EIA Sectoral Guidelines for the Power Sector** – provide sector-specific requirements for assessing environmental and social impacts associated with power-generation and related infrastructure projects.
- **Relevant NESREA Environmental Regulations** – applicable regulations will guide the management of environmental aspects of the Project, including pollution prevention, waste management, noise, air quality and other environmental concerns relevant to Project activities.
- **Applicable environmental requirements of the Kaduna State Ministry of Environment** – these requirements will apply to environmental management, monitoring and compliance within Kaduna State and will complement the applicable Federal environmental requirements.

Policy Framework

The principal national policies relevant to the Project include:

- **National Policy on the Environment (Revised 2016)** – provides the overarching policy direction for environmental protection and sustainable management of Nigeria's natural resources. The Project will apply the principles of pollution prevention, resource conservation, environmental protection and sustainable development throughout its lifecycle.
- **National Renewable Energy and Energy Efficiency Policy (NREEEP), 2015** – provides the policy framework for promoting renewable-energy development and energy efficiency in Nigeria.

The Project directly supports this policy through the deployment of solar photovoltaic generation and reduction of dependence on diesel-based electricity generation.

- **National Energy Policy, 2013** – provides the national policy framework for energy development, diversification and security and is relevant to the Project's contribution to renewable and decentralized energy supply.
- **National Climate Change Policy (2021–2030)** – provides the policy framework for climate-change mitigation and adaptation in Nigeria and is relevant to the Project's renewable-energy and greenhouse-gas-reduction objectives.
- **Nigeria Energy Transition Plan (ETP), 2022** – provides a strategic pathway for Nigeria's transition towards a low-carbon and sustainable energy system. The proposed solar-hybrid power plant is consistent with the Plan's emphasis on renewable energy and reduction of emissions from fossil-fuel-based electricity generation.

International Safeguards, Conventions and Standards

In addition to national requirements, the Project will be implemented with reference to applicable international safeguards, conventions and standards, particularly those relevant to environmental and social risk management, climate change, labour, biodiversity and sustainable infrastructure development. These include:

- **African Development Bank (AfDB) Integrated Safeguards System (ISS), 2023** – provides the principal international environmental and social safeguard framework applicable to the Project.
- **IFC Performance Standards on Environmental and Social Sustainability** – provide internationally recognized principles for identifying and managing environmental and social risks and impacts.
- **United Nations Framework Convention on Climate Change (UNFCCC), 1992** – provides the international framework for addressing climate change and is relevant to the Project's climate-mitigation objectives.
- **Paris Agreement, 2015** – provides the international framework for strengthening climate action and reducing greenhouse-gas emissions, to which the Project contributes through renewable-energy deployment.
- **International Labour Organization (ILO) Core Conventions** – provide internationally recognized principles relating to fundamental rights at work, labour standards and protection of workers.

The above framework has been selected based on its direct or material relevance to the proposed 2 MW Solar-Hybrid Power Plant and associated infrastructure at FUE Zaria. Compliance will be managed according to the respective mandates of the responsible regulatory institutions. The ESIA provides the basis for identifying environmental and social risks, establishing mitigation and management measures, and demonstrating the Project's conformity with applicable national requirements and the relevant international safeguard framework throughout the Project lifecycle.

ES2 Project Justification

Need for the Project and Benefits

The Federal University of Education (FUE), Zaria, as a major institution for teacher education, learning, research, and innovation, requires a stable, reliable, uninterrupted, and high-quality electricity supply to support teaching, research, laboratories, ICT facilities, workshops, administrative operations, student hostels, and other essential campus services. However, reliance on the national electricity grid has proven inadequate due to frequent power outages, grid instability, limited transmission capacity, and inefficiencies within the electricity distribution network. These challenges have resulted in operational disruptions, increased dependence on diesel-powered generators, high energy costs, and associated environmental impacts.

To address these challenges, the Federal Government of Nigeria, through the Rural Electrification Agency (REA), is implementing the Nigeria Electrification Project (NEP) Phase II under the Desert-to-Power Programme by deploying decentralized off-grid solar photovoltaic (PV) hybrid power systems across selected Federal tertiary institutions. The proposed 2 MW Solar-Hybrid Power Plant at FUE Zaria is designed to provide a reliable, sustainable, and cost-effective electricity supply independent of the national grid, thereby enhancing energy security, improving the University's operational efficiency, and ensuring continuity of academic, research, and administrative activities.

Beyond improving energy reliability, the Project will contribute to Nigeria's transition towards cleaner energy by reducing dependence on diesel-powered electricity generation and lowering greenhouse gas emissions. The Project therefore supports the implementation of Nigeria's Nationally Determined Contributions (NDCs) under the Paris Agreement by contributing towards the country's commitment to reduce greenhouse gas emissions by 20–30% by 2030 through the increased deployment of renewable energy technologies and improved energy efficiency.

The potential Project benefits include, amongst others:

- Stimulation of academic, teaching, research, and innovation activities through access to reliable and uninterrupted electricity supply;
- Improved operation of laboratories, ICT facilities, workshops, libraries, administrative offices, and student hostels;
- Reduction in fossil fuel consumption, greenhouse gas emissions, and the University's overall carbon footprint;
- Significant reduction in electricity generation costs through reduced dependence on diesel-powered generators;
- Enhanced campus security through improved street lighting and public illumination, thereby reducing opportunities for crime and gender-based violence;
- Establishment of a Renewable Energy Training Centre to promote capacity building, research, innovation, and certification in renewable energy technologies;
- Improvement in livelihood-enhancing activities within the University community;
- Creation of direct and indirect employment opportunities during the construction, operation, and maintenance phases of the Project;
- Increased economic activities through the award of contracts, procurement of local goods and services, and engagement of local suppliers, thereby supporting the local and regional economy;
- Strengthened collaboration among the Federal Government of Nigeria, the Rural Electrification Agency (REA), the Federal University of Education (FUE) Zaria, the African Development Bank (AfDB), and other relevant Ministries, Departments, and Agencies (MDAs); and

- Contribution to Nigeria's renewable energy transition and climate change mitigation objectives by supporting the country's commitment to reduce greenhouse gas emissions by 20–30% by 2030 under its Nationally Determined Contributions (NDCs).

Envisaged Sustainability of the Project

Technical Sustainability: The technical sustainability of the Project will be ensured through:

- Engagement of qualified and experienced EPC Contractor selected by REA;
- Compliance with international engineering standards and manufacturer specifications;
- Supervision by REA Project Management Unit (PMU);
- Oversight by FUE Zaria Department of Works and Physical Planning;
- Deployment of high-efficiency solar PV modules and lithium-ion battery storage systems;
- Use of modern monitoring systems (SCADA-based performance tracking).

The design life of the solar PV system is approximately 25 years, while associated buildings such as the training centre may exceed 40 years with proper maintenance. Upon completion of construction, an Operations and Maintenance (O&M) Contractor will be engaged to manage system performance in collaboration with University technical staff.

Environmental Sustainability*:* Environmental sustainability is achieved through:

- Utilization of renewable solar energy;
- Negligible greenhouse gas emissions during operation;
- Reduced air pollution compared to fossil fuel systems;
- Proper waste management protocols for batteries and electrical components;
- Establishment of REA PMU Environmental and Social Safeguards Specialists to oversee compliance;
- Implementation of Environmental and Social Management Plan (ESMP).

The Project aligns with Nigeria's transition toward low-carbon development pathways.

Economic Sustainability*:* The Project will significantly reduce diesel generator usage within FUE Zaria, thereby lowering operational expenditures.
Key economic sustainability mechanisms include:

- Reduced electricity payments to the Distribution Company;
- Reduced diesel fuel procurement costs;
- Reduced generator servicing and replacement costs;
- Implementation of cost-reflective service charges for connected facilities within campus (including private businesses);
- Revenue reinvestment into operations and maintenance of the solar facility.

This model reduces dependency on Federal Government allocations and promotes institutional financial autonomy.

Social Sustainability**:** Stakeholder consultations were conducted as part of the ESIA process to ensure inclusive participation and transparency. The consultation process:

- Identified relevant stakeholders within FUE Zaria and surrounding communities;

- Gathered concerns and expectations;
- Assessed community perception;
- Established early trust-building mechanisms.

A Stakeholder Engagement Plan (SEP) has been developed to guide ongoing engagement throughout the Project lifecycle. Additionally, a Grievance Redress Mechanism (GRM) has been established by REA to:

- Receive complaints;
- Address concerns promptly;
- Provide transparent conflict resolution channels;
- Ensure inclusivity, including gender-sensitive reporting mechanisms.

Project Alternatives

In assessing the most suitable technology for the 2 MW solar-hybrid system at FUE Zaria, several alternatives were evaluated based on:

- Environmental performance;
- Operational efficiency;
- Cost-effectiveness;
- Reliability under semi-arid climatic conditions;
- Lifecycle sustainability.

Alternatives considered included:

- Monocrystalline vs Polycrystalline PV modules;
- Fixed-tilt vs Tracking systems;
- Lithium-ion vs Lead-acid battery storage systems;
- Diesel-only generation;
- Grid-only reliance.

After evaluation, the preferred alternative is:

- High-efficiency photovoltaic (PV) modules suitable for high solar irradiance zones;
- Lithium-ion Battery Energy Storage System due to higher efficiency, longer lifespan, lower maintenance, and better performance under high temperature conditions.

This option provides optimal balance between environmental performance, reliability, and long-term sustainability.

ES 3 Project Description

The proposed 2 MW Solar-Hybrid Power Plant at the Federal University of Education (FUE), Zaria forms part of the Energizing Education Programme (EEP) under the Nigeria Electrification Project (NEP) Phase II. The Project is designed to provide a reliable, sustainable, and dedicated electricity supply to support teaching, research, innovation, and the overall operation of the University. The existing electricity supply from the national grid is unreliable and supplemented by diesel-powered generators, resulting in frequent power interruptions, high operating costs, and greenhouse gas emissions.

The proposed 2 MW installed capacity was selected following an assessment of the University's existing and projected electricity demand. The system is intended to provide adequate power for critical facilities, including academic buildings, laboratories, workshops, ICT centres, administrative buildings, student hostels, street lighting, and the Renewable Energy Training Centre, while allowing sufficient capacity to accommodate future growth in electricity demand and improve overall energy security.

Approximately 3.03 hectares of land within the University campus have been allocated for the Project. The solar PV facility will be developed across three separate locations because sufficient contiguous land of the required size was not available within the campus. The selected sites are strategically located close to the major electricity demand centres, thereby reducing cable routing distances, minimizing transmission losses, simplifying construction and operation, and reducing potential environmental and social impacts associated with extensive land acquisition or site disturbance. Collectively, the three sites provide the required land area for the installation of the proposed 2 MW solar-hybrid system while maintaining compatibility with existing campus infrastructure and future development plans.

The Project site is located between Latitude 11.082444°N and 11.087455°N and Longitude 7.731279°E and 7.735060°E within the Federal University of Education, Zaria, Kaduna State.

Project Components and Activities

The proposed Project comprises a 2 MW solar-hybrid power generation system consisting of:

- Ground-mounted photovoltaic (PV) arrays installed on fixed-tilt mounting structures;
- Lithium-ion Battery Energy Storage System (BESS);
- Inverters, transformers, switchgear, protection and control systems;
- Internal power distribution network and underground/overhead cabling;
- Solar-powered street lighting;
- Control room, power station, site office, and Renewable Energy Training Centre.

The principal project activities will include:

- Site surveying, setting out, and land preparation, including limited vegetation clearing, grading, and earthworks;
- Construction of foundations and mounting structures for the photovoltaic arrays;
- Installation of solar PV modules, Battery Energy Storage System (BESS), inverters, transformers, switchgear, and associated electrical equipment;
- Construction of the power station, control room, Renewable Energy Training Centre, internal access roads, and ancillary facilities;
- Installation of underground and overhead power cables, street lighting, and internal distribution infrastructure;
- Equipment testing, commissioning, grid integration, and performance verification before commencement of operation; and
- Routine operation, monitoring, inspection, preventive maintenance, and periodic replacement of components throughout the operational life of the facility.

The solar PV modules will be mounted on durable fixed-tilt structures designed to withstand the prevailing climatic conditions of Kaduna State and to ensure efficient electricity generation throughout the Project's operational life.

ES 4 Description of the Project Existing Environment

The description of the environmental and social conditions of the proposed 2 MW Solar-Hybrid Power Plant at the Federal University of Education (FUE), Zaria is based on comprehensive desktop studies and detailed field investigations undertaken within the Project Area of Influence (AoI). Baseline surveys included topography and land use, ambient air quality and noise, soil quality, surface water and groundwater quality, terrestrial ecology, socio-economic conditions, public health, and cultural heritage. A multidisciplinary team conducted the investigations in accordance with established Quality Assurance and Quality Control (QA/QC) procedures, while field samples were analysed for relevant physicochemical, microbiological, and ecological parameters using standard laboratory methods. The field investigations indicate that ambient air quality, noise levels, soil quality, and surface water and groundwater quality within the Project Area are generally within applicable national and international guideline limits, with no evidence of significant environmental contamination. The Project sites are characterized by gently undulating terrain underlain by weathered Basement Complex rocks, with vegetation typical of the Guinea Savannah ecological zone and no endangered flora or fauna recorded within the proposed development footprint. Socio-economic surveys further indicate that the Project Area is predominantly institutional, with support from the surrounding host community for the proposed development owing to the anticipated improvements in electricity supply, educational activities, employment opportunities, and local economic development. The environmental and social conditions of the Project Area of Influence are summarized below:

Climate and Meteorology: Kaduna State is characterized as a sub-humid zone with derived Guinea Savannah vegetation and patches of rainforest. The climate of the study area is tropical and is influenced by the Inter-Tropical Convergence Zone (ITCZ) or Inter-Tropical Discontinuity Zone (ITDZ). Based on the review of long-term (1991–2017) climatic data obtained from the Nigerian Meteorological Agency (NiMet), rainfall generally occurs from April to October with a peak period in August (284.74 mm). Monthly temperatures are relatively high and stable throughout the year, with the highest value of 36.01°C recorded in March. The prevailing climatic conditions are considered suitable for solar energy generation.

Topography and Land Use: The proposed project sites are generally characterized by gently undulating terrain and are located within the premises of the Federal University of Education (FUE) Zaria. Existing land use within the project footprint consists mainly of institutional land, open spaces, fallow land, and limited agricultural activities. The project sites are accessible through existing campus road networks and are not constrained by significant topographical limitations.

Geology and Hydrogeology: The geology of Kaduna State forms part of the Basement Complex geology of central Nigeria. It is composed of older high-grade metamorphosed gneisses interspersed with belts of younger metasedimentary rocks, mainly quartzites and schists. The region is underlain by older granitic crystalline and metamorphic rocks of Precambrian to Lower Paleozoic age. Groundwater occurrence within the area is associated primarily with weathered and fractured basement formations which serve as important sources of domestic water supply.

Air Quality and Noise: A total of twenty (20) stations were sampled across the three project sites and surrounding control locations. The concentrations of air quality parameters recorded within the Project site and buffer areas were generally below the National Ambient Air Quality Standards and the World Health Organization (WHO) Air Quality Guidelines. Noise levels recorded within the Project site were also within acceptable limits for educational institutions and below the FMEnv permissible limit of 90 dB(A). These results indicate that ambient air quality and noise conditions within the Project area are satisfactory and do not constitute significant environmental constraints to the proposed development.

Soil Quality: A total of eighteen (18) soil samples were collected across the three project sites. At each site, six (6) samples were obtained to ensure adequate spatial representation. Sampling was conducted at two depth intervals: topsoil (0–15 cm) and subsoil (15–30 cm). The analyses provided representative surface and subsurface soil conditions for all project locations. The results indicate that the soils are generally characteristic of the area and suitable for the proposed development, with no evidence of significant contamination that could adversely affect project implementation.

Surface Water and Groundwater Quality: Groundwater samples were collected from three (3) boreholes while surface water samples were collected from upstream and downstream locations within the study area. The concentrations of parameters analysed in both groundwater and surface water samples were generally within the FMEnv and WHO guideline limits for domestic and environmental use. The results indicate satisfactory water quality conditions and no significant contamination concerns within the Project Area of Influence.

Terrestrial Flora: The natural ecosystem of the Project site has been substantially modified by human activities, particularly institutional development and associated land-use practices. The physiognomy of the study area is characterized by open vegetation comprising grasses, shrubs, and scattered trees typical of the Guinea Savannah ecological zone. Plant species recorded include Ageratum conyzoides, Panicum maximum, Ipomoea involucrata, Sida acuta, Tridax procumbens, and Pennisetum species. Based on the International Union for Conservation of Nature (IUCN) Red List classification, no endangered or threatened plant species were identified within the project footprint. The site is not located within designated grazing reserves, breeding grounds, wildlife corridors, or migratory routes.

Terrestrial Fauna: Faunal species observed within the Project site were generally limited to small invertebrates such as earthworms, insects, grasshoppers, butterflies, and spiders. Vertebrate species observed included lizards (Agama agama), birds such as Cattle Egret, Black Kite and Green Fruit Pigeon, as well as domesticated grazing animals including cattle and sheep. Based on the IUCN Red List classification, no threatened or endangered fauna species were recorded within the study area. The ecological sensitivity of the project area is therefore considered low.

Socio-Economic and Health Environment: The identified host community within the Project Area of Influence is Gyellesu community, which hosts the University. Information obtained through focus group discussions, key informant interviews, direct observations, and household surveys indicates that the community is relatively heterogeneous in terms of ethnicity, language, and socio-economic composition. The population structure is influenced by the presence of students and university personnel, resulting in a relatively young and dynamic population profile. The community comprises indigenous Hausa residents as well as migrants from different parts of Nigeria, with seasonal population variations linked to academic activities. Islam is the predominant religion within the community.

The settlement pattern is predominantly nucleated, with residential buildings constructed mainly from cement blocks and corrugated roofing sheets. Livelihood activities are centred on trading, agriculture, educational services, transportation, and other small-scale economic enterprises. The community is served by public and private healthcare facilities, pharmaceutical outlets, educational institutions, road networks, telecommunication services, and electricity infrastructure. Most households are connected to the national grid, while some residents utilize private generators as backup power sources. Public and private boreholes, as well as commercial water vendors, serve as the primary sources of water supply.

Women participate actively in household, economic, and community affairs and are permitted to form associations and occupy leadership positions. Community consultations indicated that reported cases of Gender-Based Violence (GBV) are relatively uncommon, with dispute resolution typically involving traditional leadership structures and law enforcement agencies.

Sensitive Receptors and Cultural Heritage: Key receptors within the Project Area of Influence include students, academic and non-academic staff, nearby residents, traders, road users, and individuals undertaking limited agricultural activities within portions of the project area. Based on field investigations and stakeholder consultations, no archaeological resources, sacred groves, cultural heritage sites, monuments, or other culturally significant features were identified within the project footprint. Nevertheless, a Chance Find Procedure will be implemented during construction activities.

Community Perception of the Project: Based on interviews with community leadership and respondents, there are no direct livelihood activities or ecosystem services obtained from the proposed project sites. Community members expressed positive views regarding the proposed Project and believe it will improve electricity supply reliability, support educational activities, stimulate entrepreneurship, create employment opportunities, enhance security, and contribute positively to local economic development.

Overall Baseline Condition: The baseline assessment indicates that the proposed project area is environmentally and socially suitable for the development of the 2 MW Solar-Hybrid Power Plant. No critical environmental, biodiversity, social, health, or cultural heritage constraints were identified that would preclude project implementation. The anticipated impacts are largely site-specific and can be effectively managed through the implementation of the recommended mitigation measures and Environmental and Social Management Plan (ESMP).

ES 5 Associated and Potential Risks and Impacts

The potential environmental and social (E&S) risks and impacts associated with the proposed Project were identified, evaluated, and ranked across the various phases of project development, namely the pre-construction, construction, commissioning, operation, and decommissioning phases. Impact significance was assessed based on the nature, magnitude, extent, duration, reversibility, sensitivity of receptors, and likelihood of occurrence. The assessment indicates that while the Project has the potential to generate a number of adverse environmental and social impacts, most impacts are localized, temporary, reversible, and can be effectively mitigated through the implementation of appropriate mitigation measures and the Environmental and Social Management Plan (ESMP). No significant residual impacts were identified that would preclude project implementation.

High Risks and Impacts
The following High risks and impacts were identified during the assessment:

Occupational Health and Safety Risks
Construction and operation activities present occupational health and safety risks to workers, including injuries arising from equipment operation, electrical installations, working at heights, lifting operations, exposure to energized systems, slips, trips and falls, and other site-related hazards.

Community Health and Safety Risks
Construction activities, movement of heavy-duty vehicles, transportation of equipment, and increased traffic within the University environment may pose safety risks to students, staff, visitors, and nearby residents.

Electrical and Fire Hazards
During operation, the solar photovoltaic system, Battery Energy Storage System (BESS), transformers, and associated electrical infrastructure may present risks of electric shock, electrocution, fire outbreaks, and related injuries if not properly managed.

Moderate Risks and Impacts
Pre-Construction Phase
The principal Moderate impacts anticipated during the pre-construction phase include:
- Increased vehicular movement and traffic with associated road safety concerns.
- Soil disturbance and degradation resulting from site preparation activities.
- Temporary loss of farmlands and changes in existing land use within portions of the project footprint.

Construction Phase
The principal Moderate impacts anticipated during the construction phase include:
- Soil degradation, erosion, and localized disturbance of land resources.
- Temporary reduction in ambient air quality resulting from dust generation, earthworks, and equipment emissions.
- Increased noise levels associated with construction equipment, machinery operation, and vehicular activities.
- Community health and safety risks associated with workforce presence and construction activities.
- Labour influx-related risks, including Gender-Based Violence (GBV), Sexual Exploitation and Abuse/Sexual Harassment (SEA/SH), and community-worker conflicts.
- Generation of construction wastes and increased pressure on existing facilities and services.

Commissioning Phase
Potential Moderate impacts during commissioning include:
- Temporary noise generation associated with equipment testing and system start-up activities.
- Occupational health and safety risks associated with equipment inspection, testing, and commissioning operations.

Operational Phase
The key Moderate risks and impacts anticipated during operation include:
- Occupational injuries arising from routine maintenance and electrical works.

- Labour-related issues including discrimination, workplace grievances, and poor working conditions if not adequately managed.
- Generation of operational wastes, including end-of-life electrical components and battery-related wastes requiring proper handling and disposal.
- Potential Gender-Based Violence (GBV) and workplace conduct concerns requiring continued monitoring and awareness programmes.

Decommissioning Phase

The principal Moderate impacts anticipated during decommissioning include:

- Soil disturbance associated with dismantling and removal of project infrastructure.
- Increased traffic and transportation-related impacts resulting from equipment removal activities.
- Generation of demolition and decommissioning wastes requiring appropriate management and disposal.

Positive Environmental and Social Impacts

The proposed Project is expected to generate significant positive environmental and socio-economic benefits, including:

- Creation of direct and indirect employment opportunities during construction and operation.
- Improved reliability and sustainability of electricity supply to the Federal University of Education (FUE) Zaria.
- Promotion of renewable and clean energy generation.
- Reduction in greenhouse gas (GHG) emissions and dependence on fossil-fuel-based power generation.
- Enhanced educational, research, and institutional productivity through improved power availability.
- Capacity building, skills acquisition, and technology transfer through renewable energy training, operation, and maintenance activities.
- Improved business opportunities, entrepreneurship development, and local economic growth within the Project Area of Influence.

ES 6 Mitigation Measures

Appropriate mitigation measures have been developed to avoid, minimize, control, or compensate for the identified environmental and social risks and impacts associated with the proposed Project. These measures have been incorporated into the Project design and the Environmental and Social Management Plan (ESMP) and shall be implemented throughout the Project lifecycle.

Mitigation Measures for High Risks and Impacts

Occupational Health and Safety Risks

To minimize occupational health and safety risks, a comprehensive Health and Safety Plan shall be developed and implemented. Appropriate Personal Protective Equipment (PPE) shall be provided and its use strictly enforced. Daily toolbox meetings shall be conducted, workers shall receive regular health and safety training, and an onsite safety officer shall monitor compliance with safety requirements. Emergency response procedures, accident reporting systems, and first aid arrangements shall be established and maintained throughout project implementation.

Community Health and Safety Risks

Community health and safety risks shall be managed through the implementation of a Traffic Management Plan (TMP), provision of warning signs and barriers, restriction of public access to construction areas, driver competency assessment and training, enforcement of speed limits within the project area, and continuous stakeholder engagement throughout project implementation.

Electrical and Fire Hazards

Electrical and fire risks associated with the solar photovoltaic system, battery energy storage system (BESS), and associated infrastructure shall be managed through compliance with approved engineering standards, routine equipment inspections, implementation of standard operating procedures (SOPs), provision of safety signage, emergency preparedness training, and installation of appropriate fire prevention and control measures.

Mitigation Measures for Moderate Risks and Impacts

Soil Disturbance, Land Degradation and Erosion

Site clearing shall be restricted to approved work areas only. Topsoil shall be conserved for rehabilitation purposes, disturbed areas shall be restored as soon as practicable, and erosion control measures shall be implemented to minimize soil loss and land degradation.

Air Quality and Noise Impacts

Construction equipment shall be properly maintained and operated under optimum fuel-efficient conditions. Dust suppression measures shall be implemented where necessary, stockpiles shall be appropriately managed, and noisy activities shall be limited to daytime periods. Equipment generating excessive noise shall be maintained in good operating condition.

Loss of Vegetation and Biodiversity Impacts

Vegetation clearing shall be limited to the approved project footprint. Areas outside the working corridor shall be protected from disturbance, while disturbed areas shall be rehabilitated using suitable native vegetation where practicable.

Gender-Based Violence (GBV), Sexual Exploitation and Abuse (SEA), and Sexual Harassment (SH)

The GBV Action Plan for the Energizing Education Programme (EEP) shall be implemented throughout project implementation. All workers shall sign a Code of Conduct prohibiting GBV/SEA/SH. A Gender/GBV Officer shall be engaged, GBV-sensitive grievance reporting channels shall be established, awareness training shall be conducted regularly, and referral pathways shall be maintained in collaboration with relevant service providers.

Labour and Working Conditions

Recruitment processes shall be transparent, fair, and non-discriminatory. Local employment opportunities shall be promoted where feasible, workers' grievance mechanisms shall be implemented, and all labour practices shall comply with applicable national labour laws and international good practice requirements.

Waste Management

A Waste Management Plan shall be developed and implemented. Construction and operational wastes shall be properly segregated, stored, transported, recycled where feasible, and disposed of through approved facilities. Specific procedures shall be established for the management of electronic waste and end-of-life batteries.

Traffic and Road Safety Risks

Traffic movements associated with project activities shall be managed through route planning, driver training, speed control measures, vehicle maintenance, provision of traffic signage, and deployment of traffic marshals where necessary.

Enhancement Measures for Positive Impacts

To maximize project benefits, priority consideration shall be given to qualified local labour where feasible. Capacity building, skills acquisition, and technology transfer programmes shall be promoted through project implementation and the Renewable Energy Training Centre. Continuous stakeholder engagement shall also be maintained to ensure that local communities benefit from available economic and employment opportunities arising from the Project.

ES 7 Environmental and Social Management Plan

The Environmental and Social Management Plan (ESMP) constitutes a core component of this Environmental and Social Impact Assessment (ESIA). It provides a structured framework for managing, monitoring, and mitigating the identified environmental and social impacts associated with the proposed 2 MW Solar-Hybrid Power Plant at FUE Zaria. The ESMP covers the entire lifecycle of the Project, including pre-construction, construction, commissioning, operation, and eventual decommissioning phases. It outlines:

- Specific mitigation measures;
- Desired environmental and social outcomes;
- Performance indicators;
- Monitoring parameters and frequency;
- Institutional responsibilities; and
- Estimated implementation costs.

The recommended environmental and social management measures are detailed within the report and categorized by project phase and impact type.

Key ESMP Implementation Framework

A summary of the ESMP implementation framework is presented Table ES7.1 below. Table ES7.2 shows the summary of the Environmental Monitoring Matrix, and Table ES7.3 presents the summary of the Risk Management Matrix.

Table ES7.1: Summary ESMP Matrix

Code	Impact	Mitigation Measure	Timeline	Cost (₦)	KPI	Implementation Responsibility	Monitoring /Oversight
ESMP-01	Vegetation Loss	Restrict site clearing to approved footprint	Pre-construction	Included in EPC Cost	Area cleared within approved limits	EPC Contractor	REA-PMU
ESMP-02	Dust Emissions	Water spraying and speed control	Construction	Included in EPC Cost	Number of dust complaints	EPC Contractor	REA-PMU
ESMP-03	GBV/SEA Risk	Implement GBV Action Plan and Code of Conduct	Construction & Operation	Included in ESMP Budget	Number of GBV trainings conducted	EPC/O&M Contractor	REA-PMU
ESMP-04	Occupational Accidents	Implement HSE Plan and PPE programme	All Phases	Included in ESMP Budget	Lost Time Injury Frequency Rate (LTIFR)	EPC/O&M Contractor	REA-PMU

Table ES7.2: Summary Environmental Monitoring Matrix

Code	Parameter	Method	Frequency	Responsibility	Reporting	Estimated Cost
EM-01	Ambient Air Quality	Field monitoring and laboratory analysis	Quarterly	EPC/O&M Contractor	REA-PMU	Included in ESMP Budget
EM-02	Noise Levels	Sound level meter measurements	Quarterly	EPC/O&M Contractor	REA-PMU	Included in ESMP Budget
EM-03	Surface and Groundwater Quality	Sampling and laboratory analysis	Bi-annually	O&M Contractor	REA-PMU	Included in ESMP Budget
EM-04	Soil Quality	Soil sampling and analysis	Annually	O&M Contractor	REA-PMU	Included in ESMP Budget
EM-05	Vegetation Status	Site inspection and ecological survey	Annually	O&M Contractor	REA-PMU	Included in ESMP Budget

Table ES7.3: Summary Risk Management Matrix

Code	Event	Risk Description	Risk Level	Prevention Measure	Management Action	Alert Officer	Supervision
RM-01	Traffic Accident	Injury to workers and road users	High	Traffic Management Plan	Emergency Response Procedure	HSE Officer	REA-PMU
RM-02	Fire Outbreak	Damage to equipment and injuries	High	Fire prevention and suppression systems	Emergency evacuation and response	Site Manager	REA-PMU
RM-03	GBV/SEA Incident	Social and reputational impacts	Medium	Code of Conduct and awareness training	GRM activation and referral process	Gender Officer	REA-PMU
RM-04	Electric Shock	Injury or fatality	High	Electrical safety procedures and PPE	Emergency medical response	HSE Officer	REA-PMU

Table ES7.4: Summary Risk Management Matrix

S/N	Fundamental ESMP Activities	Cost (US $)
1	Pre-construction phase E&S management activities	4,000
2	Construction phase E&S management activities	13,500
3	Commissioning phase E&S management activities	700
4	Operational phase E&S management activities	9,000
5	Preparation of additional management plans	17,500
6	Institutional Capacity Strengthening Plan	3,000
7	Monitoring and Evaluation Programme	19,000
Total ESMP Budget		**66,700**

The Rural Electrification Agency Project Management Unit (REA-PMU) shall retain principal oversight responsibility for ESMP implementation. While certain responsibilities may be delegated to the EPC Contractor and subsequently to the Operations and Maintenance (O&M) Contractor, REA-PMU shall ensure compliance through supervision, audits, inspections, and performance reporting. Relevant regulatory authorities at Federal, State, and Local Government levels, including the Federal Ministry of Environment and Kaduna State environmental agencies, shall participate in monitoring and compliance verification as required by law.

Key ESMP Performance Indicators

The following indicators shall be used to track ESP implementation effectiveness:

- Percentage of mitigation measures implemented on schedule;
- Number of environmental non-compliance incidents recorded;

- Number of occupational accidents and lost-time injuries;
- Number of grievances received and resolved within agreed timelines; and
- Percentage of environmental monitoring activities completed as planned.

The Rural Electrification Agency Project Management Unit (REA-PMU) shall retain overall responsibility for ESMP implementation and compliance monitoring, while the EPC Contractor and subsequent Operations and Maintenance (O&M) Contractor shall implement the prescribed mitigation and monitoring measures under the supervision of REA and the relevant regulatory authorities. The implementation cost of mitigation measures incorporated into the EPC construction contract shall be borne by the Contractor. However, activities outside the EPC scope, including environmental monitoring, institutional capacity strengthening, stakeholder engagement, implementation of the Grievance Redress Mechanism (GRM), independent environmental audits, regulatory compliance monitoring, and other environmental and social management activities, have been separately costed and included in the overall ESMP budget presented in Chapter 7. These allocations will ensure adequate resources are available for effective implementation, monitoring, reporting, and continual improvement of environmental and social performance throughout the Project lifecycle. Stakeholder consultations initiated during the ESIA process shall continue throughout Project implementation in accordance with the Stakeholder Engagement Plan (SEP), while the Grievance Redress Mechanism (GRM) shall remain operational to ensure timely, transparent, and equitable resolution of stakeholder concerns.

ES 8 Remediation Plan after Decommissioning/Closure

Decommissioning refers to the process of removing all the operating assets of a project after completion of its life cycle. The average life span of the solar power plant to be provided as part of the proposed Project is 25 years (which can be extended through regular maintenance) while the training centre can last for 40 years or more. Even after the 25 years, the PV panels can still generate up to 90 % of the design capacity.

In the event of decommissioning, REA, in conjunction with the leadership of FUE Zaria, shall ensure that the Project site is left in a safe and environmentally acceptable condition. A standard decommissioning, abandonment and closure programme shall be invoked. The tasks will include, amongst others:

- Evacuation of the dismantled PV panels and other related items (such as inverters, and control devices) to the manufacturers for recycling.
- Transportation of spent batteries to recycling facilities;
- Restoration of the Project site to baseline conditions (as much as practicable) in line with legislative and regulatory requirements.
- Assessing the residual impact, if any, the project has on the environment.
- Monitoring the abandoned project environment as necessary.

Decommissioning activities will only begin after due consultation with the relevant stakeholders including the regulatory authorities.

ES 9 Stakeholder Engagement and Grievance Redress Mechanism

Stakeholder engagement was conducted as part of the ESIA for the proposed project. This included a review of the legal and administrative framework, stakeholder identification and analysis, and initial consultation with stakeholders. Comments and issues raised by relevant stakeholders consulted during the ESIA study were provided in the report. The consultations were carried out with the following:

- Kaduna State Ministry of Environment and Natural Resources
- Kaduna State Environmental Protection Authority
- Kaduna State Ministry of Women Affairs and Social Development
- Kaduna State Ministry of Youth and Sports
- Management of Nigerian Defense Academy
- FUE Zaria Physical Planning Office
- Zaria Local Government
- Seriki of Gyellesu and Abu Kongo (Local community)
- Civil Society Organizations
- Farmers within the Project site

The consultations served to provide stakeholders with information about the proposed Project and to gather information important to the ESIA. Consultation with the identified stakeholders (including regulators and potentially affected communities) showed general acceptance of the proposed Project.

A Grievance Redress Mechanism (GRM) has been developed by the Rural Electrification Agency (REA) for all components of the Nigeria Electrification Project (NEP), including the Energizing Education Programme (EEP). The GRM identifies potential sources of grievances associated with the proposed Project and establishes the procedures, institutional responsibilities, reporting channels, timelines, and resolution mechanisms for addressing complaints in a timely, transparent, and equitable manner. The mechanism provides accessible channels for receiving, documenting, investigating, resolving, and monitoring grievances throughout the Project lifecycle, including grievances related to environmental, social, labour, occupational health and safety, land access, Gender-Based Violence (GBV), Sexual Exploitation and Abuse/Sexual Harassment (SEA/SH), and community concerns. The effective implementation of the GRM will require dedicated resources for stakeholder communication, grievance registration and documentation, awareness creation, grievance investigations, meetings of the Grievance Redress Committee, monitoring, reporting, and periodic review of the mechanism. Accordingly, the associated implementation costs have been incorporated into the Environmental and Social Management Plan (ESMP) budget to ensure the continued operation and effectiveness of the GRM throughout the Project lifecycle.

ES 10 Summary and Conclusion

The ESIA of the proposed Project has been conducted in accordance with the relevant requirements of the FMEnv and other relevant regulatory agencies in Nigeria, as well as the applicable requirements of the AfDB Safeguard Policies.

Consistent with the regulatory standards, the assessment of the environmental status and the socio-economic aspects of the proposed Project's area of influence have been carefully carried out using accepted scientific methodology. Evaluation of associated and potential impacts of the proposed Project identified both positive and negative interactions with the receiving biophysical and socio-economic environment.

Based on the nature and extent of the proposed Project and the findings of the ESIA study, it is believed that the potential negative impacts associated with the proposed Project can be mitigated to as low as reasonably practicable through the implementation of the proffered mitigation measures documented in Chapter 6 of this report, while the positive impacts can also be enhanced. In addition, an ESMP has been established (Chapter 7) to assess the efficiency and effectiveness of the recommended mitigation measures and ensure long-term monitoring of the Project.

ACKNOWLEDGEMENT

The Rural Electrification Agency (REA) wishes to express its sincere appreciation to the Federal Government of Nigeria, the Federal Ministry of Finance, and the Federal Ministry of Environment for the opportunity granted to undertake this Environmental and Social Impact Assessment (ESIA) for the proposed 2 MW Solar-Hybrid Power Plant at the Federal University of Education (FUE) Zaria, Kaduna State, Nigeria, under the Nigeria Electrification Project (NEP).

The Agency acknowledges the valuable contributions of the Environmental Consultant, Bolben Energy and Environmental Services Ltd, contracted to carry out this ESIA study. Their technical expertise, professional diligence, and commitment to environmental and social best practices were instrumental in the successful completion of this assessment.

We are particularly grateful to the Management and Staff of the Federal University of Education (FUE) Zaria for their cooperation, provision of relevant information, and access to facilities throughout the duration of the study.

The Agency also appreciates the participation and constructive inputs of stakeholders, including community representatives, regulatory agencies, and other relevant institutions who contributed to the ESIA process through consultations and engagement activities.

Their collective support and collaboration have significantly enriched the quality and integrity of this assessment.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Access to reliable, affordable and sustainable electricity remains an important development requirement for public educational institutions in Nigeria. Federal tertiary institutions require dependable electricity to support teaching, research, laboratories, information and communication technology facilities, workshops, administration, student services, security and other essential institutional functions. However, limitations in grid electricity supply have resulted in frequent power interruptions, increased dependence on diesel-powered generators, higher operating costs and associated environmental impacts.

To address electricity-access and reliability challenges, the Federal Government of Nigeria, through the Rural Electrification Agency, is implementing the Nigeria Electrification Project. The Project supports the deployment of decentralized renewable-energy systems, including solar-hybrid mini-grids, stand-alone solar systems and dedicated renewable-energy infrastructure for communities, businesses, educational institutions and healthcare facilities.

The Energizing Education Programme is an intervention under the Nigeria Electrification Project intended to provide clean, reliable and sustainable electricity to selected Federal Universities and associated public facilities. The Programme also includes rehabilitation and strengthening of internal electricity-distribution infrastructure, provision of solar-powered street lighting and establishment of Renewable Energy Workshop and Training Centres.

The Federal University of Education, Zaria, Kaduna State, is one of the beneficiary institutions under the Nigeria Electrification Project – Desert-to-Power Phase II. The proposed subproject comprises a 2 MW solar-hybrid power plant and associated infrastructure, including:

- ground-mounted solar photovoltaic arrays;
- a lithium-ion Battery Energy Storage System;
- inverters, transformers, switchgear and control systems;
- integration and upgrading of the internal electricity-distribution network;
- solar-powered street lighting; and
- a Renewable Energy Workshop and Training Centre.

The Project is intended to improve the reliability and sustainability of electricity supply within FUE Zaria, reduce dependence on diesel-powered generation, support academic and administrative activities, improve campus illumination and security, and strengthen practical training and capacity development in renewable-energy technologies.

This Environmental and Social Impact Assessment has been prepared to identify and assess the potential environmental and social risks and impacts associated with the Project and to establish appropriate mitigation, monitoring and institutional measures in accordance with applicable Nigerian requirements and the African Development Bank Integrated Safeguards System.

1.2 The Proponent

The Project Proponent is the Rural Electrification Agency, located at No. 6 Umaru Dikko Street, off Ebitu Ukiwe Street, P.M.B. 5123, Jabi, Abuja, Nigeria.

The Rural Electrification Agency is an agency of the Federal Government of Nigeria under the Federal Ministry of Power and is established under Section 127 of the Electricity Act 2023. Its mandate includes facilitating the provision of reliable, affordable and sustainable electricity to unserved and underserved communities and public institutions through grid-extension and decentralized electricity solutions, including renewable-energy mini-grids and stand-alone systems.

The Federal Government of Nigeria has assigned the Rural Electrification Agency responsibility for implementing the Nigeria Electrification Project, including the Energizing Education Programme and the Desert-to-Power Phase II intervention. REA, through the Nigeria Electrification Project Management Unit, will be responsible for overall project coordination, procurement oversight, environmental and social compliance, monitoring, reporting and coordination with the African Development Bank, FUE Zaria and relevant regulatory authorities.

1.3 Objectives of the ESIA Study

The overall objective of the Environmental and Social Impact Assessment is to integrate environmental and social considerations into the planning, design, construction, operation and decommissioning of the proposed Project.

The specific objectives of the ESIA are to:

1. establish the existing biophysical, socio-economic, health and cultural-heritage conditions within the Project Area of Influence;
2. identify environmentally and socially sensitive receptors that may interact with the proposed Project;
3. describe the Project components and activities during the pre-construction, construction, commissioning, operation and decommissioning phases;
4. identify, predict and evaluate the potential positive and adverse environmental and social risks and impacts associated with the Project;
5. assess reasonable project, site and technology alternatives and demonstrate the application of the mitigation hierarchy;
6. assess compliance with applicable Nigerian environmental, electricity, labour, occupational health and safety, waste-management and planning requirements;
7. assess the Project against the applicable requirements of the African Development Bank Integrated Safeguards System;
8. obtain and document the views, concerns and expectations of relevant government institutions, FUE Zaria management, campus users, the host community and other interested stakeholders;
9. confirm the land status and existing use of the proposed project footprint and establish a requirement for documented pre-construction land-use due diligence before site handover;
10. recommend practicable measures to avoid, minimize and manage adverse environmental and social impacts and enhance identified project benefits;

11. develop a project-specific Environmental and Social Management Plan containing mitigation measures, monitoring indicators, responsibilities, implementation timeframes and cost estimates;
12. establish stakeholder-engagement, grievance-management, emergency-response and environmental and social monitoring arrangements for the Project lifecycle; and
13. provide a structured basis for regulatory review, public disclosure, environmental approval and continued environmental and social compliance monitoring.

This ESIA forms an essential component of the project approval process, ensuring that environmental and social risks are adequately anticipated and responsibly managed.

1.4 Scope of the ESIA Study

The scope of the ESIA covered the following:

1. review of applicable Nigerian policies, laws, regulations, standards, guidelines and institutional requirements;
2. review of the African Development Bank Integrated Safeguards System and applicable Operational Safeguards;
3. review of relevant project documents, engineering information, maps, previous environmental and social documents and available secondary information;
4. description of the proposed project location, components, associated infrastructure, resource requirements, implementation phases and activities;
5. assessment of reasonable project, site, technology and implementation alternatives, including the no-project alternative;
6. collection and analysis of existing biophysical baseline information covering climate, terrain, geology, hydrogeology, air quality, noise, soil, surface water, groundwater, vegetation and fauna;
7. collection and analysis of socio-economic, community-health, gender, cultural-heritage and institutional information within the Project Area of Influence;
8. laboratory analysis and interpretation of environmental samples collected during the field investigation;
9. stakeholder identification, consultation and documentation of stakeholder concerns, expectations and recommendations;
10. identification, prediction and evaluation of potential environmental and social risks and impacts during pre-construction, construction, commissioning, operation and decommissioning;
11. development of impact-avoidance, mitigation, management and enhancement measures;
12. preparation of a project-specific Environmental and Social Management Plan, monitoring programme, institutional capacity-strengthening plan and implementation budget;
13. development of stakeholder-engagement, grievance-management, waste-management, occupational health and safety, emergency-response and decommissioning requirements;
14. preparation of maps showing the national, state, local and site-level project locations and the Project Area of Influence; and
15. preparation, submission, disclosure and revision of the ESIA in accordance with applicable regulatory and financing requirements.

1.5 ESIA Study Approach / Methodology

The Environmental and Social Impact Assessment (ESIA) for the proposed 2 MW Solar-Hybrid Power Plant at the Federal University of Education (FUE) Zaria was conducted in accordance with the Federal Ministry of Environment (FMEnv) Environmental Impact Assessment (EIA) Procedural Guidelines applicable to off-grid and mini-grid projects implemented under the Nigeria Electrification Project (NEP). The study was also undertaken in alignment with the African Development Bank Group Integrated Safeguards System (ISS), 2023, including the applicable Operational Safeguards (OSs), as well as relevant international environmental and social assessment good practice requirements.

The ESIA process was designed to identify, evaluate, and manage the potential environmental and social risks and impacts associated with the proposed Project throughout its lifecycle, including the pre-construction, construction, commissioning, operation, and decommissioning phases. The assessment also aimed to establish baseline environmental and social conditions, facilitate stakeholder participation, and develop appropriate mitigation and management measures to ensure environmentally and socially sustainable project implementation.

The methodology adopted for the ESIA comprised the following key activities:

- Reconnaissance survey to obtain an understanding of the project location and surrounding environmental and social conditions;
- Desktop review of relevant project documents, regulatory requirements, policies, guidelines, and applicable environmental and social safeguard instruments;
- Stakeholder engagement and scoping consultations with University authorities, host communities, government agencies, and other interested and affected stakeholders to identify key environmental and social issues and concerns;
- Collection of baseline environmental and social data through field investigations, surveys, measurements, and sampling activities covering air quality, noise, soil quality, groundwater quality, surface water quality, vegetation, wildlife, land use, socio-economic conditions, and public health parameters;
- Laboratory analysis of environmental samples to establish existing baseline conditions within the Project Area of Influence (AoI);
- Identification, prediction, and assessment of potential environmental and social risks and impacts associated with project activities;
- Evaluation of impact significance based on established assessment criteria and applicable regulatory requirements;
- Development of mitigation measures and enhancement measures for identified adverse and beneficial impacts respectively;
- Preparation of the Environmental and Social Management Plan (ESMP), monitoring programme, and other supporting management plans required for effective implementation of mitigation measures;
- Preparation and submission of the ESIA Report for regulatory review and approval; and
- Facilitation of stakeholder disclosure and regulatory review processes in accordance with applicable national and international requirements.

The general methodology adopted for the ESIA study is illustrated in Figure 1.1. Detailed descriptions of each activity undertaken during the assessment process are presented in the relevant sections of this report.

The ESIA process was conducted in accordance with the Federal Ministry of Environment (FMEnv) Environmental Impact Assessment Procedural Guidelines, the African Development Bank Group Integrated Safeguards System (ISS), 2023, and other applicable environmental and social regulatory requirements. The approach adopted ensures transparency, regulatory compliance, technical rigour, effective stakeholder participation, and alignment with national and international environmental and social assessment requirements throughout the Project lifecycle.

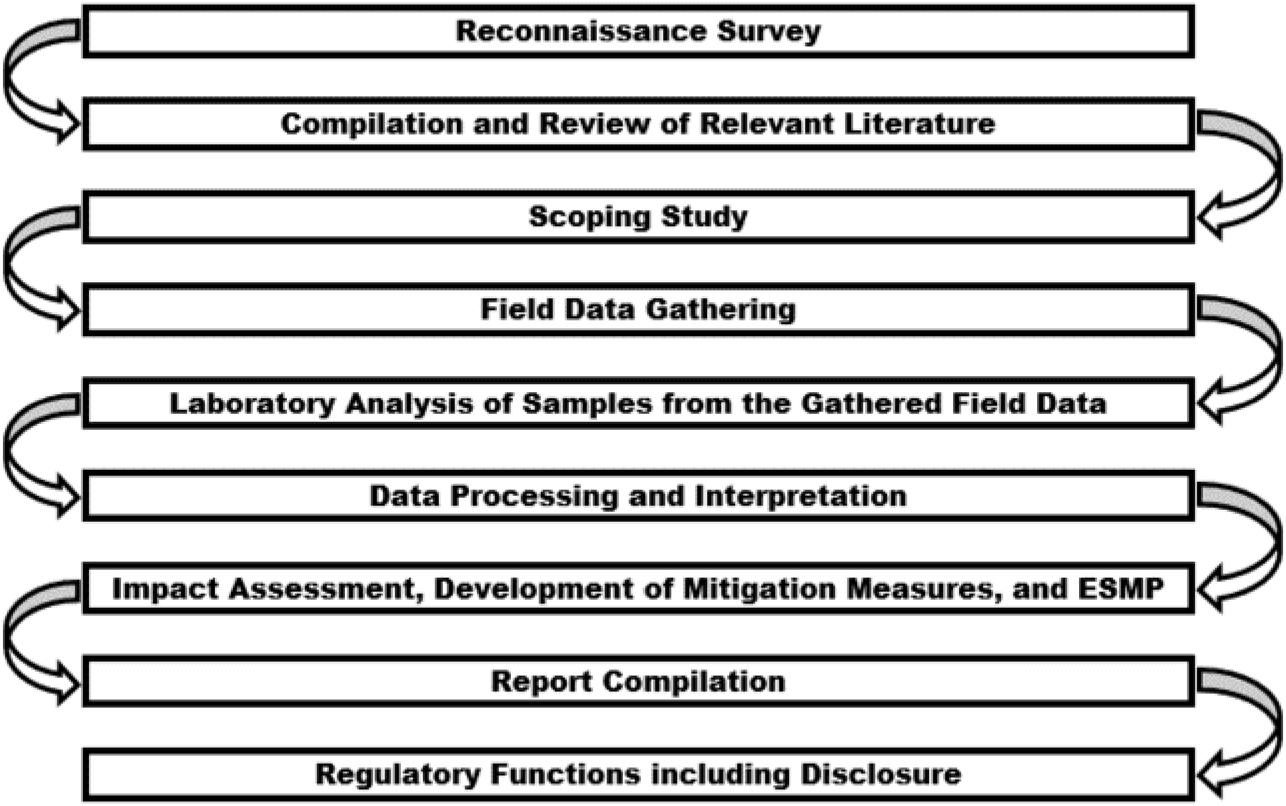


Figure 1.1: Schematic presentation of the general methodology for the EIA/ESIA
(Source: Bolben Energy and Environmental Services Ltd.)

1.6 Limitations of the ESIA Study

The ESIA was prepared using the project information, field observations, environmental samples, laboratory results, stakeholder information and secondary data available during the assessment period.

The environmental field investigation was undertaken in February 2026 and therefore represents prevailing dry-season conditions within the Project Area of Influence. Long-term meteorological information published literature and other available secondary information were used to provide seasonal context for the interpretation of the baseline conditions.

Certain detailed engineering information, including final equipment specifications, construction methods, temporary work areas and the final construction programme, may be refined during detailed design and contractor mobilization. The environmental and social requirements established in this ESIA shall therefore be incorporated into the final design, procurement documents and Contractor Environmental and Social Management Plan.

Before site handover, REA and FUE Zaria shall confirm the final project boundaries, current land-use conditions, access arrangements and nearby sensitive receptors. Any material change to the project footprint, design, technology or implementation method that could result in environmental or social risks not assessed in this report shall be subjected to additional environmental and social screening and, where required, supplementary assessment before the relevant activity commences.

The monitoring and adaptive-management provisions contained in the ESMP will enable unanticipated impacts or changes in environmental and social conditions to be identified and managed during implementation.

1.7 Policy, Legal and Administrative Framework

The proposed Project is subject to the environmental, social, electricity, labour, occupational health and safety, land-use, planning and waste-management requirements of the Federal Republic of Nigeria and Kaduna State. As an African Development Bank-financed operation, the Project is also required to comply with the applicable provisions of the African Development Bank Integrated Safeguards System.

Where national requirements and applicable lender requirements address the same environmental or social issue, the Project shall comply with the requirement that provides the more protective or stringent standard, provided that such compliance does not contravene applicable Nigerian law. The principal policies, laws, regulations, institutions, international commitments and financing requirements relevant to the Project are summarized below.

1.7.1 Constitutional Framework

The Constitution of the Federal Republic of Nigeria, 1999 (as amended) provides the overarching legal basis for environmental protection, public health, occupational safety, and sustainable development in Nigeria. Although the Constitution does not prescribe specific environmental assessment procedures, it establishes the fundamental legal principles upon which environmental legislation applicable to the proposed Project is founded.

In particular:

- **Section 20** places a responsibility on the State to protect and improve the environment and safeguard the nation's air, land, water, forests, and wildlife. This constitutional objective underpins the environmental management measures incorporated into the proposed Project.
- **Section 12** provides the legal basis for the domestication and implementation of international treaties and conventions ratified by Nigeria, thereby supporting the

application of international environmental and social safeguard requirements relevant to this Project.

- **Sections 33 and 34**, relating to the rights to life and human dignity, reinforce the need to protect workers, neighboring communities, and the environment through appropriate occupational health and safety measures, pollution prevention, and environmental management during Project implementation.

1.7.2 Policy, Legal and Institutional Framework

The Energizing Education Programme under the Nigeria Electrification Project (NEP – Desert to Power Phase II) seeks to provide off-grid captive power plants for the generation and provision of dedicated and uninterrupted power supply to Federal Universities and affiliated University Teaching Hospitals across the six geopolitical zones of Nigeria and as a result, policies laws and regulations instituted by the Nigerian Government pursuant to this constitutional requirement and relevant to the programme will be complied with. These are discussed in the following sections.

1.7.3 Policy Framework

1.7.3.1 National Environmental Policy / National Policy on the Environment (Revised 2016)

The national environmental policy launched by Government in November 1989, revised in 2016 prescribed guidelines for achieving sustainable development in fourteen vital sectors of the nation's economy, namely: Human Population; Land Use and Soil Conservation; Water Resources Management; Forestry, Wildlife and Protected Natural Areas; Marine and Coastal Area Resources; Sanitation and Waste Management; Toxic and Hazardous Substances; Mining and Mineral Resources; Agricultural Chemicals; Energy Production; Air Pollution; Noise in the Working Environment; Settlements; Recreational Spaces, Green Belts, Monuments, and Cultural Property.

It also contains Nigeria's commitment to ensure that the country's natural and built environment is safeguarded for the use of present and future generations. This commitment demands that efficient resource management and minimization of environmental impacts be the core requirements of all development activities. Accordingly, this Policy seeks to promote good environmental practices through environmental awareness and education. The goal of the National Policy on the Environment is to "ensure environmental protection and the conservation of natural resources for sustainable development". Its strategic objective is to coordinate environmental protection and natural resources conservation for sustainable development.

The proposed 2 MW Solar-Hybrid Power Plant at the Federal University of Education (FUE), Zaria is consistent with the objectives of the National Policy on the Environment by promoting environmentally sustainable energy development and minimizing adverse environmental impacts throughout the Project lifecycle. The Project incorporates environmental protection measures through careful site selection, implementation of the Environmental and Social Management Plan (ESMP), pollution prevention and waste management measures, occupational health and safety practices, biodiversity conservation, stakeholder engagement, and environmental monitoring.

Furthermore, the use of renewable solar energy in place of fossil fuel-based electricity generation supports the Policy's objective of promoting efficient resource utilization, reducing greenhouse gas emissions, and ensuring the protection of the environment for present and future generations.

1.7.3.2 Social Protection Policies

Social protection policy has been on the agenda since 2004, when the National Planning Commission, supported by the international community, drafted a social protection strategy. More recently, the National Social Insurance Trust Fund (NSITF) drafted a social security strategy. The social protection policy approached social protection using a life-cycle and gender lens, recognizing both economic and social risks, including, for example, job discrimination and harmful traditional practices. The policy was organized around four main themes: social assistance, social insurance, child protection and the labour market.

However, only a few of the instruments of this approach were adopted in the national implementation plan, most notably the provision of specific and limited social assistance, social insurance (such as expanding national health insurance to the informal sector) and labour market programmes (such as developing labour-intensive programmes). Moreover, in practice, programmes to date have been focused largely on conditional cash transfers and two health financing mechanisms driven by the federal government with little inter-sectoral or state-federal coordination. A significant number of actors are involved in funding and implementing social protection, including those from government, donors, international nongovernmental organisations and civil society. Federal government-led social protection includes three main programmes:

i. The conditional cash transfer in Care of the People (COPE) (funded initially through the debt relief gains (DRG fund) targeted at households with specific social categories (those with children of school-going age that are female-headed or contain members who are elderly, physically challenged, or are fistula or HIV/AIDS patients);
ii. The health fee waiver for pregnant women and children under five (financed through the debt relief gains (DRG fund); and
iii. The community-based health insurance scheme, which was redesigned in 2011 because the previous scheme had design challenges.

Other social assistance programmes are implemented in an ad hoc manner by various government ministries, departments and agencies at state level, and some are funded by international donors. These include conditional cash transfer programmes for girls’ education (in three states), child savings accounts, disability grants, health waivers, education support (such as free uniforms) and nutrition support. HIV and AIDS programming at state level also include social protection sub-components (although not as the primary objective), including nutrition, health and education support. Labour market programmes include Federal and State level youth skills and employment programmes, and Nigeria also has agricultural subsidies/inputs.

The proposed 2 MW Solar-Hybrid Power Plant at the Federal University of Education (FUE), Zaria will be implemented in a manner that supports the principles of Nigeria's Social Protection Policy by promoting inclusive development, protecting vulnerable groups, and ensuring equitable access to project benefits. During project implementation, priority will be given, where feasible, to local employment and skills development, while recruitment and labour practices will be conducted in a fair, transparent, and non-discriminatory manner. Appropriate measures will be implemented to safeguard workers' rights, prevent child and forced labour, promote gender equality, and protect vulnerable and disadvantaged groups. In addition, stakeholder engagement, the Grievance Redress Mechanism (GRM), and community health and safety measures incorporated into the Environmental and Social Management Plan (ESMP) will help ensure that potential adverse social impacts are effectively managed while enhancing the Project's social and economic benefits.

1.7.3.3 National Policy on Climate Change / National Climate Change Policy for Nigeria 2021-2030

Given Nigeria's status as a fossil-fuel dependent economy with a large climate sensitive agricultural sector, the development of a climate change policy and response strategy is critical, as climate change presents a serious threat to poverty eradication and sustainable development in general. One of the key pillars of the Vision 20:2020 is investment in low carbon fuels and renewable energy. Achieving the goal of low carbon, high growth and resilient socio-economic system for equitable and sustainable socio-economic and environmental development faces some challenges which include stability and sustainability of the enabling environment, adequate institutional and human resource capacity and availability of adequate resources to address mitigation and adaptation initiatives to address climate change. Thus, the Government needs to ensure that economic growth, resource management and climate change mitigation and adaptation can all happen simultaneously if this will be done effectively. The National Climate Change Policy for Nigeria 2021-2030 was established to promote a low-carbon, climate-resilient and gender-responsive sustainable socio-economic development. The revised National Policy on Climate Change was to define a new holistic framework to guide the country's response to the development challenge of climate change.

The proposed 2 MW Solar-Hybrid Power Plant at the Federal University of Education (FUE), Zaria directly supports the objectives of the National Climate Change Policy for Nigeria (2021–2030) by promoting the deployment of renewable energy as a sustainable alternative to fossil fuel-based electricity generation. The Project will reduce dependence on diesel generators and unreliable grid electricity, thereby contributing to the reduction of greenhouse gas emissions and supporting Nigeria's transition to a low-carbon and climate-resilient economy. Furthermore, the Project enhances climate change mitigation through the use of clean energy technologies, promotes energy efficiency, improves energy security within the University, and contributes to the implementation of Nigeria's Nationally Determined Contributions (NDCs) under the Paris Agreement. The incorporation of environmental and social management measures, climate-resilient infrastructure design, and continuous environmental monitoring further demonstrates the Project's alignment with the objectives of the National Climate Change Policy.

1.7.3.4 The National Electric Power Policy (NEPP), 2001

In order to ensure a safe, steady, reliable and progressively improved electric power sector in Nigeria, the Electric Power Reform Implementation Committee (EPIC) was inaugurated by the BPE and resulted in Federal Executive Council (FEC) of Nigeria approving the National Electric Power Policy in September 2001, which recommended, amongst others: establishment of the electric power sector regulator and the privatisation of the electric power sector. The National Electric Power Policy (NEPP), 2001 outlines the realization of an adequate and reliable supply of electricity in three phases - the privatization of the state-own utility NEPA and the introduction of the Independent Power Producers (IPPs); increasing the competition between market participants, partial removal of subsidies, and sale of excess power to distribution companies (DISCOs); and the freedom to select suppliers by large consumers and the creation of a fully liberalized and competitive market. In 2004, the National Integrated Power Project (NIPP) was initiated to boost power supply by the launch of gas-powered stations. The National Electric Power Policy (NEPP) of 2001 resulted in the Electric Power Sector Reform (EPSRA) Act of 2005 establishing the Nigerian Electricity Regulatory Commission (NERC). The EPSRA provided the statutory basis for the privatization of the power sector.

The proposed 2 MW Solar-Hybrid Power Plant at the Federal University of Education (FUE), Zaria is consistent with the objectives of the National Electric Power Policy (NEPP), 2001, which promotes the development of a reliable, efficient, and sustainable electricity sector through private sector participation, increased investment, and diversification of electricity generation sources. The Project supports the Federal Government's drive to improve electricity access and supply by deploying an off-grid renewable energy system that complements the national grid, enhances energy security, and reduces dependence on conventional fossil fuel-based power generation. Furthermore, the Project aligns with the policy objective of encouraging independent and decentralized power generation to improve electricity reliability for critical public institutions while contributing to the modernization and sustainability of Nigeria's power sector.

1.7.3.5 The National Energy Policy (NEP) 2013

The National Energy Policy (NEP) 2013 is a revised version of the NEP 2003, emphasizes the effective and efficient use of energy and proposes major areas to be considered for energy efficiency and conservation including amongst others: transportation, services/commercial sector, and energy efficient building designs.

The proposed 2 MW Solar-Hybrid Power Plant at the Federal University of Education (FUE), Zaria is consistent with the objectives of the National Energy Policy (NEP), 2013, which promotes the efficient utilization of energy resources, diversification of the national energy mix, and increased deployment of renewable energy technologies. By providing a dedicated off-grid solar-hybrid electricity supply, the Project enhances energy efficiency, improves energy reliability for critical educational infrastructure, reduces dependence on diesel-powered generation, and contributes to the sustainable development of Nigeria's energy sector in line with the policy objectives.

1.7.3.6 The National Energy Efficiency Action Plans of Nigeria

The first version of the National Energy Efficiency Action Plans (NEEAP) for Nigeria (2015-2030) was approved on July 14, 2016 by the National Council on Power (NACOP). It has been formulated within the framework of United Nations' Sustainable Energy for All (SE4All) and adopted by the Inter-Ministerial Committee on Renewable Energy and Energy Efficiency (ICREEE). The NEEAP includes baseline data and information on energy efficiency activities and programmes in Nigeria, barriers to the development and promotion of energy efficiency in the country and suggested achievable energy efficiency targets, including gender disaggregated indicators, based on national potentials and socio-economic assessments. The implementation of the NEEAP is being monitored by the Federal Ministry of Power.

The proposed Project directly supports the implementation of the National Energy Efficiency Action Plan (NEEAP) by promoting the deployment of energy-efficient renewable energy technologies within a Federal tertiary institution. The Project incorporates high-efficiency photovoltaic (PV) modules, lithium-ion Battery Energy Storage Systems (BESS), modern power management and monitoring systems, and energy-efficient electrical infrastructure to optimize electricity generation and utilization. By reducing dependence on inefficient diesel-powered generation and improving energy efficiency within the University, the Project contributes to the achievement of the NEEAP objectives of reducing energy intensity, improving energy conservation, promoting sustainable energy use, and supporting Nigeria's transition to a more energy-efficient and low-carbon economy.

1.7.4 National Legal Framework

1.7.4.1 The Environmental Impact Assessment Act No. 86, 1992 / Environmental Impact Assessment Act Cap E12 LFN 2004

The EIA Act makes it mandatory for any person, authority, corporate body private or public, to conduct EIA prior to the commencement of any new major development or expansion that may likely have significant effects on the environment. The Act sets out the EIA objectives and the procedures for consideration of EIA of certain public or private projects. The proposed 2 MW Solar-Hybrid Power Plant and Associated Infrastructure in Federal University of Education (FUE) Zaria, Kaduna State is considered to be a minor development, which is expected to have minimum impact on the environment. Hence, the programme is categorized as a Category II (B) EIA. The EIA guidelines (procedural and sectoral) issued by the FMEnv derives from this Act and the programme proponents shall conduct their activities in conformance with these guidelines.

1.7.4.2 Electric Power Sector Reform Act 2005

The Electric Power Sector Reform Act No. 6 of 2005 provides for the licensing and the regulation of the generation, transmission, distribution and supply of electricity. Part IV of the Act contains requirements for licensing and stipulates that no person may construct, own or undertake any of the following activities without a license, unless the generating capacity and distribution capacity is below 1 MW and 100 kilowatts (KW) respectively for electricity generation, excluding captive generation, electricity transmission, system operation, electricity distribution and trading in electricity.

1.7.4.3 Energy Commission of Nigeria Act CAP E10 LFN 2004

The Act was promulgated to create the Energy Commission of Nigeria (ECN) with responsibility for coordinating and general surveillance over the systematic development of the various energy resources of Nigeria. Subject to this Act, the ECN is charged with the responsibility for the strategic planning and co-ordination of national policies in the field of energy in all its ramifications. The mandates of ECN include statistical analysis of Electricity Generation, Transmission and Distribution.

1.7.4.4 Land Use Act CAP L5 LFN 2004

The Land Use Act (formerly Cap 202, 1990; now Cap L5, Laws of the Federation of Nigeria 2004) is the principal legislation governing land administration in Nigeria and is directly relevant to the proposed project. The Act regulates land ownership, transfer, acquisition, resettlement, and compensation matters.

Under the Act, all land within a State is vested in the Executive Governor of that State, who holds it in trust for the people. Land is categorized into urban and non-urban (local) areas. The Governor administers urban land, while Local Government Councils administer non-urban land. Individuals do not own land outright but hold rights of occupancy, either statutory (granted by the Governor) or customary (granted by Local Governments).

Statutory rights of occupancy may be granted for all lawful purposes for a definite term not exceeding 99 years, subject to contractual terms, and may include easements and payment of rent. Customary rights of occupancy may be granted for agricultural, grazing, residential, or other purposes, subject to prescribed hectare limits unless the Governor's consent is obtained. The Act provides procedures for revocation of rights of occupancy for public purposes and establishes compensation mechanisms. Each State is required to establish a Land Use and Allocation Committee to determine disputes relating to compensation (Section 2(2)(c)). Local Governments must also establish Land Allocation Advisory Committees. Where a right of occupancy is revoked for public purpose, compensation is payable for unexhausted improvements, defined as permanent improvements resulting from capital or labour that enhance the land's utility or productivity, including buildings, plantations, fencing, roads, irrigation, and reclamation works. Compensation is not payable for bare or vacant land without such improvements. Developed land is defined under Section 50(1) as land with physical improvements such as roads, water, electricity, drainage, or buildings that enhance its value. In cases of compensation dispute, Section 30 provides that such disputes shall be referred to the appropriate Land Use and Allocation Committee, and Section 47(2) limits further appeal. Compensation is payable to the holder and occupier according to their respective interests, as provided under Section 6(5). The provisions of the Land Use Act shall guide any land acquisition, compensation, or resettlement matters relating to the proposed 2 MW Solar-Hybrid Power Plant at FUE Zaria.

The proposed 2 MW Solar-Hybrid Power Plant will be developed on approximately 3.03 hectares of land located entirely within the premises of the Federal University of Education (FUE), Zaria, which has been allocated by the University for the Project. The proposed sites are under the control and administration of the University, and no acquisition of privately owned land is required. Field investigations and stakeholder consultations confirmed that the selected sites are generally free from significant encumbrances that would impede Project implementation. Although limited seasonal farming activities were observed within portions of the proposed Project area, these activities are informal and do not constitute legal ownership or statutory rights of occupancy. Consequently, no physical displacement or resettlement is anticipated. Where temporary disturbance to crops or other unexhausted improvements is unavoidable during construction, such impacts will be managed in accordance with the provisions of the Land Use Act, the Project's Resettlement Policy Framework (where applicable), and the applicable requirements of the African Development Bank Integrated Safeguards System (ISS), including the payment of fair and appropriate compensation where required.

1.7.4.5 The Nigerian Urban and Regional Planning Act CAP N138, LFN 2004

The Urban and Regional Planning Act is aimed at overseeing a realistic, purposeful planning of the country to avoid overcrowding and poor environmental conditions. In this regard, the following sections are relevant:

- Section 30 (3) requires a building plan to be drawn by a registered architect or town planner.
- Section 39 (7) establishes that an application for land development would be rejected if such development would harm the environment or constitute a nuisance to the community.
- Section 59 makes it an offence to disobey a stop-work order. The punishment under this section, is a fine not exceeding ₦10,000 (Ten thousand naira) and in the case of a company, a fine not exceeding ₦50,000.
- Section 72 provides for the preservation and planting of trees for environmental conservation.

The proposed 2 MW Solar-Hybrid Power Plant at the Federal University of Education (FUE), Zaria will be planned, designed, and constructed in accordance with the requirements of the Nigerian Urban and Regional Planning Act. All engineering drawings, building plans, and associated civil works will be prepared and certified by appropriately registered professionals and implemented only after obtaining the necessary planning approvals from the relevant authorities. The selected project sites are located within land designated for institutional development and are compatible with the University's existing physical development plan and surrounding land uses. Furthermore, the Project has been designed to avoid environmental nuisance through appropriate site planning, implementation of the Environmental and Social Management Plan (ESMP), and preservation of vegetation where practicable, including landscaping and restoration of disturbed areas following construction.

1.7.4.6 Harmful Waste (Special Criminal Provisions) Act CAP H1, LFN 2004

The Harmful Waste Act prohibits, without lawful authority, the carrying, dumping or depositing of harmful waste in the air, land or waters of Nigeria. The following sections are notable:

- Section 6 provides for a punishment of life imprisonment for offenders as well as the forfeiture of land or anything used to commit the offence.

- Section 7 makes provision for the punishment accordingly, of any conniving, consenting or negligent officer where the offence is committed by a company.
- Section 12 defines the civil liability of any offender. He would be liable to persons who have suffered injury as a result of his offending act.

During the construction and operational phases, the proposed 2 MW Solar-Hybrid Power Plant may generate small quantities of hazardous or harmful wastes, including waste oils and lubricants from construction equipment, spent fuel and oil filters, used batteries, damaged or end-of-life lithium-ion battery cells, contaminated rags and absorbent materials, waste paints and solvents, electrical and electronic waste (e-waste), and other hazardous materials associated with equipment maintenance. The Project will ensure that all hazardous wastes are properly identified, segregated, labelled, stored, transported, treated, recycled, or disposed of through licensed waste management contractors and approved facilities in accordance with the Harmful Waste (Special Criminal Provisions) Act, applicable NESREA Regulations, and the Project's Waste Management Plan. These measures will prevent the unlawful handling or disposal of harmful wastes and minimize potential risks to human health and the environment.

1.7.4.7 Factories Act CAP F1 LFN, 2004

The Factories Act, as contained in the Laws of the Federation of Nigeria 1990, seeks to legislate and regulate the conduct of health and safety in the Nigerian work environment. It was enacted in June 1987 with the objective to protect workers and other professionals against exposure to occupational hazards. The Director of Factories at the Federal Ministry of Employment, Labour and Productivity is responsible for the administration of the provisions or requirements of this Act. Section 13 allows an inspector to take emergency measures or request that emergency measures be taken by a person qualified to do so, in cases of pollution or nuisances. This Act deals with working conditions at work sites, including construction sites, such as those to be undertaken for the 2 MW Solar-Hybrid Power Plant and associated infrastructure at FUE Zaria. Hence, the occupational requirements applicable to construction sites, as well as other work sites to be used by the project shall be subjected to the provisions of this Act.

1.7.4.8 Labour Act CAP L1 LFN 2004

This Act deals with labour issues, including payment of wages, recruitment, discipline, employee welfare, employment of women and child labour.

- Sections 54 to 58 deal with employment of women, prescribe period of absence from work for nursing mothers and allow her half an hour twice a day during her working hours to attend to the baby for a period of up to six months after she resumes work. Section 55 also exempts women from night work, except when they are employed as nurses.
- Sections 59–64 deal with the employment of young adults.

1.7.4.9 Employee Compensation Act of 2010

The Act makes provisions for the payment of compensation to workmen for injuries suffered in the course of their employment. The compulsory insurance covers employees for injury or death resulting in the course of work or in work places. All types of workers are covered including those employed under a contract for service or an apprenticeship with an employer, whether by way of manual labour, clerical work or otherwise, and whether the contract is expressed or implied, is oral or in writing. The project will employ both skilled and non-skilled labour and shall be subject to this law as applicable.

1.7.4.10 National Environmental Standards & Regulations Enforcement Agency (NESREA) Act, 2007

Administered by the Ministry of Environment, the National Environment Standards and Regulations Enforcement Agency (NESREA) Act of 2007 replaced the Federal Environmental Protection Agency (FEPA) Act. It is the embodiment of laws and regulations focused on the protection and sustainable development of the environment and its natural resources. The following sections are worth noting:

- Section 7 provides authority to ensure compliance with environmental laws, local and international, on environmental sanitation and pollution prevention and control through monitoring and regulatory measures.
- Section 8 (1)(K) empowers the Agency to make and review regulations on air and water quality, effluent limitations, control of harmful substances and other forms of environmental pollution and sanitation.
- Section 27 prohibits, without lawful authority, the discharge of hazardous substances into the environment. This offence is punishable under this section with a fine not exceeding ₦1,000,000 (One Million Naira) and an imprisonment term of 5 years. In the case of a company, there is an additional fine of ₦50,000 for every day the offence persists.

The proposed 2 MW Solar-Hybrid Power Plant at the Federal University of Education (FUE), Zaria shall be implemented in compliance with the provisions of the National Environmental Standards and Regulations Enforcement Agency (NESREA) Act, 2007. During the construction, operation, and decommissioning phases, the Project will adopt appropriate environmental pollution prevention and control measures to minimize emissions, noise, waste generation, and accidental releases of hazardous substances. The Project will also implement the Environmental and Social Management Plan (ESMP), environmental monitoring programme, and waste management procedures in accordance with applicable NESREA Regulations to ensure compliance with national environmental quality standards. Furthermore, the Project Proponent shall cooperate with NESREA and other relevant regulatory authorities in environmental monitoring, inspections, and compliance reporting throughout the Project lifecycle.

1.7.4.11 Applicable NESREA Environmental Regulations

Pursuant to the National Environmental Standards and Regulations Enforcement Agency (NESREA) Act, 2007, several environmental regulations have been developed to establish environmental quality standards and compliance requirements applicable to the proposed 2 MW Solar-Hybrid Power Plant at the Federal University of Education (FUE), Zaria. The principal regulations relevant to the Project are summarized below.

a) National Environmental (Sanitation and Wastes Control) Regulations, 2009

These Regulations provide requirements for the handling, storage, transportation, treatment, and disposal of solid and hazardous wastes. The Project shall ensure proper segregation, collection, storage, recycling, and disposal of construction and operational wastes in accordance with the provisions of the Regulations.

b) National Environmental (Noise Standards and Control) Regulations, 2009
The Regulations prescribe permissible noise limits for various land-use categories and require the implementation of measures to minimize noise pollution. Construction and operational activities associated with the Project shall comply with the applicable noise standards.

c) National Environmental (Surface and Groundwater Quality Control) Regulations, 2011
The Regulations establish standards for the protection and management of surface water and groundwater resources. Project activities shall be implemented in a manner that prevents contamination of water resources within and around the Project Area of Influence.

d) National Environmental (Soil Erosion and Flood Control) Regulations, 2011
These Regulations provide measures for the prevention and control of soil erosion, land degradation, and sedimentation. Appropriate erosion control and site rehabilitation measures shall be implemented throughout the Project lifecycle.

e) National Environmental (Electrical/Electronic Sector) Regulations, 2011
The Regulations provide guidance on the environmentally sound management of electrical and electronic equipment and associated wastes. The provisions are particularly relevant to the management of solar panels, inverters, batteries, transformers, and end-of-life electrical components associated with the Project.

f) National Environmental (Air Quality Control) Regulations, 2014
The Regulations establish air quality standards and emission limits aimed at protecting human health and the environment. Construction-related dust emissions and exhaust emissions from equipment and vehicles shall be managed in accordance with the requirements of the Regulations. Compliance with the above NESREA Regulations shall be ensured throughout the planning, construction, operation, and decommissioning phases of the proposed Project.

1.7.4.12 National Environmental Regulations

Section 34 of the NESREA Act, 2007 empowers the Minister of Environment to make regulations for a safe and sustainable environment. In exercise of this power, the Minister issued national environmental regulations covering various environmental components and sectors of development. The regulations relevant to the proposed project are as follows:

- National Environmental (Energy Sector) Regulations, 2014, S.I. 63.
- National Environmental (Electrical/Electronic Sector) Regulations, 2011, S.I. No. 23.
- National Environmental (Battery Control) Regulations, 2024, S.I. No. 11 of 2024.
- National Environmental (Sanitation and Wastes Control) Regulations, 2009, S.I. No. 28.
- National Environmental (Noise Standards and Control) Regulations, 2009, S.I. No. 35.
- National Environmental (Air Quality Control) Regulations, 2013, S.I. No. 64.
- National Environmental (Soil Erosion and Flood Control) Regulations, 2010, S.I. No. 12.

- National Environmental (Surface and Groundwater Quality Control) Regulations, 2010, S.I. No. 22.
- National Environmental (Control of Vehicular Emissions from Petrol and Diesel Engines) Regulations, 2010, S.I. No. 20.

The implementation of the proposed Solar-Hybrid Power Plant shall conform to these regulations throughout its life cycle.

1.7.4.13 EIA Procedural Guidelines

This procedure prescribes the steps to be followed in the EIA process from project conception to commissioning and post-commissioning impact mitigation, in order to ensure that the project is implemented with maximum consideration of environmental factors. This ESIA study for the proposed 2 MW Solar-Hybrid Power Plant at FUE Zaria has been conducted in compliance with these guidelines.

1.7.4.14 EIA Sectorial Guidelines (Infrastructures)

This provides general guidelines for EIA of projects in infrastructure sectors of Nigeria, with specific details for sub-sectors. The proposed power project falls within the infrastructure and energy sector and shall comply accordingly.

1.7.4.15 FMEnv ESMP Guidelines for Solar Mini-Grid Projects in Nigeria

The ESMP Guidelines for Solar Mini-Grid Projects in Nigeria were developed as an abridged form of the EIA Procedures Guidelines with the aim of simplifying the method of preparing ESMPs for proposed solar mini-grid projects. The simplified method also optimizes the mini-grid project EIA timeline and cost of development. The proposed Solar-Hybrid Power Plant, although larger in capacity, adopts the ESMP framework principles contained within this guideline.

1.7.4.16 Other Relevant National Regulatory Frameworks

The following national standards and guidelines are also applicable to the proposed 2 MW Solar-Hybrid Power Plant at the Federal University of Education (FUE), Zaria:
a) National Building Code, 2006: The National Building Code establishes the minimum standards for the planning, design, construction, alteration, maintenance, and occupancy of buildings in Nigeria. The Code is intended to safeguard public health, safety, and welfare through sound engineering and construction practices. The Project shall ensure that all permanent structures, including the control room, inverter stations, battery energy storage facilities, site office, and Renewable Energy Training Centre, are designed and constructed in accordance with the requirements of the National Building Code to ensure structural integrity, fire safety, accessibility, and public safety.**b) National Guidelines for Decommissioning of Facilities in Nigeria (2014):** The Guidelines provide a framework for the orderly decommissioning, dismantling, restoration, and environmental management of facilities at the end of their operational life to prevent adverse environmental and social impacts. The proposed Project shall implement an approved Decommissioning Plan at the end of its operational life to ensure the safe

removal of solar panels, battery storage systems, electrical equipment, foundations, and ancillary facilities, as well as the restoration of disturbed areas in accordance with the applicable national decommissioning requirements and the Environmental and Social Management Plan (ESMP).**c) Standards Organization of Nigeria (SON) Act, 2015:** The Standards Organization of Nigeria (SON) Act empowers the Standards Organization of Nigeria to establish, approve, and enforce national standards for products, materials, equipment, and engineering practices to ensure quality, safety, and consumer protection. All construction materials, photovoltaic modules, battery energy storage systems, transformers, cables, electrical components, and associated equipment to be utilized for the Project shall comply with applicable Nigerian Industrial Standards (NIS) or internationally recognized standards approved by SON. Compliance will ensure product quality, reliability, operational safety, and long-term performance of the solar-hybrid power system.

d) Engineering Design Codes and Standards: Engineering design codes and internationally recognized technical standards establish the requirements for the safe design, construction, testing, commissioning, operation, and maintenance of engineering infrastructure. The design, procurement, installation, testing, commissioning, and operation of the proposed solar photovoltaic system, battery energy storage system, substations, electrical installations, and associated civil works shall conform to applicable Nigerian engineering requirements and internationally recognized engineering codes and standards to ensure technical reliability, operational efficiency, electrical safety, and environmental sustainability throughout the Project lifecycle.

1.7.4.17 State Legal and Regulatory Frameworks (Kaduna State)

In Nigeria, States and local government councils are empowered under the law to set up their own environmental protection bodies for the purpose of maintaining good environmental quality in the areas of related pollutants under their control. The proposed Project will be located within FUE Zaria campus in Zaria Local Government Area (LGA) of Kaduna State. The key State and local government administrative authorities with statutory functions related to the Project are briefly described below:

- ***Kaduna State Ministry of the Environment and Natural Resources***

The Kaduna State Ministry of the Environment and Natural Resources is responsible for the policy awareness and intervention of key environmental issues in Kaduna State. The key environmental issues include desertification and deforestation, pollution and waste management, climate change and clean energy, flood and erosion, and environmental standards and regulations.

- ***Kaduna State Environmental Protection Authority***

The Kaduna State Environmental Protection Authority (KEPA) was established by edict of 1994 and later revised in 1998 to ensure sustainability in Kaduna State. The authority is charged with the responsibility of addressing all environmental problems in the state including but not limited to organizing programmes aimed at changing people's negative attitudes towards environmental management for sustainable development. The functions of KEPA include, amongst others, the following:

- Enact and enforce State regulations, procedures, guidelines, and environmental standards for effective prevention, remediation, control and monitoring of point and non – point sources of pollution and degradation;
- Implement and review environmental policy in the State; and in particular to demand and review environmental impact assessments/statements for new development projects.
- Monitor environmental quality, conduct programmes for continuing surveillance and regular periodic inspection of actual or potential contaminants of point and non-point sources of environmental pollution in accordance with the laid down regulations as the Authority may deem fit;
- Without prejudice to the provision of any existing law relating to refuse disposal, the Authority shall establish operational mechanisms for refuse collection, transportation and disposal in cooperation with the Local Governments of the State.

❖ ***Zaria Local Government Area***

The Local Government has an Environmental Health Department which ensures compliance with environmental sanitation law, which includes maintaining good housekeeping and proper management of waste, amongst others.

1.7.5 International Legislation

The International Conventions to which Nigeria is a signatory, and which are relevant to this project, include:

- African Convention on the Conservation of Nature and Natural Resources;
- Convention on Biological Diversity;
- Convention on the Conservation of Migratory Species of Wild Animals 1973;
- Framework Convention on Climate Change 1992;
- Convention to Combat Desertification 1994;
- Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW);
- UNFCCC Paris Agreement of 2016;
- United Nations Guiding Principles on the Human Environment, 1972;
- The Rio Declaration on Environment and Development, 1992;
- African Charter on Human and Peoples' Rights on the Rights of Women in Africa 2005;
- International Covenant on Civil and Political Rights;
- International Covenant on Economic, Social and Cultural Rights;
- Convention on the Elimination of All Forms of Violence Against Women;
- Convention on the Rights of the Child.

1.7.6 Institutional Framework

The relevant institutions involved in the planning and implementation of the proposed project include:

- Federal Ministry of Power;
- Federal Ministry of Environment (FMEnv);

- Nigerian Electricity Regulatory Commission (NERC);
- National Environmental Standards and Regulations Enforcement Agency (NESREA);
- National Universities Commission (NUC);
- Rural Electrification Agency (REA);
- Kaduna State Ministry of Lands and Survey;
- Local Government Authority (Zaria LGA).

Their respective roles include policy formulation, regulatory oversight, licensing, environmental compliance monitoring, land administration and stakeholder coordination.

1.7.7 Funding Agency Requirements

The proposed 2 MW Solar-Hybrid Power Plant at the Federal University of Education (FUE), Zaria is financed under the Federal Government of Nigeria's Energizing Education Programme (EEP) with support from the African Development Bank (AfDB) under the Nigeria Electrification Project (NEP). Accordingly, the Project shall comply with the applicable environmental and social safeguard requirements of the funding agency in addition to the relevant national legal and regulatory requirements. These safeguard requirements are intended to ensure that potential environmental and social risks are appropriately identified, avoided, minimized, mitigated, and monitored throughout the Project lifecycle.

1.7.7.1 Applicable Environmental and Social Safeguards

The Project has been classified as a **Category II** development under the applicable environmental assessment requirements. The following environmental and social safeguards are applicable:

- **Environmental and Social Assessment:** The Project has been subjected to a comprehensive Environmental and Social Impact Assessment (ESIA) to identify potential environmental and social impacts and establish appropriate mitigation and monitoring measures before implementation.
- **Biodiversity and Ecosystem Services Protection:** Although ecological surveys confirmed that no critical habitats or endangered species occur within the Project footprint, the Project will minimize vegetation clearing, protect surrounding ecosystems, and implement biodiversity management measures to prevent unnecessary disturbance to flora and fauna.
- **Pollution Prevention and Hazardous Materials Management:** Appropriate measures will be implemented to prevent pollution arising from construction activities, control dust and noise emissions, manage solid and hazardous wastes, and ensure the safe storage, handling, transportation, and disposal of batteries, oils, and other hazardous materials throughout the Project lifecycle.
- **Labour Conditions, Occupational Health and Safety:** The Project will provide safe and healthy working conditions through implementation of occupational health and safety procedures, provision of appropriate personal protective equipment (PPE), emergency preparedness and response measures, worker training, fair labour practices, and compliance with applicable national labour legislation and international good practice.

1.7.8 International Conventions

The Nigerian Government is an important player in the international support for the protection of the environment. As such, the country is a signatory to some international laws and conventions, which are targeted towards conservation and protection of the environment in order to ensure sustainable development. The international conventions (ratified by Nigeria) and regulations that are relevant to the proposed Project include:

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

The African Convention on the Conservation of Nature and Natural Resources was adopted in Algiers, Algeria, on September 15, 1968 and entered into force on June 16, 1969. The Convention stipulates that the contracting States shall undertake to adopt the measures necessary to ensure conservation, utilization and development of soil, water, flora and fauna resources in accordance with scientific principles and with due regard to the best interest of the people.

- ***Basel Convention on the Control of Trans-boundary Movement of Hazardous Wastes and their Disposal***

The Convention was adopted on March 22, 1989 and entered into force on May, 1989. It focuses attention on the hazards of the generation and disposal of hazardous wastes. The Convention defines the wastes to be regulated and controlled in order to protect human and environmental health against their adverse effects.

- ***The United Nations Convention on Biological Diversity***

The Convention was adopted in 1994. The objectives of the Convention include the conservation 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.

- ***The United Nations Framework Convention on Climate Change***

The Convention on Climate Change was adopted in 1992 during the Rio Earth Summit in Rio De Janeiro, Brazil, and entered into force in 1994 to limit Greenhouse Gas (GHG) emissions.

- ***Protocol to the African Charter on Human and Peoples' Rights on the Rights of Women in Africa (Maputo Protocol)***

This calls on states to protect rights of women and girls, such as property rights, rights to a consensual marriage, protection against child marriage, widows' rights, inheritance rights, and protection against all forms of violence. Nigeria ratified this protocol in 2004 to address the historical discrimination and marginalization of women and girls, including GBV.

- ***International Health Regulations (2005)***

The International Health Regulations (IHR) is an international legal instrument that is binding on 196 countries across the globe, including all the member states of World Health Organisation (WHO). This binding instrument of international law entered into force on 15 June 2007. The purpose and scope is "to prevent, protect against, control and provide a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks and which avoid unnecessary interference with international traffic and trade".

- ***Declaration of the United Nations Conference on Human Environment***

The principles of this Declaration relevant to the proposed Project are summarized below:

Principle 2: The natural resources of the earth, including the air, water, land, flora and fauna 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 3: The capacity of the earth to produce vital renewable resources must be maintained and, wherever practicable, restored or improved.
Principle 4: Nature conservation, including wildlife, must receive importance in planning for economic development.
Principle 15: Planning must be applied to human settlements and urbanization with a view to avoiding adverse effects on the environment and obtaining maximum social, economic and environmental benefits for all.
Principle 18: Science and technology, as part of their contribution to economic and social development, must be applied to the identification, avoidance and control of environmental risks and the solution of environmental problems and for the common good of mankind.

- ***International Labour Organisation (ILO): ILO-OSH 2001 – Guidelines on Occupational Safety and Health (OSH) Management Systems***

These guidelines call for coherent policies to protect workers from occupational hazards and risks while improving productivity. The guidelines present practical approaches and tools for assisting organizations, competent national institutions, employers, workers and other social partners in establishing, implementing and improving occupational safety and health management systems, with the aim of reducing work-related injuries, ill health, diseases, incidents and deaths. Nigeria ratified the guidelines in 2001.

1.7.9 International Guidelines, Conventions and Industry Codes

An overview of international guidelines, conventions and industry codes that are relevant to the proposed Project is provided in the sub-sections below:

- *International Electrochemical Commission (IEC)*

The IEC Technical Specification 62257 series contain recommendations for small renewable energy and hybrid systems for rural electrification projects. It outlines international best practice solutions to support energy access in developing countries across a range of technologies. The purpose of this series is to assist renewable energy project managers, engineers and system designers as well as operators to choose the right system for the right place and to design, operate and maintain the system.

- *AfDB Safeguard Policies*

The Integrated Safeguards System (ISS) is the African Development Bank's environmental and social risk management framework applicable to all AfDB-financed operations. The ISS establishes mandatory requirements for borrowers to identify, assess, manage, and monitor environmental and social risks and impacts throughout the project life cycle. The ISS promotes sustainable development by ensuring that projects:

- Avoid or minimize adverse environmental and social impacts
- Protect vulnerable populations
- Promote stakeholder participation and transparency
- Enhance environmental and social performance

As indicated in Table 1.1, there are a total of eight (8) environmental and social safeguard policies of the AfDB, of which only Operational Policy (OS) 1, 3, 4, 5 6 and 7 is triggered by the proposed Project, and its requirements have been taken into consideration in the ESIA study.

Table 1.1: Applicability of the AfDB Integrated Safeguards System (ISS, 2023) Operational Safeguards to the Proposed Project

AfDB Operational Safeguard (ISS 2023)	Scope / Requirement	Triggered?	Justification	Sections of the ESIA Report Addressing the Requirement
OS1 – Assessment and Management of Environmental and Social Risks and Impacts	Requires environmental and social screening, categorization, ESIA preparation, stakeholder engagement, ESMP development, disclosure, monitoring and reporting.	Yes	The proposed 2 MW Solar-Hybrid Power Plant may result in environmental and social impacts during construction, operation and decommissioning phases, requiring a comprehensive ESIA and ESMP.	Executive Summary; Section 1.5 (ESIA Methodology); 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 Closure Plan)
OS2 – Labour and Working Conditions	Promotes fair treatment, non-discrimination, workers' rights, occupational health and safety, grievance mechanisms, and prohibition of child and forced labour.	Yes	Construction and operation activities will involve direct and contracted workers, with associated occupational health and safety risks.	Sections 3.7 (Health and Safety); 5.2 (Impact Assessment); Chapter 6 (Mitigation Measures); Chapter 7 (ESMP)
OS3 – Resource Efficiency and Pollution Prevention and Management	Promotes efficient use of resources and prevention of air, water, soil, noise, waste and hazardous material pollution.	Yes	Construction activities may generate dust, noise, solid waste and wastewater, while operation may involve management of batteries and electronic waste.	Sections 3.6 (Water Use and Supply); 3.8 (Waste Management); Sections 4.2.4–4.2.7 (Air, Noise, Soil and Water Quality); Chapter 5 (Impact Assessment); Chapter 6 (Mitigation Measures); Chapter 7 (ESMP)
OS4 – Community Health, Safety and Security	Requires assessment and management of risks to affected communities, including traffic, emergency preparedness, security and public safety.	Yes	Construction traffic, workforce activities and electrical infrastructure may create temporary risks to campus users and neighbouring communities.	Section 5.2 (Impact Assessment); Chapter 6 (Mitigation Measures); Chapter 7 (ESMP); Section 7.8 (Grievance Redress Mechanism)
OS5 – Land Acquisition, Restrictions on Access to Land and Land Use, and Involuntary Resettlement	Avoid or minimise displacement and livelihood impacts and provide compensation where unavoidable.	No (Subject to Confirmation)	The project is proposed within existing university premises and no physical displacement or land acquisition is anticipated.	Sections 3.2 (Project Site Description); 4.3 (Socio-Economic Environment); Chapter 5 (Impact Assessment)
OS6 – Habitat and Biodiversity Conservation and Sustainable Management of Living Natural Resources	Protect biodiversity, ecosystem services and natural habitats and apply mitigation hierarchy.	Yes (Low Risk)	Minor vegetation clearing may occur during site preparation; however, no critical habitats or protected areas have been identified within the project footprint.	Sections 4.2.8 (Terrestrial Flora and Fauna); Chapter 5 (Impact Assessment); Chapter 6 (Mitigation Measures); Chapter 7 (ESMP)
OS7 – Vulnerable Groups	Requires identification, assessment and inclusion of vulnerable and disadvantaged	Yes	The project area includes students, women, support staff and other potentially vulnerable groups requiring	Section 4.3 (Socio-Economic Environment); Chapter 5 (Impact Assessment); Section 7.6

AfDB Operational Safeguard (ISS 2023)	Scope / Requirement	Triggered?	Justification	Sections of the ESIA Report Addressing the Requirement
	groups in project planning and implementation.		inclusive engagement and access to project benefits.	(Stakeholder Engagement); Section 7.8 (GRM)
OS8 – Cultural Heritage	Protect tangible and intangible cultural heritage and establish chance-find procedures.	Low Risk / Conditional	No known cultural heritage resources occur within the project footprint; however, a Chance Find Procedure will be implemented.	Section 4.3 (Socio-Economic Environment); Chapter 5 (Impact Assessment); Chapter 6 (Mitigation Measures); Chapter 7 (ESMP)
OS9 – Financial Intermediaries	Applies where AfDB financing is channelled through financial intermediaries.	No	The proposed project does not involve a financial intermediary arrangement.	Not Applicable
OS10 – Stakeholder Engagement and Information Disclosure	Requires meaningful stakeholder engagement, information disclosure, consultation and grievance management throughout the project lifecycle.	Yes	Stakeholder consultations, information disclosure and grievance redress mechanisms are required throughout project implementation.	Section 4.3 (Socio-Economic Environment); Section 7.6 (Stakeholder Engagement); Section 7.8 (Grievance Redress Mechanism); Appendices on Stakeholder Consultations

1.8 Project Location

The proposed 2 MW solar-hybrid power plant and associated infrastructure will be located entirely within the campus of the Federal University of Education, Zaria, in Zaria Local Government Area of Kaduna State, North-West Nigeria. Kaduna State is bounded by Katsina and Kano States to the north, Bauchi and Plateau States to the east, Nasarawa and the Federal Capital Territory to the south, and Niger, Zamfara and Kebbi States to the west. Zaria is a major educational, commercial and cultural centre located in the northern part of Kaduna State.

The Project will occupy a combined area of approximately 3.03 hectares distributed across three separate locations within the FUE Zaria campus. The project locations lie approximately between Latitude 11.082444°N and 11.087455°N and Longitude 7.731279°E and 7.735060°E. The three sites are existing institutional land under the control and administration of FUE Zaria. They were identified as open and undeveloped land without residential occupation, commercial use or productive livelihood activity within the proposed construction footprint.

Before construction-site handover, REA and FUE Zaria shall jointly verify the final boundaries and current land-use conditions and document the verification through geo-referenced photographs and a signed site-availability record. Any material change in occupation or land use identified before construction shall be assessed and resolved in accordance with applicable Nigerian and AfDB requirements before work proceeds in the affected area.

Figure 1.2 presents the location of Kaduna State within Nigeria, while Figure 1.3 presents Zaria Local Government Area, the FUE Zaria campus and the proposed project locations.

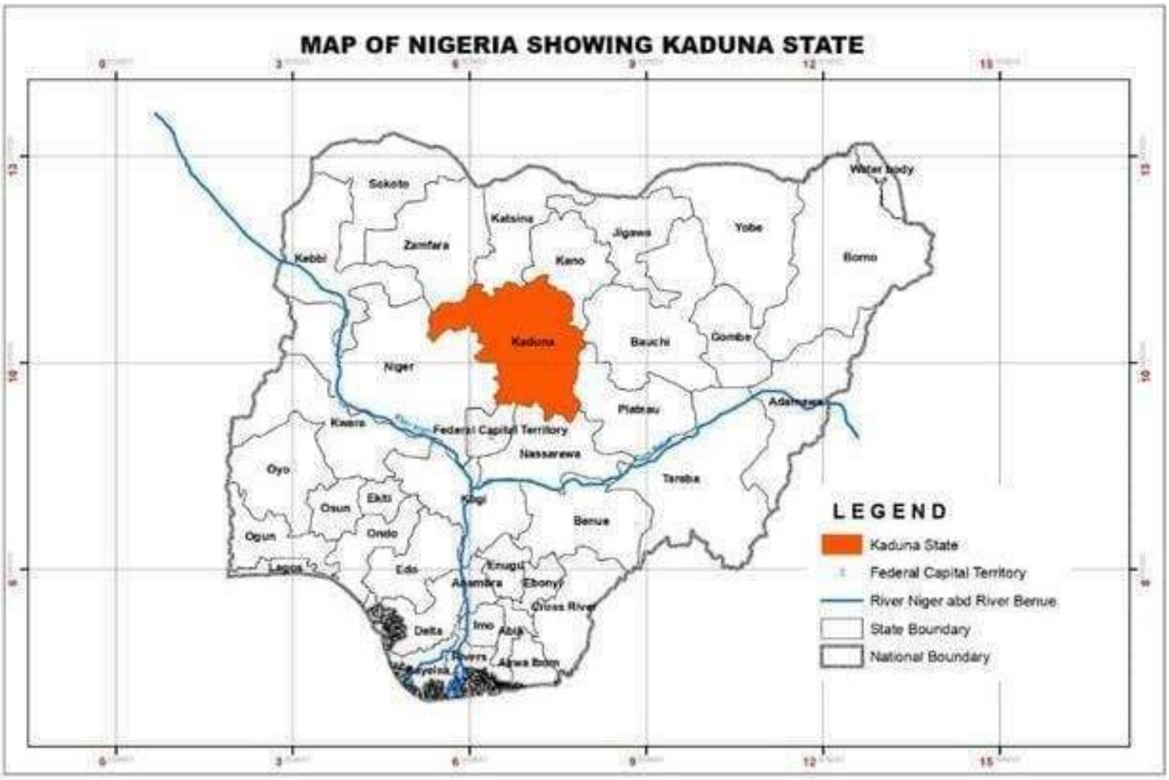


Figure 1.2: Project location map showing Kaduna State within Nigeria.

Kaduna State is located in the north-central geopolitical zone of Nigeria, bounded to the north by Katsina and Kano States, to the east by Bauchi and Plateau States, to the south by Nasarawa and Kogi States, and to the west by Niger and Kebbi States. The State lies approximately between latitudes 9°00′N and 11°32′N, and longitudes 6°15′E and 8°38′E. Zaria LGA is situated in the northern part of Kaduna State and serves as an important educational, commercial, and cultural hub in the region.

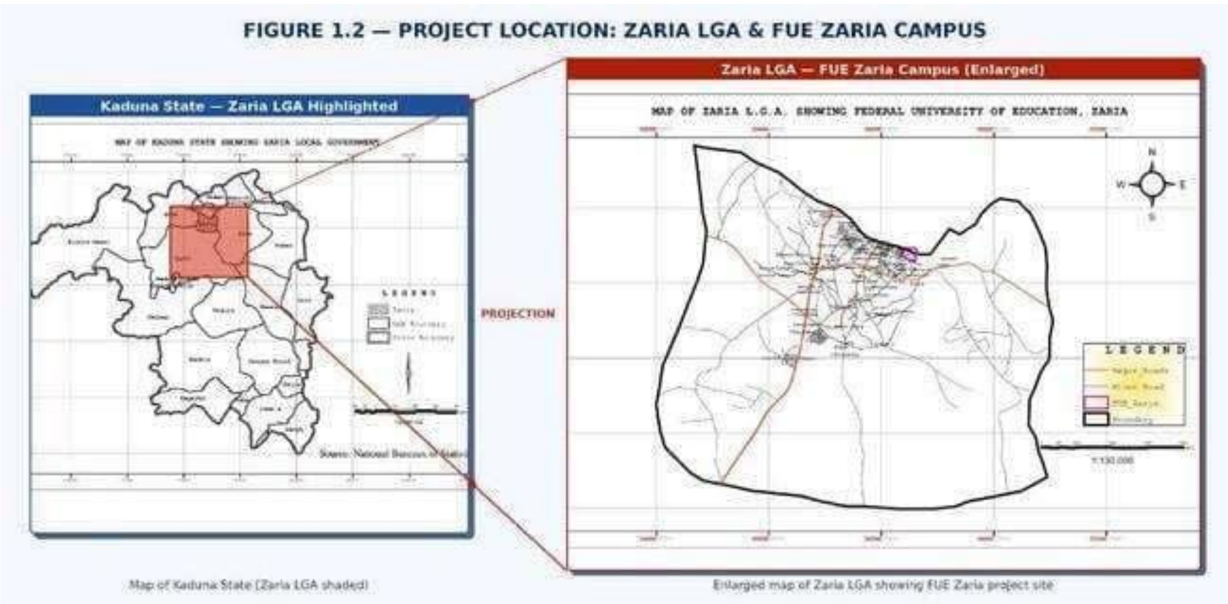


Figure 1.3: Zaria LGA and FUE Zaria location maps

The project site is located entirely within the existing institutional land holdings of FUE Zaria.

1.9 Report Structure

The ESIA report is structured as follows:

- **Preliminary Sections:** Title pages, document-control information, table of contents, lists of figures, tables and plates, acronyms, Executive Summary and acknowledgement.
- **Chapter One – Introduction:** Project background, proponent, ESIA objectives, scope, methodology, limitations, policy and legal framework, project location and report structure.
- **Chapter Two – Project Justification and Alternatives:** Project need, benefits, sustainability considerations and assessment of project, site and technology alternatives.
- **Chapter Three – Project Description:** Project location, technical components, resource requirements, implementation phases, activities, waste streams and implementation schedule.
- **Chapter Four – Description of the Environmental and Social Baseline:** Field and desktop methods and the physical, biological, socio-economic, health and cultural-heritage conditions of the Project Area of Influence.
- **Chapter Five – Associated and Potential Impacts:** Impact-assessment methodology and evaluation of environmental and social risks and impacts across the Project lifecycle.
- **Chapter Six – Mitigation and Enhancement Measures:** Measures for avoiding, minimizing and managing adverse impacts and enhancing positive impacts.
- **Chapter Seven – Environmental and Social Management Plan:** Implementation measures, monitoring requirements, responsibilities, management plans, institutional capacity and ESMP budget.
- **Chapter Eight – Decommissioning, Closure and Site Remediation:** End-of-life management, dismantling, waste recovery, site restoration and post-closure monitoring.
- **Chapter Nine – Stakeholder Engagement and Grievance Redress Mechanism:** Stakeholder identification, consultation outcomes, engagement programme, disclosure and grievance-management arrangements.
- **Chapter Ten – Summary, Conclusion and Recommendations:** Summary of findings, environmental and social feasibility conclusion and conditions and recommendations for project implementation.

CHAPTER TWO
PROJECT JUSTIFICATION

This chapter presents the justification for the proposed 2 MW solar-hybrid power plant and associated infrastructure in FUE. Zaria, Kaduna State, as part of the Federal Government of EEP and Nigeria Electrification Project (NEP) Phase II (Desert-to-Power). It also includes the description of alternatives and development options considered for the proposed Project.

2.1 Need for the Project

The Federal Universities in Nigeria remain the top choice for a large percentage of students seeking admission into tertiary institutions in the country. However, inadequate power supply from the grid is a major challenge facing many of these universities. To cope with the situation, most of the universities rely on diesel-fuelled generators for power generation, with significant economic and environmental implications.

Part of the FGN's initiatives to address inadequate power supply in the country is the NEP. NEP is an innovative programme that seeks to provide electricity access to off-grid communities across the country through renewable power sources. It is being implemented by REA and co-financed by the AfDB.

The Energizing Education Programme (EEP) is a key component of the Nigeria Electrification Project (NEP), designed to provide dedicated, clean, and reliable electricity to Federal Universities and their affiliated University Teaching Hospitals nationwide. The current phase of implementation covers three universities and is ongoing. Among the beneficiary institutions under the Desert-to-Power (DtP) initiative is the Federal University of Education (FUE), Zaria, located in Kaduna State in the Northwest region of Nigeria. The EEP also supports Nigeria's commitment to reducing greenhouse gas emissions by 20–30% by 2030, as outlined in its Nationally Determined Contributions (NDCs) under the Paris Agreement.

The proposed project at FUE Zaria forms part of EEP Phase II under NEP. It is expected to substantially alleviate the University's existing power supply challenges, generating significant academic and operational benefits. Additional project components, including a renewable energy training centre, will enhance capacity building and professional certification opportunities, while improved street lighting infrastructure will strengthen campus security through better illumination.

2.2 Value of the Project

NEP is being co-financed by the AfDB through a $250 million. Initially, the World Bank had co-financed $350 million has been allocated for the implementation of EEP as a component of NEP. The finance required for the proposed FUE Project. Zaria will be obtained from the $250 million.

2.2.1 Alignment with Nigeria's Energy Transition Plan (ETP), 2022

The proposed Project aligns with the Federal Government of Nigeria's Energy Transition Plan (ETP), 2022, which provides a roadmap for achieving universal energy access, energy security, sustainable economic development, and net-zero emissions by 2060. The ETP identifies renewable energy as a critical component of Nigeria's future energy mix and targets significant expansion of solar power generation to support electricity access and decarbonization objectives. Nigeria currently faces a substantial electricity access deficit, with millions of citizens lacking reliable electricity supply and many institutions relying heavily on self-generation through fossil-fuel-powered generators. The deployment of the proposed 2 MW Solar-Hybrid Power Plant at FUE Zaria contributes directly to the ETP objectives by increasing renewable energy penetration, reducing dependence on diesel-powered generation, lowering greenhouse gas emissions, and improving energy security within the education sector. The Project also contributes to Nigeria's Nationally Determined Contributions (NDC 3.0) by supporting low-carbon development pathways and facilitating the transition from fossil-fuel-based electricity generation to cleaner energy sources.

2.2.1.1 Financial and Economic Justification

The cost of electricity generation from diesel-powered generators has increased significantly in recent years due to fluctuations in global oil prices, exchange rate pressures, and the removal of fuel subsidies. Current diesel prices in Nigeria frequently exceed ₦1,000–₦1,500 per litre depending on location and market conditions. For a university environment with substantial energy demand, reliance on diesel generators can result in annual operating expenditures running into hundreds of millions of Naira due to fuel procurement, maintenance, lubricants, spare parts, and equipment replacement costs. By contrast, although solar-hybrid systems require higher upfront capital investment, operating and maintenance costs are significantly lower over the project lifecycle. The proposed Project is therefore expected to improve the long-term financial sustainability of electricity supply within the University while reducing exposure to future fuel price volatility.

2.2.1.2 Energy Sustainability and Cost Savings

The Project is designed to provide a dedicated and reliable power supply to support academic, administrative, research, and residential activities within the University. Existing electricity supply to many tertiary institutions in Nigeria is often characterized by a combination of grid supply limitations and dependence on backup diesel generators. This arrangement is associated with high operating costs, frequent service interruptions, equipment downtime, and environmental impacts. The proposed solar-hybrid system will reduce dependence on diesel-powered electricity generation and grid instability, resulting in lower energy expenditure over the project life. The financial sustainability of the Project is further enhanced by the relatively low operating costs associated with solar photovoltaic technology and the long service life of solar modules.

2.2.2 Greenhouse Gas Emission Reduction Benefits

Conventional diesel generators emit significant quantities of greenhouse gases (GHGs), particularly carbon dioxide (CO_2), as well as other pollutants including nitrogen oxides (NOx), sulphur oxides (SOx), and particulate matter. Assuming a typical diesel generator consumes approximately 0.25–0.30 litres of diesel per kWh generated, a facility requiring several megawatt-hours of electricity daily would consume substantial volumes of diesel annually. Such consumption would result in considerable carbon emissions over the project lifecycle. The proposed 2 MW Solar-Hybrid Power Plant is expected to significantly reduce the University's dependence on diesel generation and thereby avoid substantial GHG emissions. In addition to climate benefits, the Project will contribute to improved local air quality and reduced noise pollution associated with generator operation. Where diesel consumption records become available, a detailed GHG inventory and emissions reduction analysis shall be undertaken in accordance with recognized international methodologies.

2.2.3 Socio-Economic Benefits

Federal Universities serve large populations of students, academic staff, non-academic staff, contractors, service providers, and visitors. Reliable electricity supply is critical for teaching, learning, research, digital infrastructure, laboratory operations, security systems, and residential services. The proposed Project is expected to positively affect thousands of direct and indirect beneficiaries within the University community by improving educational outcomes, enhancing research capacity, supporting digital learning, and creating a more conducive learning environment. The Project will also generate employment opportunities during construction and operation, support local businesses, improve security through street lighting, and facilitate skills acquisition through the Renewable Energy Workshop and Training Centre.

2.2.4 Technical Standards, Certification and Quality Assurance

To ensure reliability, safety, and performance, all equipment proposed for the Project shall be sourced from reputable Original Equipment Manufacturers (OEMs) with demonstrated experience in solar photovoltaic and battery energy storage technologies. Solar panels, inverters, batteries, transformers, switchgear, and other components shall comply with applicable international standards and Nigerian regulatory requirements. Products supplied to the Project shall possess Standards Organization of Nigeria (SON) certification and, where applicable, Mandatory Conformity Assessment Programme (MANCAP) certification. Installation, testing, and commissioning activities shall be undertaken by qualified personnel with appropriate technical competence. Electrical installations shall be inspected and certified in accordance with the requirements of the Nigerian Electricity Management Services Agency (NEMSA).

2.2.5 Occupational Health and Safety and Community Health and Safety

Construction and operation of the proposed Project will involve activities that present occupational health and safety risks, including electrical hazards, working at heights, equipment handling, excavation works, and vehicular movement. Appropriate safety management systems, training programmes, emergency preparedness procedures, and use of personal protective equipment shall be implemented to reduce occupational risks. Community health and safety measures shall include traffic management, access control, warning signage, public awareness programmes, emergency response planning, and implementation of grievance redress mechanisms to address stakeholder concerns.

2.2.6 Evaluation of Technology and Battery Storage Alternatives

Battery Energy Storage Systems (BESS) are critical components of solar-hybrid power systems because they enhance reliability, support load management, and improve system stability. The two principal battery technologies considered for the Project are Lead-Acid Batteries and Lithium-Ion Batteries. Lead-acid batteries generally have lower capital costs but shorter lifespans, lower energy density, higher maintenance requirements, and lower charging efficiency. Lithium-ion batteries have higher upfront costs but offer longer service life, greater depth of discharge, higher efficiency, lower maintenance requirements, reduced space requirements, and superior lifecycle economics. Based on technical performance, operational reliability, maintenance requirements, and lifecycle cost considerations, Lithium-Ion Battery Energy Storage Systems are considered the preferred option for the Project.

2.2.7 Solar E-Waste and End-of-Life Management

The deployment of solar photovoltaic systems and battery storage technologies generates future obligations relating to the management of end-of-life equipment. Solar modules typically have operational lifespans of approximately 25–30 years, while lithium-ion batteries generally have service lives ranging from 10–15 years depending on operating conditions and usage patterns. At the end of their useful lives, solar panels, batteries, inverters, transformers, cables, and associated electrical equipment may constitute electronic waste (e-waste) requiring environmentally sound management. The Project shall implement a comprehensive e-waste management strategy consistent with applicable NESREA Regulations and international good practice. This shall include inventory management, reuse and recycling where feasible, engagement of licensed waste management contractors, and environmentally responsible disposal of equipment that cannot be reused or recycled.

2.3 Project Benefits

The proposed Project is envisaged to have a range of associated benefits, since the importance of gaining access to reliable and steady power supply cannot be overemphasized. Some of the benefits are a function of the objectives of the Project, while others are a function of the way in which the Project is designed to meet its objectives.

The potential benefits of the proposed Project include but are not necessarily limited to the following:

- Stimulation of academic and research activities within the University as a result of access to constant and reliable power supply, thereby promoting educational advancement.
- Reduction in fossil fuel consumption by the University thereby leading to reduction in carbon emissions and improvement in eco-balance.

- Significant reduction in the cost of power generation by the University through diesel-fuelled generators. Such savings would be used for other undertakings that will benefit the University.
- Increase in social interactions within the University. There will be enhanced security in the University as a result of more streetlights for illumination which would help keep off opportunistic crimes and gender-based violence.
- Enhancement of learning in renewable energy leading to certification as a result of training centre to be provided as part of the Project.
- Improvement in livelihood enhancing activities within the University.
- Direct and indirect employment opportunities during Project development and operation. The employment opportunities will lead to acquisition of new skills and introduction of all manners of income generating spill-over effects.
- Increase in local and regional economy through award of contracts and purchase of supplies for Project development.
- Increase in financial and technical collaborations between the FGN, the University, REA, World Bank and other relevant Ministries, Departments and Agencies (MDAs).
- Contributing to the Nigeria's NDC to cut carbon emission by 20 % to 30 % by the year 2030, under the Paris Agreement.

2.4 Envisaged Sustainability

2.4.1 Technical Sustainability

The Project development shall be handled by qualified and experienced EPC contractor (to be selected by REA through a competitive process) according to preestablished standards and procedures. The design and construction phase of the Project shall be overseen by qualified engineers from REA and the Department of Works and Physical Planning in FUE Zaria. In addition, standard operating manuals and appropriate documentation regarding the operation and maintenance of the Project shall be developed and put in place by the EPC Contractor. These documents will be used as the basis for providing facility-specific training to relevant personnel prior to start-up to further ensure technical sustainability of the Project. Upon completion of the construction phase, the EPC contractor will operate and maintain the Project in conjunction with the team from FUE Zaria's Works and Physical Planning Unit. In addition, adequate capacity building shall be provided to the University personnel that will work with the O&M Contractor for the day-to-day operations of the Project in the long run.

2.4.2 Environmental Sustainability

The environmental sustainability measures for the Project include the use of renewable source of energy (solar) for electricity generation (with negligible greenhouse gas (GHG) emissions compared to fossil fuel-burning power plants). In addition, the establishment of REA-PMU (which includes experienced Environmental and Social Safeguards Specialists) to oversee the implementation of the Project will contribute to environmental sustainability of the Project. More so, this ESIA study undertaken at the early stage of the Project development phase (and the commitment to implement the recommended mitigation measures and the ESMP developed as part of the ESIA) is geared towards ensuring the environmental sustainability of the Project.

2.4.3 Economic Sustainability

The proposed Project is part of the FGN's EEP initiative, a component of NEP. NEP is being funded by the World Bank with Three Hundred and Fifty Million US Dollars ($350,000,000) loan, with an additional finance from the AfDB through a two hundred and fifty Million US Dollars ($250,000,000) is allocated for projects under the EEP and Desert-to-Power (DtP) initiative. The proposed Project in FUE Zaria, as part of the EEP Phase II, will be financed from the AfDB fund. Upon completion, the Project will significantly reduce the use of diesel generators in the University thereby saving costs on diesel fuel and generator maintenance, amongst others. Also, the monthly payment to distribution company (Kaduna Electricity Distribution Company) for power consumption through the grid would stop. Part of such savings will be used for the maintenance of the Project facilities in the long run. A cost-reflective service charge (to be determined based on consultation with University management and users) shall be implemented for all facilities within the University campus. Private business establishments within the University campus shall be allowed to connect to the power Project and metered for billing to generate additional revenue to the University. The generated funds shall be used to sustain the operational costs of the project as well as for the procurement of project components that may be replaced (e.g. spent batteries, panels, etc.) in the future. Additionally, the Project will enhance the University's Internally Generated Revenue (IGR) for other development activities and minimize dependency on allocation from the Federal Government.

2.4.4 Social Sustainability

Stakeholder consultation has been carried out as part of the ESIA process in ensuring that all relevant stakeholders are presented with the opportunity to provide input into the Project at the early stage. This has also assisted in laying a good foundation for building relationship with the stakeholders. In addition, initial stakeholder engagement activities carried out during the ESIA have been presented in the report. A Stakeholder Engagement Plan (SEP) shall be developed to ensure continuous engagement with relevant stakeholders throughout the Project life cycle. In addition, a grievance redress mechanism (GRM) has been developed by REA for the Project. The GRM provides the communication channel to receive any complaints from stakeholders on the proposed Project and ensures that they are timely and adequately addressed. Details on stakeholder consultations carried out till date on the proposed Project are provided in Chapter 9 of this report.

2.5 Project Alternatives

2.5.1 Site Alternatives

An approximately 3.03 hectares of land within the FUE Zaria campus has been allocated by the University authority for the proposed Project based on three sites section. The Project site has been selected based on a number of considerations including: i) proximity to the existing substation which is located about 25m away from the site; ii) accessibility – the Project site can easily be accessed through the existing road network within the campus; iii) security; iv) absence of any physical structure that could be affected by the proposed Project; v) absence of any rocky outcrops on the site that could pose constraints to the solar panels to be installed; vi) absence of any ecologically sensitive areas and/or cultural resources within and around the Project site. Other sites considered within the University campus for the proposed Project were rejected due to some factors such as: i) presence of physical structure and agricultural crops which could trigger major displacement and relocation issues; ii) far distance from the existing substation; iii) poor accessibility; iv) technical considerations for installation of solar panels, for example, topography.

2.5.2 Alternatives Considered within the Context of the proposed Solar-Hybrid

Power Plant

The power plant to be provided as part of proposed Project in FUE Zaria has been conceptualized to be a renewable energy source (solar technology) since that is part of the objectives of the EEP initiative (i.e. carbon emission reduction). Thus, this section specifically focuses on the alternatives considered within the proposed solar-hybrid power plant and eliminates discussion on other possible sources of power generation in Nigeria such as the use of natural gas fired power plant, coalfired plant, oil-fuelled plant, etc.

2.5.2.1 Overview

Solar power generation is currently one of the fastest growing areas in renewable energy. Beyond panel production, it does not emit any significant GHGs. Compared to alternative renewable generation technologies such as wind turbines or biofuel generators, Solar energy is produced by converting the sun’s radiation – a process void of any smoke, gas, or other chemical by-product, which makes this technology to meet the clean development mechanism of the Kyoto Protocol. This is the main driving force behind all green energy technology, as nations attempt to meet climate change obligations in curbing emissions. The use of solar energy for the proposed power plant in FUE Zaria will significantly avoid the generation of GHG emissions associated with fossil-fuelled power plants. Thus, the proposed Project will help contribute to Nigeria’s NDC on climate change. In addition, the high solar irradiation in Kaduna State (as indicated in Figure 2.1) will be able to support the proposed power plant.

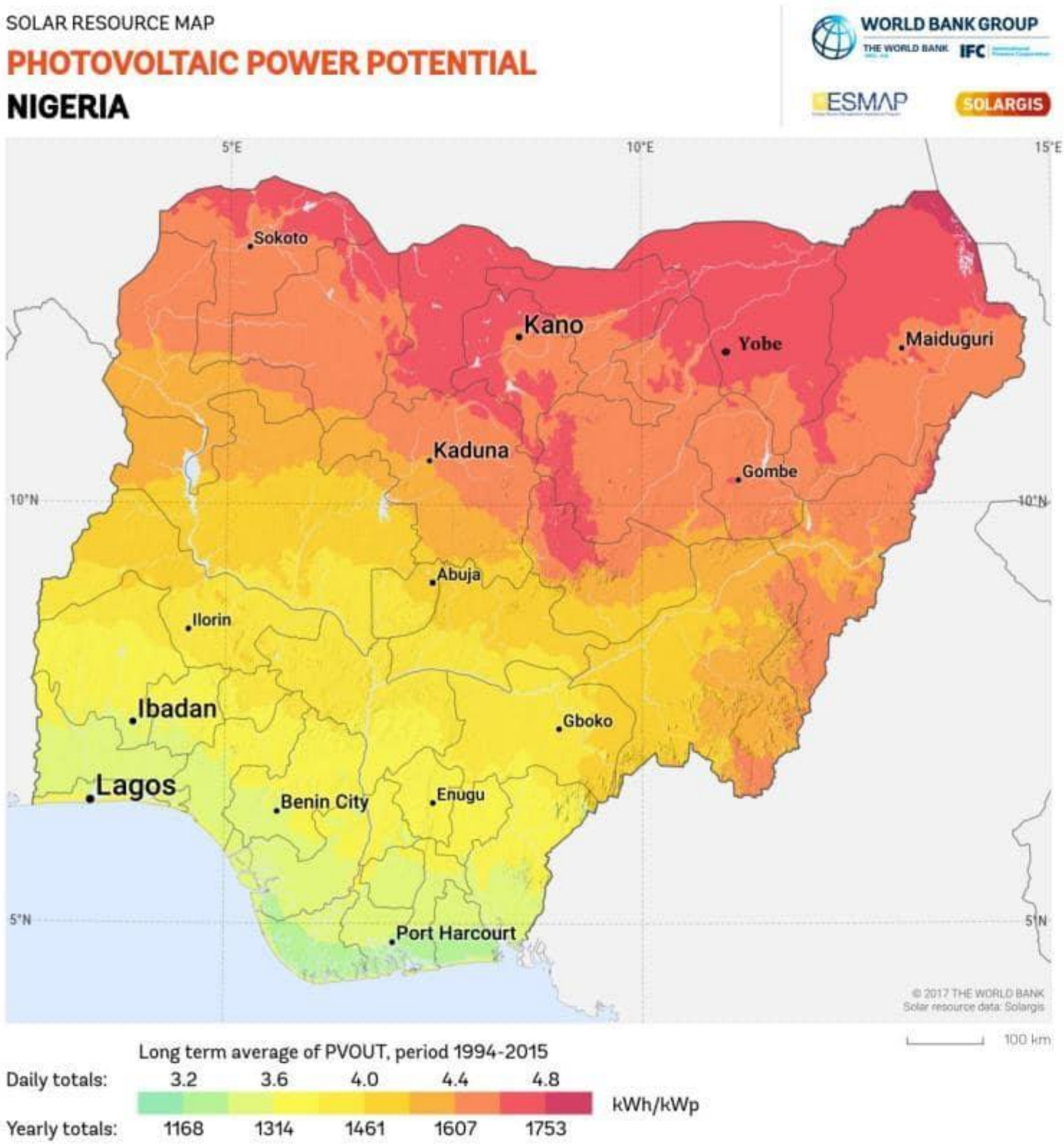


Figure 2.1: Photovoltaic power potential of Nigeria
Source: © 2017 The World Bank, Solar resource data: Solargis

2.5.2.2 Solar Power Technology Alternatives

The solar technologies considered for the proposed power plant in FUE Zaria are:

- Concentrated Solar Power (CSP) Systems
- Photovoltaic (PV) Solar Panels

However, the preferred option for the proposed power plant is the use of PV Solar Panel since it is highly flexible and requires low installation and maintenance cost in comparison to CSP technology. Water requirement for PV system is also low when compared to CSP system.

The comparison between CPS and PV Solar technologies considered for the Project is summarized in Table 2.1.

Table 2.1: Comparison between CSP and PV Solar Technology

Features CSP Technology PV Technology

Features	CSP Technology	PV Technology
Description .	CSP technology uses concentrated radiation from the sun, to heat a liquid substance which is used to generate steam which in turn passes through a steam-turbine to generate electricity. CSP Technology produces electricity through indirect means. Energy output with CSP technology is of AC type	PV technology uses sunlight through the 'photovoltaic effect' to generate direct electric current (DC). PV Technology produces electricity through direct means. Energy output with PV technology is of DC type but commonly converted to AC through an inverter.
Applications/Scale	CSP is used for utility scale power generation, mostly for Grid Connections, and also supporting conventional thermal power and desalination plants.	PV technology is suitable for off grid small and medium-sized applications, and for utility scale applications
Land requirement	CSP technology is best suited for areas of high direct normal solar radiation. CSP technology requires about 4 hectares of land per MW of capacity	PV technology has a wider geographical area of application. PV technology requires about 2 hectares of land per MW of capacity
Land requirement	CSP technology is best suited for areas of high direct normal solar radiation. CSP technology requires about 4 hectares of land per MW of capacity	PV technology has a wider geographical area of application. PV technology requires about 2 hectares of land per MW of capacity
Cost	CSP technology has an high installation and maintenance cost compared to PV	PV technology has a low installation and maintenance cost in comparison to CSP
Construction Time	CSP plant construction is technical more complex than PV	Utility scale PV plants are easier to install and require less time than CSP for Plant construction
Water Requirement	Water requirement is variable depending on the CSP technology option adopted. CSP may utilize wet, dry, and hybrid cooling techniques	Typically requires less water than CSP technology. Water is occasionally required for cleaning of dust from the panels
Design Options	Less flexible in comparison to PV technology. Can be hybridized with fossil fuels like natural gas.	Highly flexible and adaptable to the project specific requirement
Average life span	25 years	25 years
Efficiency	Power production efficiency of CSP technology are as high as 45%	Power production fluctuates with the sunlight's intensity. For practical use this usually requires conversion to certain desired voltages or AC, through the use of inverters.
Environmental Risks	CSP systems have been recorded to pose environmental risks to bird species, which may be killed by the intense heat generated by the concentrated solar radiation which is reflected off the mirrors.	PV systems are considered to be generally benign.

2.5.2.3 PV Panel Alternatives

Solar PV panel is an assembly of photovoltaic cells, also known as solar cells. It is an essential component of a PV system that converts sunlight directly into direct current (DC) electricity. To achieve a required voltage and current, a group of PV panels (also called PV modules) are wired into large array that called PV array. PV panels can be wired together in series and/or parallel to deliver voltage and current in a particular system requires. The types of solar cells that are commonly used in PV technology are: i) monocrystalline silicon; ii) poly-crystalline silicon; and iii) thin film. The typical appearance of each of these PV panels is shown in Figures 2.2 to 2.4. Based on the consideration of cost and efficiency, polycrystalline silicon PV panels are envisaged to be used for the proposed Project.

Figure 2.2: Typical appearance of mono-crystalline silicon PV panels

Figure 2.3: Typical Appearance of Polycrystalline Silicon PV panels

Figure 2.4: Typical appearance of Thin-Film CdTe panels

2.5.3 Battery Types Alternative

The proposed solar power plant in NDA is an off-grid system, which will involve the storage of power. Storage allows the PV array to continue providing power even when the demand is down, instead of having to disconnect and refrain from generating power. The batteries for the proposed power plant would be required to meet the demands of heavy cycling (charging and discharging) and irregular full recharging. There are a variety of battery types fitted for these requirements; however, four (4) of these batteries are the best available technology for solar power plants. These are: lead-acid, lithium-ion, flow, and nickel-cadmium batteries. Following the careful consideration of factors such as safety, charging cycles, depth of discharge and life span, lithium-ion batteries are envisioned to be used as the preferred battery for the proposed solar power plant. An overview of the battery types considered for the Project is provided below:

- ***Lead-Acid Batteries***

These are the oldest and cheapest form of batteries used in solar systems. They are widely used in Solar PV installations due to their wide availability and ability to work in a wide range of conditions. They internally convert hydrogen and oxygen into water and do not require maintenance. However, proper disposal of end-of-life lead-acid batteries is important. The lead-acid battery life is typically 3-10 years.

- ***Lithium-Ion Batteries***

Lithium-ion batteries can deliver more cycles in their lifetime than lead-acid. They can be lighter and more self-contained than lead-acid batteries. They are solid, and do not require refills or maintenance. The most important benefit lithium-ion provides for solar is its high charge and discharge efficiencies, which help harvest more energy. Lithium-ion batteries also lose less capacity when idle, which is useful in solar installations where energy is only used occasionally. Lithium-ion batteries usually have longer lifespan when compared to the lead-acid batteries, average of 5 years.

- ***Flow Batteries***

The vanadium redox flow battery (VRFB) is the most common technology in this type of batteries. In VRFB, the vanadium electrolyte does not degrade over time, so they can last much longer than other technologies. With other technologies, adding more batteries is the only way to increase hours of storage; however, adding more electrolyte (vanadium) can increase battery size in VRFB. The VRFB has no cycling limitations, and batteries can be charged and discharged completely without impact on their lifespan. They can last up to 20 years. The recycled vanadium in flow batteries is not toxic and can be reused repeatedly for other purposes, such as in making steel. However, the high cost of vanadium and ion selective membrane within the cell will lead to significant cost implications for the Project.

- ***Nickel-cadmium Batteries***

Nickel cadmium or NiCd batteries are as old as the lead-acid batteries. Though they may not have the energy density (the power) of other technologies, they provide long life and reliability without complex management systems. They are also as cheap as lead-acid batteries. NiCd batteries are rugged batteries with a high life span of up to 20 years. However, the major disadvantage of NiCd batteries is the relatively low energy density and susceptibility to self-discharge. Thus, making NiCd batteries an unreliable alternative for the proposed Project.

2.6 Project Options

2.6.1 No Project Option

One of the reasons for the proposed Project in FUE Zaria is that the current demand for electricity in the University significantly exceeds generation/supply and, that the current power supply through the grid is unreliable and suffers interruptions. If the Project does not go ahead, access to reliable, safe and cheaper power supply may be difficult to realize. In addition, the potential benefits associated with the Project would not be realized. Furthermore, the no project option would mean that the University will continue to significantly rely on diesel-fuelled generators for self-generation of power considering the current situation of electricity supply to the University through the grid. This has serious economic implications to the University and would not also be in line the FGN’s efforts in achieving its carbon emission targets. Thus, the No Project option is not considered a viable option to adopt.

2.6.2 Delayed Option

This option implies that the planned Project will be delayed until a much later date. Such option is usually taken when conditions are unfavourable to project implementation such as in war situation, or where the stakeholders are deeply resentful of the Project. Also, if the prevailing economic climate is not quite favourable to the Project, then delayed project option may be feasible. But none of these conditions is applicable. Indeed, both the economic and the political environments are most favourably disposed towards the Project. The implication of delayed project option will mean that all the preliminary work and associated efforts/costs incurred would have come to nothing. Also, because of inflationary trends, such a delay may result in unanticipated increases in project costs, which may affect the final profit accruable from the Project. The delayed option is considered unviable for the Project.

2.6.3 Go Ahead Option

The inherent benefits of allowing the Project to go ahead as planned are multifarious. The quality of education, capacity for research and innovation, training opportunities, improved security within the University campus, job opportunities for Nigerian professionals, skilled and semi-skilled craftsmen will increase. Thus, the option to go ahead as planned does outweigh the other options as clearly highlighted above.

CHAPTER THREE

PROJECT DESCRIPTION

3.1 Introduction

This chapter presents the technical description of the proposed Project including the Project location, associated components, power generation and evacuation approach, and development activities. Waste streams associated with the proposed Project over its life cycle, and the proposed handling techniques are also discussed.

3.2 Project Location

3.2.1 About FUE Zaria

FUE Zaria is a Federal Government-owned tertiary institution, with its campus situated in Zaria Local Government Area of Kaduna State, Northwestern geo-political region of Nigeria (Figures 3.1 to 3.4). The Federal University of Education (FUE), Zaria, Kaduna State, traces its origins to 1962, when it was established as the Advanced Teachers' College, Zaria, to train qualified teachers for secondary schools in Northern Nigeria. In 1976, following the Federal Government's restructuring of teacher education institutions, it was renamed the Federal College of Education (FCE), Zaria, with a mandate to award the Nigeria Certificate in Education (NCE) and later run degree programmes in affiliation with established universities.

In a major reform of teacher education in Nigeria, the institution was officially upgraded to a full-fledged university in February 2023, when the President of the Federal Republic of Nigeria assented to the bill establishing it as the Federal University of Education, Zaria. This transition expanded its mandate to include the award of bachelor's and postgraduate degrees in education and related disciplines. The university now serves as a specialized institution dedicated to advancing teacher education, educational research, and human capacity development across Nigeria, particularly in the northern region.

3.2.2 Description of the Project Site

The proposed solar-hybrid power plant will be developed within the existing landholding of Federal University of Education Zaria. No additional land acquisition, involuntary resettlement, physical displacement or economic displacement is anticipated as part of the project. The selected location is within an existing institutional facility and will utilize land already under the control of the University.

Approximately 3.03 hectares of land distributed across three separate locations within the FUE Zaria campus has been allocated by the University authority for the proposed Project. The adoption of three separate sites was necessitated by the limited availability of large, contiguous land within the institution. The three sites collectively provide the required land area for the proposed 2 MW Solar-Hybrid Power Plant and are all located within the geographical extent bounded by Latitude 11.082444°N to 11.087455°N and Longitude 7.731279°E to 7.735060°E. The sites are referenced using the Minna Datum, Universal Transverse Mercator (UTM) Zone 32N, with a Transverse Mercator projection. Coordinates are presented in Eastings and Northings to ensure accurate spatial referencing and compatibility with other survey and planning data. Prior to commencement of construction, the exact project footprint shall be surveyed and confirmed to ensure that no third-party users, agricultural activities or informal occupants are affected. An existing access road is shown on the DTA plan, providing convenient access to the site and supporting potential development activities.

The surrounding land use within the university environment is predominantly institutional, with academic buildings, open spaces, and support facilities. The elevation of the site ranges approximately from 616.92 to 629.60 meters above mean sea level, as indicated by the height legend on the Digital Terrain Analysis plan (Table 3.1). This represents a vertical relief that ranges from 3.0 to 5.8 meters across the entire site area (Table 3.1). Such a limited elevation difference indicates a generally low-relief terrain. The contour distribution across the site shows gradual and smooth changes in elevation, with no evidence of sharp breaks or steep escarpments. Higher elevations occur in some sections of the site, while lower elevations are found in other areas, creating a gentle natural slope. The moderate relief conditions are favourable for construction works, as they reduce the need for extensive cutting and filling operations.

Table 3.1 Topography of Sites

Sites	Elevation (M)	Relief (M)
A	623.24 to 629.04	5.8
B	616.92 to 619.94	3.0
C	624.34 to 629.60	5.26

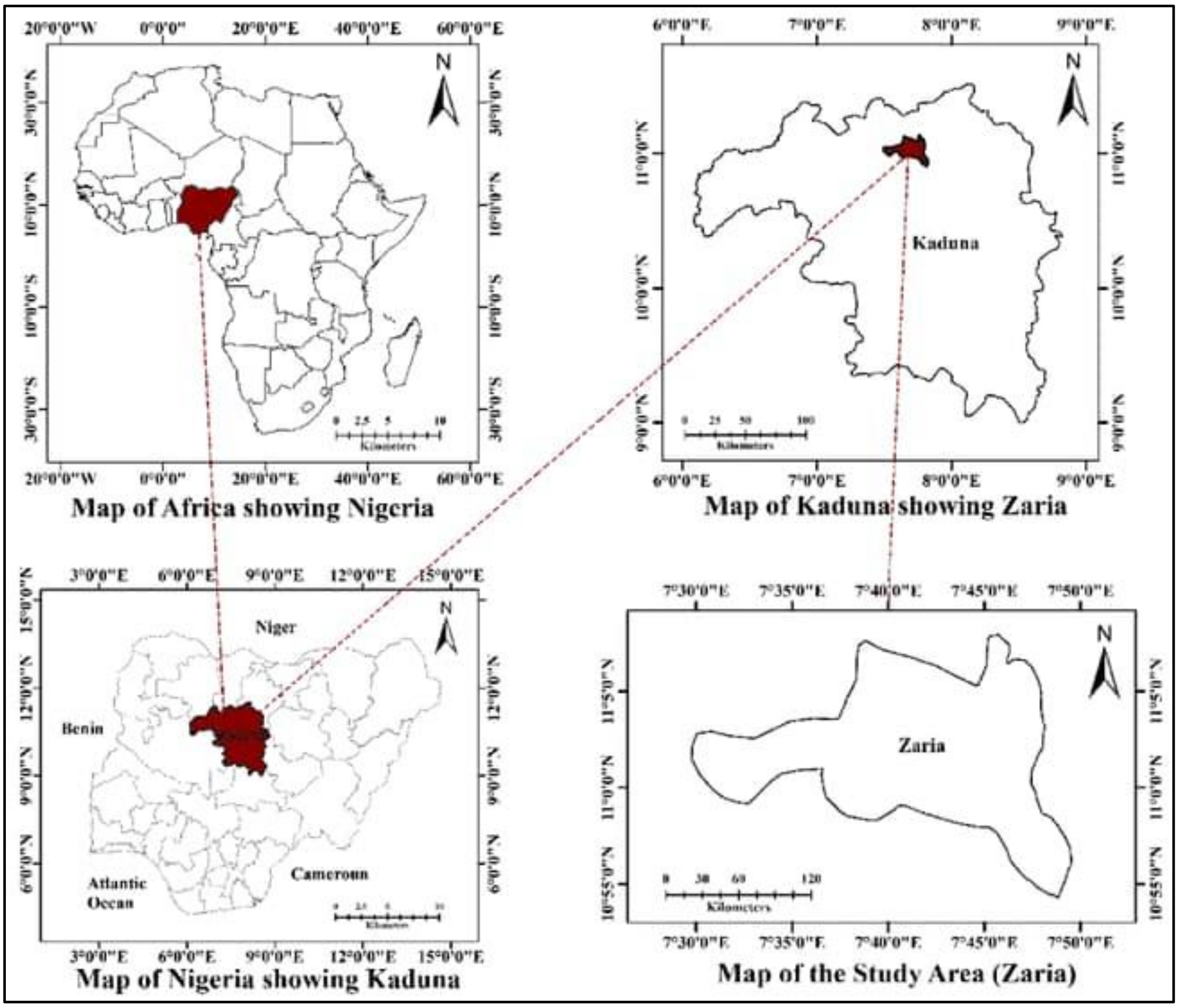


Figure 3.1: Map showing of Nigeria highlighting Kaduna State and Zaria

3.3 Project Components

As previously stated, the scope of the EEP includes the provision of an independent power plant, rehabilitation of existing electricity distribution infrastructure, provision of street lighting, as well as a Renewable Energy Workshop and Training Centre. The Project comprises the following major components:

- Solar PV Farm complete with inverters and transformers;
- Battery Energy Storage System (BESS);
- Substation;
- Internal Transmission and Distribution Network;
- Access Roads;
- Buildings (Control Room, Site Office, Renewable Energy Workshop and Training Centre); and

• Solar-powered Street Lighting.

Figure 3.2: University Master Plan and Layout Showing the Proposed Sites Area.

The power plant will use solar panels fitted on fixed structures (mounts). The main characteristics of the fixed mounted structure is stated in Table 3.3. The advantages of solar energy include its non-polluting nature; it is non-depletable, reliable, and free fuel. The disadvantages of solar energy are that the solar energy concentration is very dilute, so collectors with large surface area are needed. In addition, solar radiation is neither constant nor continuous for terrestrial applications (i.e. low-capacity factor). The solar energy received depends on latitude, season, time-of-day, and atmospheric conditions.

Table 3.2: Main characteristics of the fixed mounting structure

Fixed structure characteristics	
Structure type	1H
Tilt angle	9.0 °
Poles type	Bi pole
Pitch distance	3.04 m
Designed for	MONOFACIAL modules
Minimum ground clearance	0.2 M
Gap between modules in the axis direction	0.0 mm
Gap between modules in the pitch direction	0.0 mm

(Source: REA EEP 3 FEED)

Table 3.4 gives a summary of the project's characteristics and figure 3.3 shows the electrical configuration of the PV plant.

Table 3.3: Key Project Characteristics

Main characteristics	
Location	Nigeria, Adamawa
Rated power (AC)	4180.0 kWac
Peak Power (DC)	5018.3 kWdc
Ratio DC/ AC	1.20
Civil characteristics	
Suitable plot area	15. 02 ha
Ground coverage ratio (GCR)	32.00 %
Structure type	Fixed structure
Pitch distance	3.07m
Electrical characteristics	
PV modules 335.0 (Wp)	14980
Power station (up to 1980.0 kW)	3
Number of inverters (up to 110.0 KVA)	38

Environmental Characteristics	
Gaseous Emissions	None
Discharges	Uncontaminated storm water to be diverted around plant, to be made discharged to natural watercourses as appropriate.
Noise	< 15 dB(A) at nearest noise sensitive premises ≤ 15 dB(A) at plant boundary
Roads	An existing single road offering access to the field will be rehabilitated within the university to link the plants perimeter. All other means of transportation will be held within the boundaries of the field.

(Source: REA EEP 3 FEED)

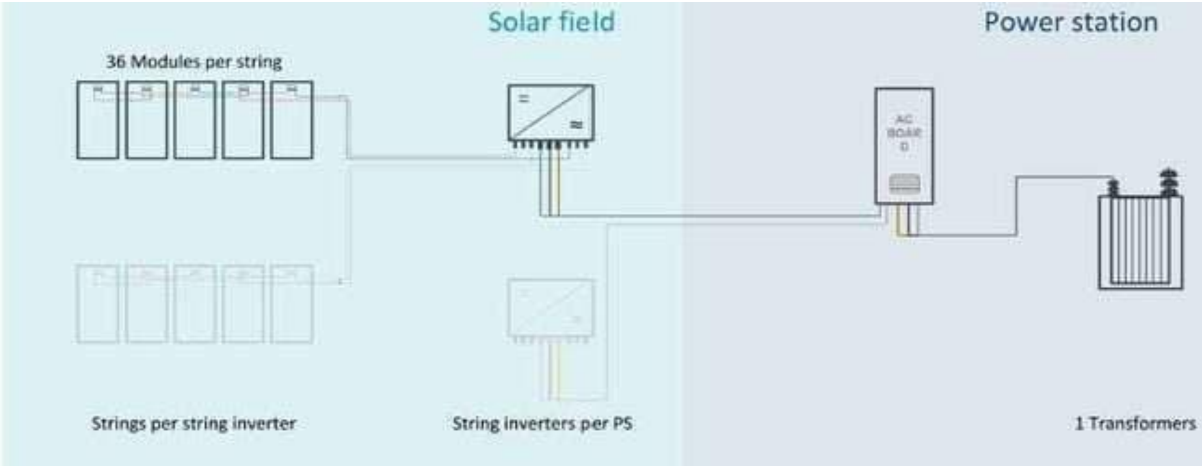


Figure 3.3: Simplified electrical configuration diagram
(Source: REA EEP 3 Front End and Engineering Design)

3.3.1 Component 1: Solar PV Farm

❖ *Solar PV Modules*

A PV cell is a semiconductor device that converts sunlight into electricity using photovoltaic effect. Multiple cells can be combined to form a PV module. The efficiency of a PV module is measured by its ability to absorb light particles called photons. The more photons that are absorbed, the more efficient the panel is at converting light into electricity.

The proposed solar farm would consist of arrays modules, mounted on fixed structures to obtain a total project capability of about 2,000 (kWp) of direct current (DC). The feedstock (solar radiation) is readily available as a byproduct from sunlight, and the long-term supply is guaranteed. The panels are generally considered to have a lifetime of upwards of 30 years.

The selected minimum reference photovoltaic module has a peak power of 415.0 W, and the technology of the cells is Si-poly. The features of the photovoltaic module are shown in Table 3.5, an example picture of a Monofacial Si-poly module is shown in Figure 3.4.

Table 3.4: Photovoltaic module characteristics

Main characteristics	
Technology	Si-poly
Type of module	Monofacial
Maximum voltage	1500 V
Standard test conditions (STC)	
Peak power	415.0 W
Efficiency	18.79 %
MPP voltage	39.3 V
MPP current	10.55 A
Open circuit voltage	47.8 V
Short circuit current	11.14 A
Temperature coefficients	
Power coefficient	-0.370 %/°C
Voltage coefficient	-0.291 %/°C
Current coefficient	0.050 %/°C
Mechanical characteristics	
Length	2108.0 mm
Width	1048.0 mm
Thickness	0.04 mm
Weight	24.9 kg

(Source: REA EEP 3 FEED)

Figure 3.4: Example of a Monofacial Si-poly photovoltaic module
(Source: REA EEP 3 FEED)

❖ Inverters

Inverters are installed in the containers or outside on proper mounting solution. Inverter receives DC electrical energy that flows from photovoltaic panels and transforms it into AC electrical energy that is passed to the national grid. The inverter adapts itself to the photovoltaic string to get the maximum electrical energy available and pass it to the grid. This method is called Maximum Power Point Tracking (MPTT).

In Figure 3.5, a commonly used photovoltaic inverter for utility-scale PV plant. is presented, and its characteristics detailed in table 3.6. The single line diagram for the inverter is shown in figure 3.6.

Figure 3.5: Example of string photovoltaic inverter
(Source: REA EEP 3 FEED)

Table 3.5: Inverter characteristics

Inverter characteristics Main characteristics	
Inverter type	STRING
Maximum DC to AC conversion efficiency	98.79 %
Input side (DC)	
MPPT search range	880- 1300 V
Maximum input voltage	1500 V
Output side (AC)	
Rated power	110.0 Kva
Power at 30 C (datasheet)	110.0 kVA
Power at 50 C (datasheet)	100.0 kVA
Output voltage	800 V
Output frequency	50 Hz

(Source: REA EEP 3 FEED)

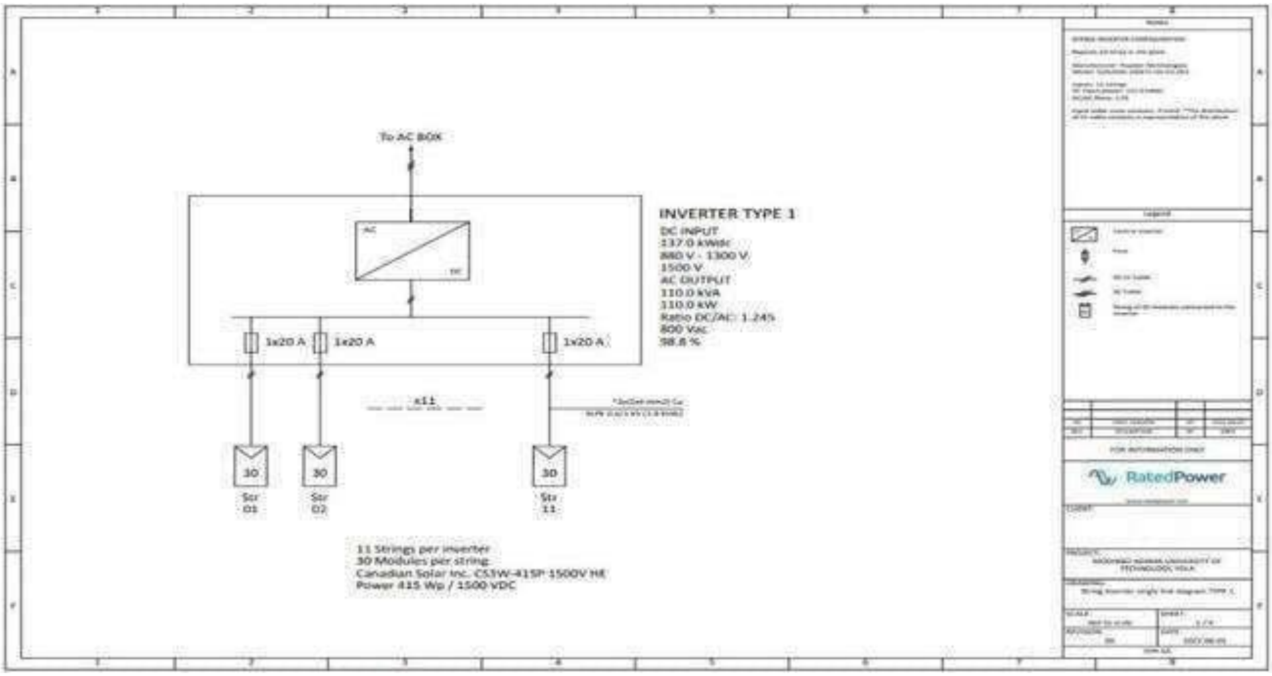


Figure 3. 6: String Inverter Single Line Diagram
(Source: EEP3 FEED)

❖ <u>Transformers</u>

All inverters are connected to a transformer. The role of the transformers is to step- up the voltage from an inverter nominal voltage to a medium voltage of the national grid. Transformers consist of three coils. One coil is connected to the high voltage; two coils are connected to each of the inverter unit's master / slave. The proposed project layout comprising the solar power plant site and transmission line have taken into account the solar radiation, wind direction and evacuation corridor. An example of a power transformer is shown in Figure 3.7.

Figure 3. 7: Example of Transformer
(Source: REA EEP 3 FEED)

The main features of the power transformer are shown in Table 3.7.

Table 3.6: Transformer characteristics

Transformer characteristics	
Rated power	1980.0 kVA
Voltage ratio	0.8/ 11.0kV
Cooling system	ONAN
Tap changer	2.5%, 5%, 7.5%, 10%
Short circuit (Xcc)	0.08

(Source: REA EEP 3 FEED)

- Weather Station

The Solar Monitoring Weather Station includes common meteorological sensors, mounting accessories, a data logger or the signal translator, power supply, and communications hardware. The equipment can be powered from a solar panel power system. The standard sensor array includes two pyranometers, a combined temperature and relative humidity sensor, wind speed and wind direction sensors, and surface mounted temperature sensors to measure solar panel temperature.

3.3.2 Component 2: Power station

The power stations or transformer stations are indoor buildings or containers. The voltage of the energy collected from the solar field is increased to a higher level to facilitate the evacuation of the generated energy. The power transformers will be housed in the power station. An example of an Indoors power station is shown in Figure 3.8.

Figure 3. 8: Example of a power station
(Source: REA EEP 3 FEED)

The power station shall be supplied with medium voltage switchgears that include one transformer protection unit, one direct incoming feeder unit, one direct outcoming feeder unit and electrical boards. Particularly, for the first power station of each MV line, a direct incoming unit will not be installed. The main features of the default power station are shown in Table 3.8, and Figure 3.9 is the Power Station Single Line Diagram.

Table 3.7: Power station characteristics

Power station characteristics	
Number of transformers	1
Voltage ratio	0.8/20.0kV
Service Indoors	Indoors

(Source: REA EEP 3 FEED)

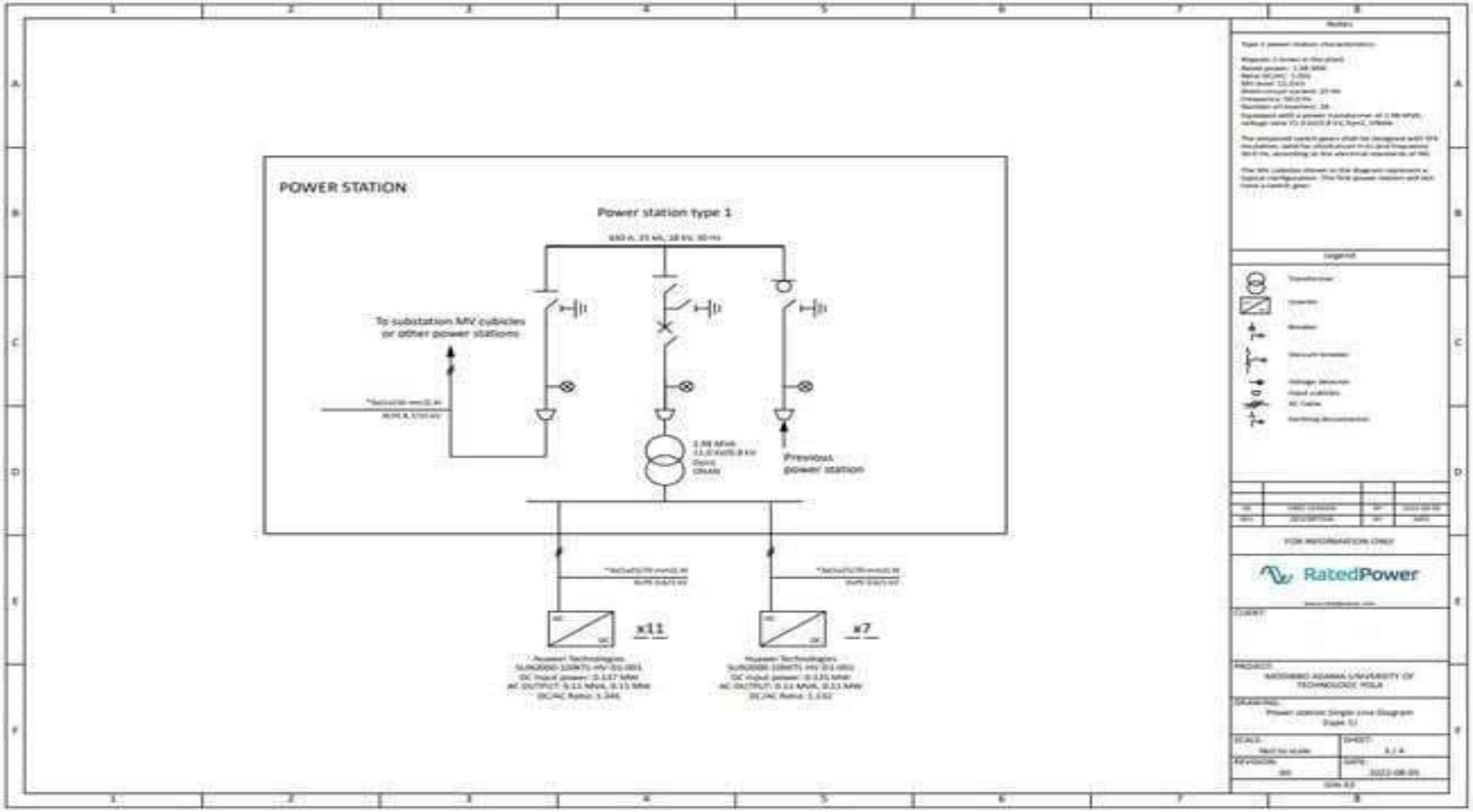


Figure 3.9: Power station Single line Diagram
(Source: EEP3 FEED)

3.3.3 Component 3: Access Roads

Gravel-paved access roads will be constructed within the Project area to provide access to the solar PV arrays, Battery Energy Storage System (BESS), substation, control room, and other associated facilities (Figure 3.10). The roads will be designed to facilitate the movement of personnel, equipment, construction materials, and maintenance vehicles throughout the Project lifecycle.

Construction of the access roads will involve the following activities:

- Site surveying, setting out, and alignment of the road corridor;
- Vegetation clearing and grubbing within the approved right-of-way;
- Stripping and temporary stockpiling of topsoil for subsequent site restoration;
- Earthworks, including excavation, filling, grading, and compaction of the road formation;
- Construction of drainage features, where necessary, to control surface runoff and prevent erosion;
- Placement and compaction of approved gravel materials to form the road surface;
- Installation of road signage and other traffic safety measures, where required; and
- Site reinstatement and stabilization of disturbed areas following completion of construction.

During operation, the access roads will be inspected and maintained periodically to ensure safe access for routine operation, inspection, and maintenance activities. For the design of the proposed PV plant, roads of 4.0 m have been used. These roads run a total distance of 404.09 m. Road ditches used for drainage and for channeling water are placed on one side of the roads. Figure 3.10 shows a Typical

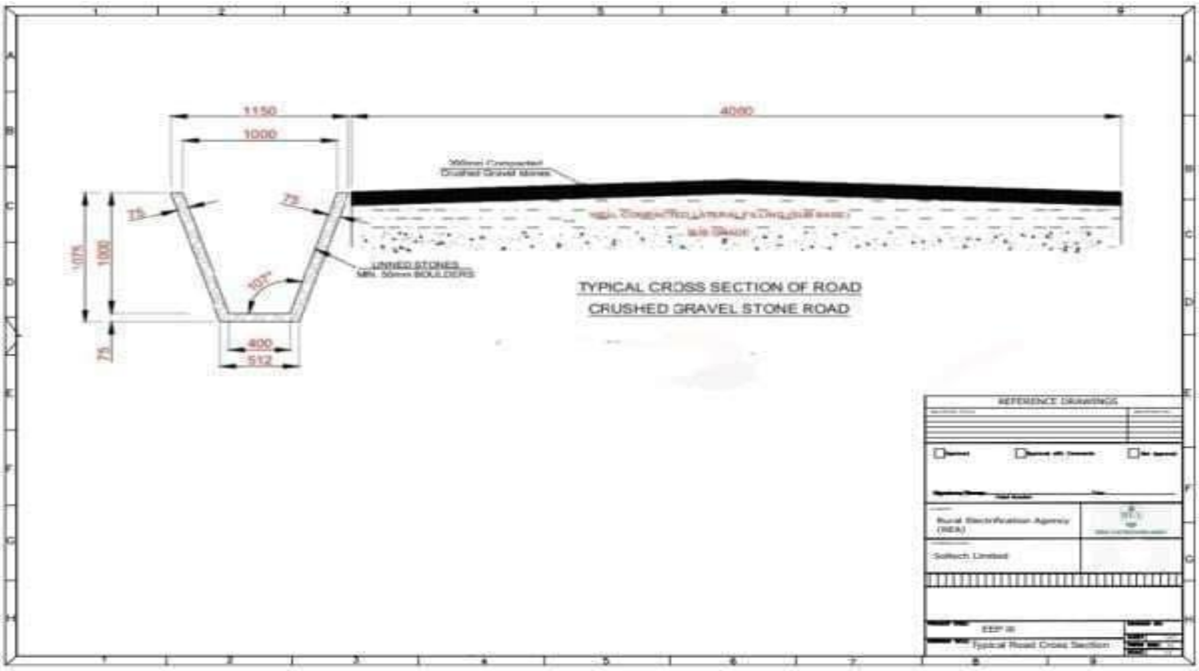


Figure 3.10: Typical Road Cross Section

(Source: EEP3 FEED)

Road Cross Section for the university. A total perimeter of 1135.42 m of chain link fence surrounds the different areas of the PV plant. The fence has at least 2.0 m of height and 3.0 m between posts. For every 50.0 m of fence, a light post of 4.0 m of height and a microwave barrier system are installed. For every 100.0 m of fence, a video camera post of 6.0 m of height is installed.

3.3.4 Component 4: Buildings

A renewable workshop centre will be built and ancillary facilities that include residential quarters for the security, maintenance, and control room staff who will be required full-time, a guard house and an office/control centre. Figure 3.11 is an illustration of the elevation plans of the training Centre.

- *Control Building*

The control building would take up an area of approximately 30 m × 12 M. The main construction compound would temporarily require an area of approximately 60 m × 40 m, however; this area would be fully reinstated after construction.

- *Lay down and Staging Area*

A temporary laydown and staging area will be established within the Project site during the construction phase to facilitate the receipt, inspection, storage, and assembly of solar photovoltaic (PV) modules, mounting structures, electrical components, and other construction materials prior to installation. The staging area will be secured with temporary fencing and controlled access to safeguard personnel, equipment, and materials.

Figure 3.11: Elevation plans of the training Centre

The area will also provide space for temporary storage of construction equipment, tools, and consumables, while ensuring orderly site operations and minimizing interference with ongoing construction activities. Construction wastes generated within the staging area, including wooden crates, plastic wrapping materials, Styrofoam packaging, pallets, and other non-hazardous wastes, will be segregated and managed in accordance with the Project Waste Management Plan.

3.3.5 Component 5: Transmission Line

The power generated from the proposed 2 MW solar-hybrid power plant will be evacuated through an 11 kV underground transmission line to the University's central load center. The underground cable will be routed alongside the existing internal road network within the campus to minimize land disturbance and avoid interference with existing infrastructure. The total distribution network length is approximately 3 km downstream, with no upstream extension required since the generation source is located within the university premises. The underground installation is designed to enhance system reliability, improve safety, reduce visual impact, and protect the infrastructure from weather-related damage and vandalism.

3.3.6 Component 6: Street lights Quantity

As part of the associated infrastructure under the project, a total of 200 single-arm streetlights and 10 double-arm streetlights will be installed across the university campus. The street lighting system is intended to improve visibility, enhance security, and support academic and social activities during night-time hours. The lighting units will be energy-efficient and integrated into the hybrid power system to ensure sustainable and reliable operation. This component will contribute significantly to campus safety, operational efficiency, and overall improvement of the learning environment.

Operation and Maintenance

Operation and maintenance of the system would be expected to occur on a limited basis at certain points during the system's estimated 25-year life cycle. To enhance the performance and reliability of the plant, the following types of maintenance will be carried out:

Preventive Maintenance: which involves routine inspection and servicing of plant equipment to prevent breakdowns. This includes panel cleaning, vegetation management, wildlife prevention, water drainage, monitoring of electrical components. It also involves retro- commissioning to improve the efficiency of the PV plant by detecting and solving problems in the system.

Corrective Maintenance: which involves repair of broken-down equipment. This includes on- site monitoring and mitigation, and critical and non-critical repairs of plant components.

Condition-based maintenance: which involves monitoring equipment and plant operations real- time and addressing potential problems early on in order to prevent plant downtime. This includes continuous monitoring via remote and on-site methods, warranty enforcement, and planned and unplanned equipment replacement.

Maintenance activities will be carried out by skilled manpower with backgrounds in electrical/electronic engineering and unskilled local labour where applicable. Specific maintenance activities include the following:

- <u>PV Modules</u>

The photovoltaic (PV) modules shall be inspected regularly and cleaned as required, taking into account seasonal dust accumulation, rainfall patterns, and system performance monitoring. Cleaning frequency shall be determined based on manufacturer's recommendations, site-specific environmental conditions, and operational performance to maintain optimum energy generation while minimizing water consumption. Where feasible, water-efficient cleaning methods, including the use of soft brushes, deionized water, or other approved cleaning technologies, shall be adopted. The availability of water for cleaning activities shall be considered during operation, and cleaning shall be scheduled to optimize both system performance and resource efficiency. In addition, the cabling around the modules shall be inspected regularly for damage, while the panels shall be routinely checked for cracks, breakages, and other defects. Performance testing shall be undertaken periodically in accordance with the manufacturer's operation and maintenance requirements to ensure continued operational efficiency and compliance with warranty conditions.

❖ Electrical System

- Inverter components need to be checked to prevent breakdown which can occur during very hot weather conditions.
- Electrical wiring and earthing protection need to be checked for wear and tear. Also, the underground cabling needs to be monitored regularly for damages from pests. Infra- red technology may be employed to identify spots where there are electricity leaks.

❖ Civil Structures

- Mounting structures need to be checked regularly for bending damage which can affect the PV modules
- Access roads, drainage works, plant foundation and array structures need to be checked by visual inspection for water damage during the rainy season.

❖ Vegetation

- Growth of shrubs and other vegetation needs to be curtailed to prevent shadowing effect on the solar panels leading to a decrease in the output from the plant. Weeds also need to be eliminated as they present a fire hazard.
- Vegetation around the transmission line RoW needs to be cleared quarterly to maintain a vegetation height at less than 2 ft (0.61 m).

A stockpile of spare parts will be kept on-site to facilitate replacement of broken-down or out- dated solar panels and inverters. On-site security and inventory management will be implemented to prevent theft of spare parts and installed plant components.

Monitoring of the PV system components needs to be conducted to ensure increased system output and to reduce down-time. Traditional monitoring methods that compare actual energy generation against predicted energy generation will help to track the system’s relative health.

3.4 Engineering Codes and Standards

The Project components shall be designed and installed in compliance with the relevant codes and standards of the British Standard- Europe Norms (BS–EN), the International Electrotechnical Commission (IEC), International Organization for Standardization (ISO) and the Standard Organization of Nigeria (SON). Examples of the relevant codes and standards include ISO 15673:2005 “Guidelines for the simplified design of structural reinforced concrete for buildings” and BS EN 60529:2013 “Degree of Protection by Enclosures (IP Code)”, amongst others.

3.5 Project Implementation Phases

3.5.1 Pre-construction Phase Activities

Following the completion of engineering design for the Project and receipt of relevant approvals, the major activities during this phase include site clearing and preparation, and mobilization of equipment, materials and personnel to site. Clearing will involve removal of existing vegetation from the site and preparing a level working surface in readiness for construction activities.

3.5.2 Construction Phase Activities

The construction phase of the Project will include civil, mechanical and electrical works; installation of PV panels and associated plant facilities; construction of a training centre; installation of streetlights as well as underground armoured cable for power evacuation. Also, where required, an upgrade of some of the existing power distribution infrastructure within the University will be carried out.

It is envisaged that the construction phase will require an estimated 80–120 workers, with a peak workforce of approximately 120 personnel, depending on the construction schedule and activities being undertaken. The workforce will comprise unskilled workers, semi-skilled personnel such as drivers, equipment operators and technicians, and skilled personnel including engineers, supervisors, HSE officers and electrical specialists. Most of the unskilled and semi-skilled workers would be drawn from the nearby local community (located outside the University campus) to enhance the job opportunities associated with the proposed Project. Moderate level of migrant workers may also be associated with the construction phase activities (potential impacts associated with the migrant workers as well as the proffered mitigation measures are covered in Chapters 5 and 6). No workers camp is planned to be established onsite during construction.

3.5.3 Commissioning Phase Activities

The commissioning phase of the proposed Project will include testing and checking individual equipment /system, as well as the associated infrastructure to ensure they have been installed correctly and can be handed over for use.

3.5.4 Operational Phase Activities

The operational phase of the Project will involve power generation and distribution to various sections of the University as well as the preventative, corrective and predictive maintenance of the power plant and associated facilities. In addition, the training centre will be put into use to enhance learning in renewable energy. The EPC contractor shall develop standard operating procedures (SOPs) for the operation and maintenance of the solar panels, inverters, batteries, and other associated components of the Project. If need be, the SOPs shall be further reviewed and updated by the O&M Contractor during operation. The day-to-day operations of the plant will involve both regular preventive and corrective maintenance carried out by the O&M contractor in order to keep the power plant in optimal working condition throughout its operating life. The preventive maintenance follows a routine service schedule aimed at preventing faults from occurring and keeping the power plant operating at its optimum level. The frequency of the preventive maintenance would depend on a number of factors such as the technology selected, environmental conditions of the site, warranty terms and seasonal variances. It contains, for example, activities like PV panel cleaning, inverter servicing, and checks on structural integrity of the mounting structure.

Corrective maintenance will be carried out in response to failures, for example, the repair / exchange of damaged or faulty equipment. Maintenance will consist mostly of panel / battery replacement and other mechanical and electrical infrastructure repairs. Faulty components will be replaced as soon as the problems are identified. The average life span of the PV power plant is 25 years which can be extended through regular maintenance. Even after the 25 years, the PV panels can still generate up to 90% of the design capacity. Chapter 8 of this report contains detailed information on the activities associated with the decommissioning of the proposed solar power plant and its ancillary facilities (in the event of final decommissioning), including the environmental and social measures to be implemented to address potential impacts of the decommissioning activities.

3.6 Water Use and Supply

One of the key benefits of the proposed 2 MW Solar-Hybrid Power Plant is the generation of electricity using freely available solar energy, thereby reducing dependence on fossil fuels and contributing to lower greenhouse gas emissions. Water requirements during the construction phase will be minimal and will be limited primarily to minor civil works, equipment cleaning, and domestic use by the construction workforce. During the operational phase, water will be required principally for the periodic cleaning of photovoltaic (PV) modules to remove accumulated dust and debris that may reduce energy generation efficiency. The frequency of cleaning will be determined by seasonal dust accumulation, rainfall patterns, operational performance monitoring, and the manufacturer's recommendations rather than fixed intervals. The Project is expected to comprise approximately 3,700 photovoltaic modules, and assuming an average water requirement of 5 litres per module per cleaning cycle, approximately 18,500 litres (18.5 m^3) of water will be required for each complete cleaning cycle. Water for panel cleaning and other minor operational requirements will be supplied from a dedicated borehole to be developed within the Project site, while water use will be managed efficiently through condition-based cleaning practices and appropriate operation and maintenance procedures. Detailed assessment of water demand, groundwater availability, and the potential environmental implications of water abstraction are presented in the subsequent impact assessment chapters of this report.

3.7 Waste Management

This section discusses the waste streams associated with the proposed Project and the intended management plan.

3.7.1 Overview

It is the goal of REA that the proposed Project is designed, developed and operated in a sustainable manner. Thus, effective waste management practices that comply with the relevant local requirements and international best practices shall be implemented during all phases of the proposed Project. To achieve this, all contractors engaged during the lifecycle of the Project will put in place and comply with a site waste management plan.

Waste management principles shall be based on an integrated approach which involves a combination of techniques and programs to manage waste. Source reduction is at the top of the approach, followed by reuse and recycling as preferred options to disposal.

Generally, wastes associated with the proposed Project shall be managed using the following prioritized program:

- **Reduction at Source** – The elimination or minimization of waste generation through equipment modifications and installation of pollution abatement equipment.
- **Reuse** – Using an item for its original purpose, or similar purpose, in its original form. Wastes generated from one operation shall be put to use in standards and safety.
- **Recycling** – conversion of waste materials into reusable objects. This will involve using FMEnv/NESREA approved companies involved in recycling business using best available technology that meet international standards.
- **Residue Disposal** - disposal of wastes in a Government-approved dumpsite.

3.7.2 Associated Waste Streams

The waste streams associated with the proposed Project are discussed as follows:

Pre-construction Phase

The waste streams associated with the pre-construction phase of the Project will include cleared vegetation arising from site preparation, food waste generated by the workforce, and general solid waste such as packaging materials and domestic refuse. Cleared vegetation, comprising mainly grasses and shrubs, will be removed from active work areas and allowed to biodegrade at designated locations approved by the University, while usable wood from felled trees, where applicable, may be made available to the University or surrounding community subject to the University's approval. General solid waste generated during the pre-construction phase will, as far as practicable, be managed through the existing waste management system of the Federal University of Education (FUE), Zaria, in collaboration with the University's Works and Physical Planning Department. Where specialized handling or disposal is required, wastes will be collected and disposed of through a licensed waste management contractor approved by the Kaduna State Environmental Protection Authority (KEPA) in accordance with applicable environmental regulations.

Construction Phase

The planned activities during the construction phase include civil, mechanical and electrical works, installation of PV panels, Battery Energy Storage Systems (BESS), substations, and associated electrical infrastructure. Waste streams associated with construction activities will include excavated soil, general refuse, food waste, inert construction materials, concrete waste, metal scraps, used packaging materials, damaged electrical components, and damaged or defective photovoltaic (PV) panels generated during transportation, handling, or installation. In line with the NEP Environmental and Social Management Framework (ESMF), the EPC Contractor shall prepare and implement a Site Waste Management Plan covering all identified waste streams in accordance with applicable national regulations. Construction materials shall be stored in compliance with applicable building and environmental requirements. Concrete mixing will be undertaken on impermeable surfaces to prevent soil contamination, while excavated soils will be segregated and reused, where suitable, as backfill during site reinstatement. Scrap metals will be collected for recycling, and damaged or defective PV panels shall be stored separately in designated containers to prevent breakage and environmental contamination before being returned to the supplier or manufacturer, or managed through an approved manufacturer take-back or recycling programme in accordance with the manufacturer's requirements and applicable environmental regulations. Hazardous wastes, including used oil, contaminated rags, spent filters, and other hazardous materials generated during construction, shall be stored in properly labelled containers and transferred to licensed waste management contractors approved by the Kaduna State Environmental Protection Authority (KEPA) for treatment and disposal.

Operational Phase

Solid wastes generated during the operational phase of the Project will be incorporated into the existing FUE Zaria waste management approach (there is a dedicated site within the University environment where solid wastes are collected for disposal). Approximately 3.00 cm^3 of solid waste is estimated to be generated per week during the operational phase. In line with NEP ESMF, the University shall be encouraged to prepare e-waste management plans that account for safe end-of-life disposal of equipment from the solar power plant. The Extended Producer Responsibility program (EPR) will be implemented for solar panels, inverters, batteries and other electrical components to be installed for the Project. Damaged or discarded PV panels and inverters will be collected and sent to the manufacturer for recycling in line with the EPR model.

Spent, damaged or expired batteries will also be returned to the manufacturer for recycling. Alternatively, the spent batteries will be recycled by local and accredited battery recycling companies in Nigeria. These batteries shall be stored in red coloured waste receptacles before they are transported to the accredited battery recycling companies. The quantity of waste batteries generated typically depends on a number of factors such as type, capacity and number of batteries installed and depth of discharge. Storm water shall drain away to the natural environment via gravity. Paved and concreted areas will be sloped to allow for proper drainage. Sanitary wastes (sewage) generated during the facility operation shall be channeled to a septic tank to be installed onsite. The septic tank shall be of reinforced concrete and will be located away from any groundwater source. As at when due, the contents of the septic shall be evacuated by an accredited waste contractor for treatment at a sewage treatment plant approved by KEPA.

Decommissioning

The waste streams associated with the decommissioning phase of the Project would be similar to the construction waste. These will include refuse, e-waste, general rubbish and demolition debris. The University will also be encouraged to prepare e-waste management plans that account for safe end-of-life disposal of equipment from solar installations. Wastes will be segregated onsite, and non-reusable/recyclable wastes will be disposed of through an accredited third-party waste contractor. The summary of wastes stream associated with the Project is provided in Table 3.8 and the Summary of Construction Workforce, Equipment, Electrical Infrastructure and Estimated Waste Generation is presented in Table 3.9.

Table 3.8: Summary of Wastes Stream associated with the proposed Project and Handling Techniques

Waste Stream	Sources	Waste Generation Phase Construction (C), Operation (O), Decommissioning (D)	Handling Techniques
General rubbish, refuse, and putrescible wastes (food wastes)	Wood splinter, domestic waste, food packs, used Bottles	C, O, D	On-site waste segregation; disposal of non-reusable waste through a third party waste contractor approved by Kaduna State Environmental Protection Agency (KEPA).
Cleared vegetation	During site clearing and Preparation	C	Composting, collection for biomass fuel
Scrap metals		C, O, D	Scrap metals will be collected for recycling
Excavated materials	Foundation works	C, D	Excavated materials generated during foundation works will be used for back-filling. Excess excavated spoil will be stockpiled and reused as part of materials for construction of plant buildings.
Damaged/expired PV panels	PV modules	C, O, D	Return to the manufacturer for recycling using the EPR model
Expired inverters	Electrical Installation	O, D	Return to the manufacturer for recycling using EPR model
Damaged/expired Batteries	Power Generation	O, D	Return to the manufacturer using the EPR model
Sanitary waste	Training centre	C, O, D	Periodic evacuation of content of the septic tank by KEPA accredited third party waste contractor.

Table 3.9: Summary of Construction Workforce, Equipment, Electrical Infrastructure and Estimated Waste Generation

Activity Component	Description	Estimated Quantity/Number
Construction Workforce	Total Construction Workforce	65 Personnel
	Engineers and Supervisors	10 Personnel
	Skilled Workers (Electricians, Technicians, Welders, Installers)	25 Personnel
	Semi-skilled Workers	15 Personnel
	Low-skilled/Unskilled Workers (Local Recruitment)	15 Personnel
Site Clearing and Grading Equipment	Excavators	2 Units
	Bulldozers	1 Unit
	Motor Grader	1 Unit
	Backhoe Loader	1 Unit
	Dump Trucks	4 Units
	Water Tankers	2 Units
	Vibratory Roller/Compactor	1 Unit
	Pickup Trucks	3 Units
Electrical Works and Interconnection Infrastructure	Solar PV Modules (550–600 W)	Approximately 3,500–3,700 Modules
	String Inverters	10 Units
	Battery Energy Storage System (BESS)	1 Integrated System
	Battery Containers	2 Units

Activity Component	Description	Estimated Quantity/Number
	Distribution Transformers	2 Units
	Medium Voltage Switchgear Panels	2 Units
	Protection and Control Panels	4 Units
	Distribution Boards	8 Units
	Solar Street Lights	Approximately 120 Units
Estimated Construction Waste Generation	Vegetation Waste	8–10 Tonnes
	Excavated Soil and Earth Materials	350–500 m^3
	Packaging Waste (Wood, Plastic, Cartons)	3–5 Tonnes
	Scrap Metal	1–2 Tonnes
	Concrete and Masonry Waste	5–8 Tonnes
	Domestic Waste from Workforce	20–30 kg/day
	Used Oil and Lubricants	150–250 Litres
	Electrical/Electronic Waste	Less than 0.5 Tonne
Waste Management Approach	Reuse of Excavated Materials for Backfilling	Applicable
	Recycling of Scrap Metal and Packaging Materials	Applicable
	Disposal through FMEnv/NESREA Approved Contractors	Applicable
	Compliance with Project ESMP and Waste Management Plan	Applicable

3.9 Project Schedule

The proposed Project is planned to be operational by the fourth quarter (Q4) of 2028. The tentative Project schedule is provided in Table 3.10.

Table 3.10: Tentative Project Schedule

Project Schedule	Timeline											
	2026				2027				2028			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Site allocation												
Energy demand Audit												
ESIA study and Approval												
Selection of EPC Contractor and contract signing												
Civil, electrical, and mechanical design												
Procurement (Manufacturing and transportation)												
Preconstruction and construction Phase Activities												
Commissioning												
Commencement of Operation												

Bolben Energy and Environmental Services Limited
Suite B214, Zitel Plaza, Jabi Abuja
ceo@bolben.org
Draft Report, September 2026.

CHAPTER FOUR
DESCRIPTION OF THE ENVIRONMENT

4.0 Introduction

This chapter outlines the prevailing environmental and socio-economic characteristics within the Project's area of influence, encompassing the proposed site and adjoining environments where potential direct and cumulative impacts may occur. The baseline conditions presented herein are derived from both primary data collected through field investigations and measurements, and secondary data obtained from a review of relevant literature, reports, and existing documented sources.

The field sampling was carried out in February 2026 by different specialists. Based on the consideration of the potential environmental and social footprints of the proposed Project, the observations noted during the preliminary visit to the Project sites as well as the need to ensure that all the sensitive receptors that could be potentially affected by the proposed Project have been captured, a 1km radius from the centre of the Project site was selected as the spatial boundary for biophysical sampling while the socio-economic survey was extended to approximately 3 km radius from the centre of the Project site, as illustrated in Figure 4.1.

4.1 Baseline Data Collection

The baseline data collection was conducted using a multidisciplinary methodology and implemented under a structured Quality, Health, Safety, and Environment (QHSE) management framework. This ensured that all required data and environmental samples were obtained in compliance with established scientific protocols and regulatory standards, utilizing suitable equipment, materials, and qualified personnel.

The study approach includes the following:

- Desktop review of existing materials relevant to the Project environment;
- Designing and development of field sampling strategies to meet the scope of the ESIA study and regulatory requirements;
- Pre-mobilization activities (including calibration/pre-testing of field equipment, review of work plan with team members);
- Mobilization to site for fieldwork sampling (sample collection, in-situ measurements, sample handling, documentation, and storage);
- Demobilization from field; and
- Transfer of field samples to the laboratory for analysis.

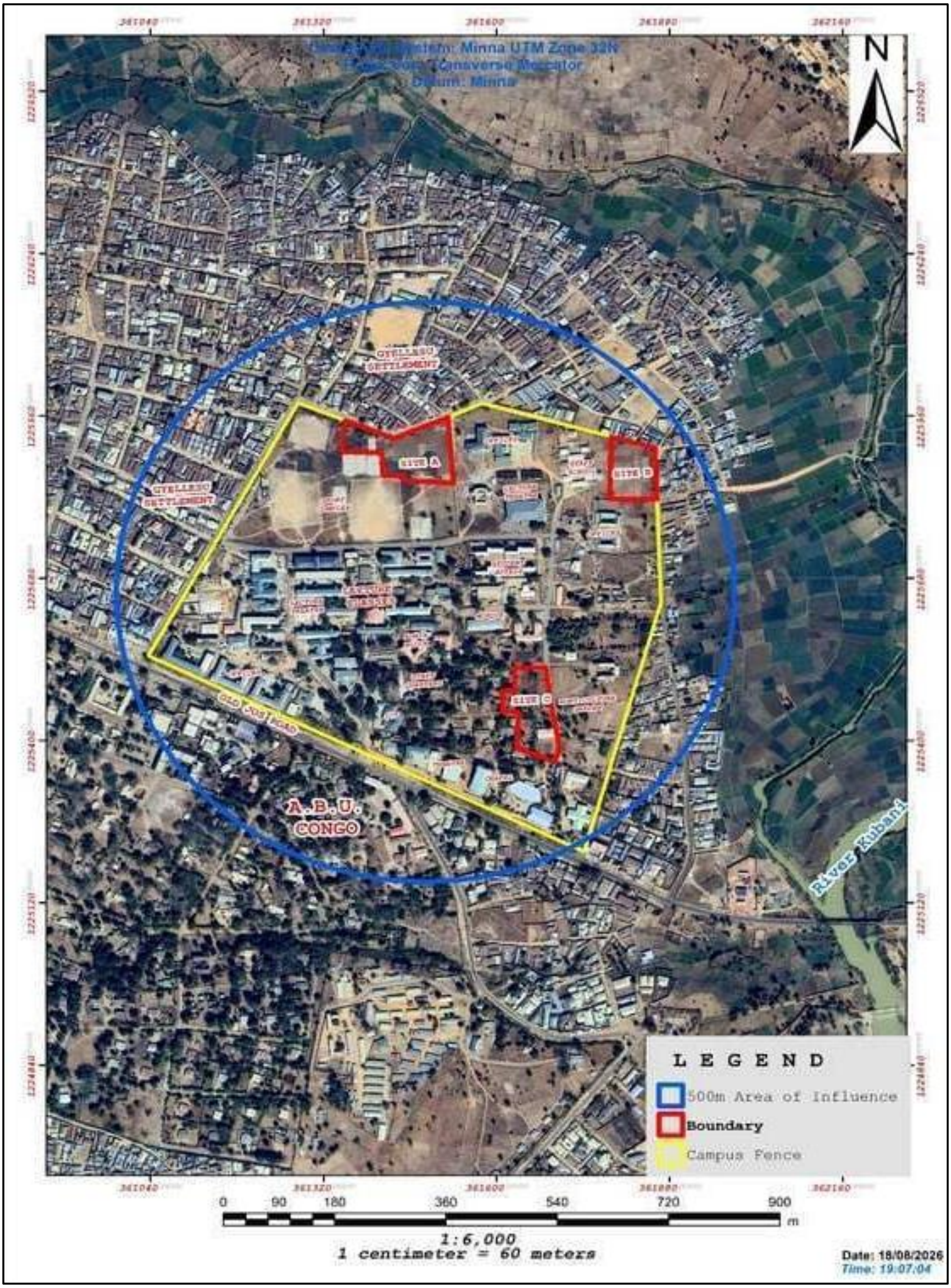


Figure 4.1: Aerial imagery of the Institution, Proposed Sites and Project's Area of Influence.

4.1.1 Desktop Studies/Literature Review

Desktop studies involved the acquisition of relevant background information on the biophysical and socio-economic environment of the Project area. Information was sourced from the relevant government authorities including the Nigerian Meteorological Agency (NiMet), the National Bureau of Statistics (NBS) and the Federal Ministry of Environment (FMEnv). Other sources of information employed include online publications, textbooks, articles etc. Secondary information used for this ESIA was obtained from published literature, previous environmental assessment studies, government reports, institutional records, and relevant technical publications. Key documents reviewed included the ESIA and ESMF reports prepared under the Nigeria Electrification Project (NEP), previous EIA studies undertaken within Kaduna State, REA project documents, NiMet climatic reports, National Bureau of Statistics publications, and relevant environmental baseline studies undertaken within Zaria and surrounding areas.

4.1.2 Field Sampling and Laboratory Analysis

4.1.2.1 Field Sampling

In order to effectively characterize the environment of the Project area, field sampling was conducted in February 2026. The objective of the field survey was to obtain the baseline data of the Project's area of influence and describe its environmental and social context. Sampling locations were identified using recent satellite imagery of the Project area. The basis of the sampling design was informed by a preliminary characterization of the Project area through desktop research and nearby sensitive receptors.

Sampling locations for biophysical components were randomly selected to cover as much as possible the land area for the proposed Project as well as the surrounding environment, while the socio-economic survey focused on the potentially affected community identified within the Project's area of influence. All sampling locations were geo-referenced using Garmin Map-62 series Global Positioning System (GPS) handsets. Quality assurance and quality control (QA/QC) procedures, aligned with applicable national and international standards, were rigorously applied throughout the field sampling activities. These measures included, but were not limited to:

- In-situ measurements of parameters with short holding time in water samples immediately after collection.
- Proper calibration of all portable meters used for in-situ measurements.
- Separate samples were collected for parameters requiring different treatment/preservation before analysis.
- Field samples were adequately preserved and labelled.
- The chemical reagents used for sample preservation were adequately labelled to avoid mix-up.

The summary of sample management program put in place to safeguard the integrity of the field samples collected during the baseline data gathering is provided in Figure 4.2.

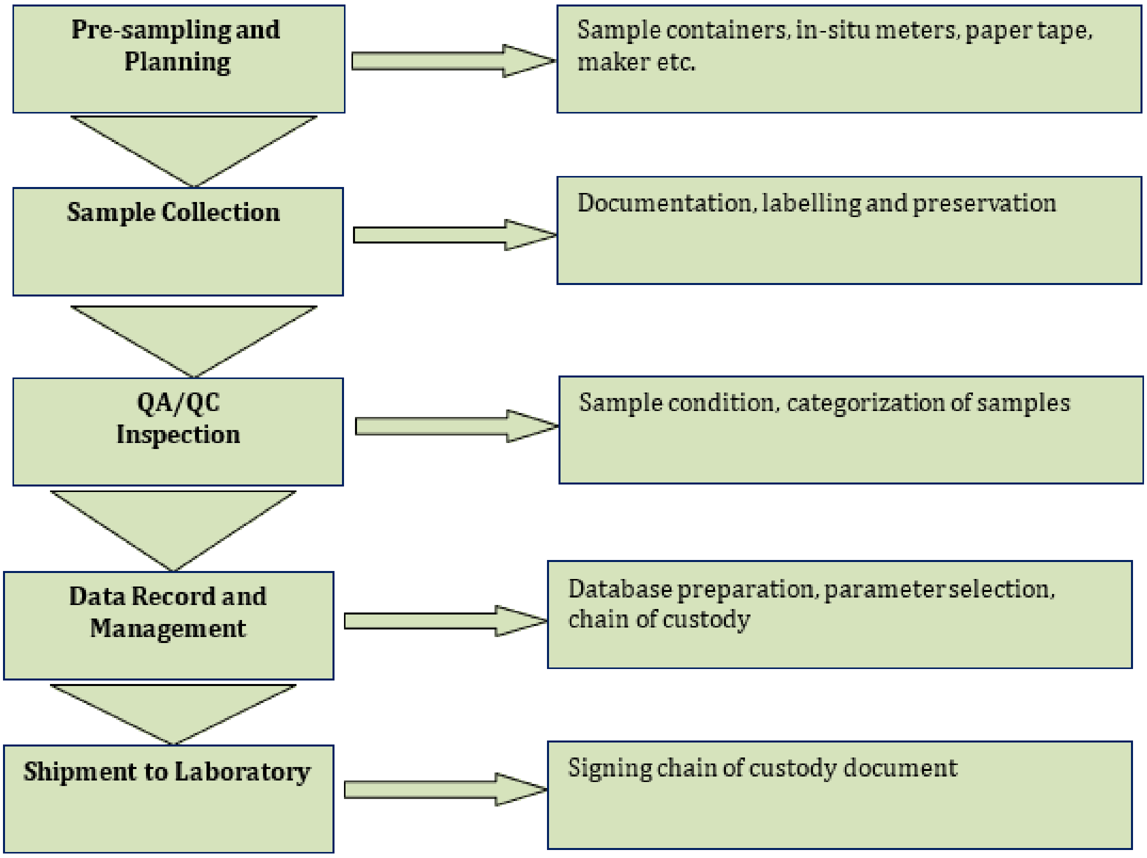


Figure 4.2: Management program employed for field sampling

4.1.2.2 Laboratory Analysis of Field Samples

Field samples collected during the baseline survey were conveyed to the laboratory for analysis, along with the completed chain of custody forms. The samples were preserved with appropriate reagents (such as nitric acid and sulphuric acid), and the recommended temperature of 4^0C for the samples was maintained in-transit with the use of ice-chest and ice chips in different insulating containers.

The field samples were analyzed for physico-chemical and microbial parameters at a government approved Laboratory at the **Centre for Dryland Agriculture (CDA), Ultramodern Lab, Bayero University Kano (BUK), Kano State.** The Laboratory is accredited by FMEnv and other relevant regulatory agencies.

The laboratory analyses were undertaken in consistent with the approved standard methodologies such as those recommended by the American Society for Testing and Materials (ASTM) International, the American Public Health Association (APHA) and the FMEnv. The summary of analytical methods employed is presented in Table 4.1.

Table 4.1: Analytical methods employed for field sample analysis

S/N	Parameters	Analytical Methods	Units	
			Water Sample	Soil sample
1.	Total Suspended Solids	Gravimetric method	mg/l	-
2.	Biological Oxygen Demand	Dilution method	mg/l	-
3.	Chemical Oxygen Demand	Closed Reflux dichromate method	mg/l	-
4.	Oil and Grease	N-Hexane Extraction Method	mg/l	mg/kg
5.	Alkalinity	Titration method	mg/l	-
6.	Total Hardness	EDTA/Titration method	mg/l	-
7.	Nitrate	Spectrophotometric method	mg/l	mg/kg
8.	Sulphate	Spectrophotometric method	mg/l	mg/kg
9.	Phosphate	Spectrophotometric method	mg/l	mg/kg
10.	Nitrite	UV/VIS Spectrophotometry	mg/l	mg/kg
11.	Sodium	Flame photometric method	mg/l	mg/kg
12.	Potassium	Flame photometric method	mg/l	mg/kg
13.	Calcium	Titration with ethylenediamine tetra-acetic acid method	mg/l	mg/kg
14.	Magnesium	Titration with EDTA method	mg/l	mg/kg
15.	Lead	Atomic Absorption Spectrophotometry	mg/l	mg/kg
16.	Nickel	Atomic Absorption Spectrophotometry	mg/l	mg/kg
17.	Cadmium	Atomic Absorption Spectrophotometry	mg/l	mg/kg
18.	Zinc	Atomic Absorption Spectrophotometry	mg/l	mg/kg
19.	Copper	Atomic Absorption Spectrophotometry	mg/l	mg/kg
20.	Chromium	Atomic Absorption Spectrophotometry	mg/l	mg/kg
21.	Manganese	Atomic Absorption Spectrophotometry	mg/l	mg/kg
22.	Total Iron	Atomic Absorption Spectrophotometry	mg/l	mg/kg
23.	Mercury	Cold Vapour Atomic Absorption Spectrophotometry	mg/l	mg/kg

4.2 Description of the Study Area

4.2.1 Climate and Meteorology

Kaduna State falls within the sub-humid ecological belt and is predominantly characterized by derived Guinea savannah vegetation, interspersed with isolated patches of rainforest and drought-resistant plant species. The study area experiences a tropical climate influenced by the Inter-Tropical Convergence Zone (ITCZ), also referred to locally as the Inter-Tropical Discontinuity Zone (ITDZ).

Seasonal variations in the movement of these air masses give rise to two distinct seasons: a wet season extending from April to October, and a dry season from November to March. The dry season is occasionally marked by the harmattan, a period of dry, dust-laden winds accompanied by relatively cooler temperatures, typically occurring between December and January. In this section of the report, the dominant climatic elements and factors within the regional Project area are discussed. These include rainfall, ambient temperature, relative humidity, sunshine, wind speed and wind direction. Information on the climatic data of the Project area is sourced from NiMet, and it spans from 1991 to 2024. Table 4.2 summarizes the monthly mean climatic characteristics of the Project area from 1991 to 2024.

Table 4.2: Monthly Mean Climatic Characteristics of the Project Area (1991-2024)

Month	Temperature (^{0}C)		Rainfall (mm)	Relative Humidity (%)		Sunshine hours	Wind speed (m/s)
	Min.	Max.		9:00 hrs	15:00 hrs		
January	15.38	31.60	0.00	21.56	18.48	8.57	6.58
February	17.97	33.80	0.06	23.00	18.59	8.83	6.74
March	21.12	36.01	7.77	30.85	22.30	7.82	5.64
April	22.74	35.34	47.70	52.22	34.04	8.00	5.46
May	22.12	32.97	104.23	67.41	50.00	7.86	5.55
June	20.74	30.49	174.03	75.07	58.89	7.40	5.62
July	20.53	28.91	230.66	79.30	63.30	5.68	5.24
August	20.62	28.54	284.60	81.70	67.04	5.25	4.49
September	20.01	30.03	239.74	76.15	59.41	6.31	3.77
October	19.55	31.61	81.71	65.89	43.89	7.81	3.30
November	16.33	32.81	0.05	32.59	23.85	9.25	4.95
December	14.77	31.58	0.00	24.70	21.22	8.98	5.69

(Source: NiMet, 2024)

Rainfall: The rainfall pattern in the area is characterized by high precipitation in the months of April to October (wet season) while the no rainfall was recorded in December and January. Of the total amount (1170.55 mm), about 1162.67 mm is recorded during the wet season (April – October) while only 7.88 mm is recorded in the dry season (November to March) as shown in Figure 4.3).

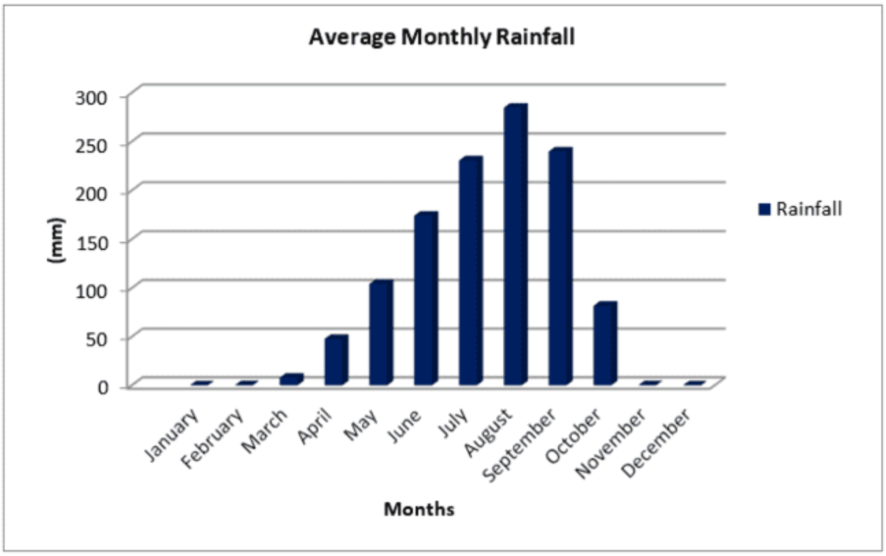


Figure 4.3: Average rainfall characteristics of the Project area (1991- 2024)
(Source: NiMet, 2024)

Ambient Temperature: Temperature is relatively high all the year round in view of the location of the study area around the tropic. The highest temperature values are recorded in the dry season months and the lowest at the peak of wet season period (Figure 4.4).

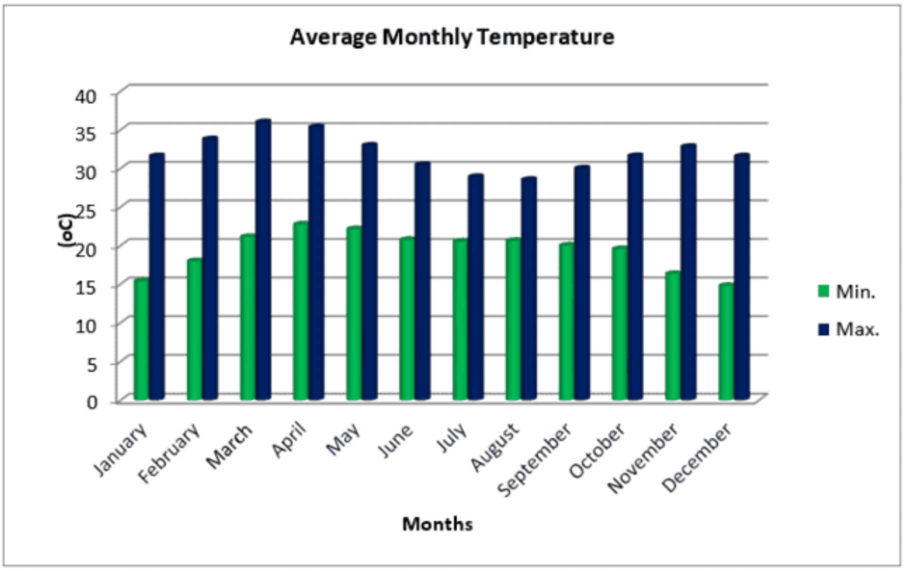


Figure 4.4: Monthly Mean Temperature Characteristics of the Project Area (1991-2024)
(Source: NiMet, 2024)

Relative Humidity: High relative humidity is experienced in the area as a result of the prevailing Tropical Maritime (Tm) air mass that blows over the environment almost all the year round. Data for Kaduna State indicate that humidity measured in the morning ranges between 23.00 % in February and 81.70 % in August while at night the value ranges from 18.48 % (in January) to 67.04 % (in August) as shown in Figure 4.5.

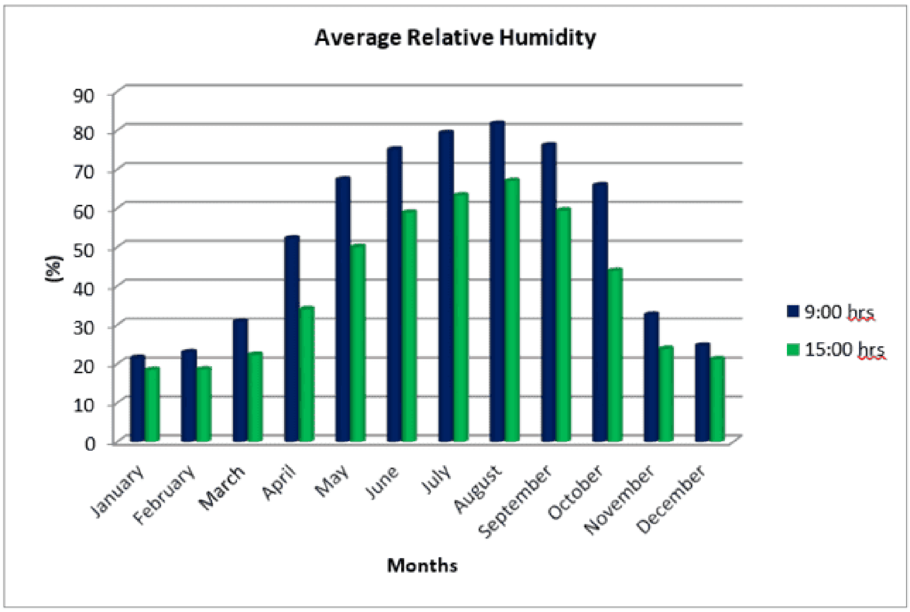


Figure 4.5: Monthly Relative Humidity Characteristics of the Project Area (1991-2024)
(Source: NiMet, 2024)

Wind Direction and Speed: Wind follows the distinctive pattern of the Tropical continental, (Tc) (Northeast) and Tropical maritime, Tm (Southwest) directions depending on the apparent location of the sun and the dominant of the two. The moisture laden and rain bearing Southwesterly from the Atlantic predominates during the wet season. It is calmer due to its higher moisture load. The Tc is of less intensity and prevails between December and March. The two major wind patterns are however modified marginally by warm Benguela Current and the North-East Harmattan winds. The monthly average wind speed in the area ranges from 3.30 m/s to 6.74 m/s (Figure 4.6). Highest speed is recorded at the onset and offset of seasons when squalls, lightning and thunder accompany torrential rains.

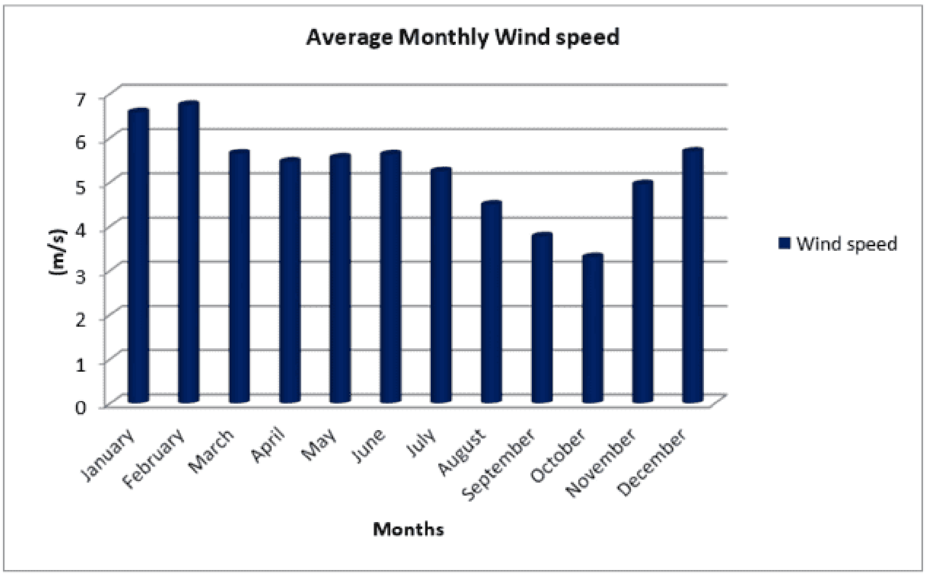


Figure 4.6: Monthly Average Wind Speeds of the Project Area (1991- 2024)
(Source: NiMet, 2024)

Sunshine Hours
Solar energy availability is one of the principal factors influencing the technical and economic viability of the proposed 2 MW Solar-Hybrid Power Plant at the Federal University of Education (FUE), Zaria. To provide a site-specific assessment, long-term solar resource data corresponding to the Project coordinates were obtained from the NASA Prediction of Worldwide Energy Resources (NASA POWER) database. The data indicate that the Project area receives high levels of solar radiation throughout the year, making it highly suitable for photovoltaic (PV) power generation. The analysis shows that average sunshine duration varies seasonally, with the lowest values occurring during the peak of the rainy season (July and August) as a result of increased cloud cover and atmospheric moisture (Figure 4.7). Sunshine duration gradually increases from September and reaches its maximum during the dry season, particularly between November and February, when cloud cover is minimal and atmospheric visibility is enhanced. Consequently, the Project area experiences high solar energy availability for most of the year.

The long-term average Global Horizontal Irradiance (GHI) for the Project area is approximately 5.7–6.2 kWh/m²/day, while the corresponding Peak Sun Hours (PSH) average about 5.8 hours/day. These values are significantly above the minimum threshold generally considered suitable for utility-scale solar photovoltaic development and demonstrate the excellent solar resource potential of the Project area. The relatively high annual solar irradiance is expected to support efficient electricity generation and improve the operational performance of the proposed solar-hybrid system. Although seasonal reductions in sunshine duration occur during the wet season, the incorporation of a Battery Energy Storage System (BESS) within the Project design will enhance energy reliability by storing excess electricity generated during periods of high solar radiation for use during periods of reduced solar availability and at night. Overall, the prevailing sunshine duration and solar radiation characteristics confirm that the Project location is technically suitable for the development and long-term operation of the proposed solar PV facility.

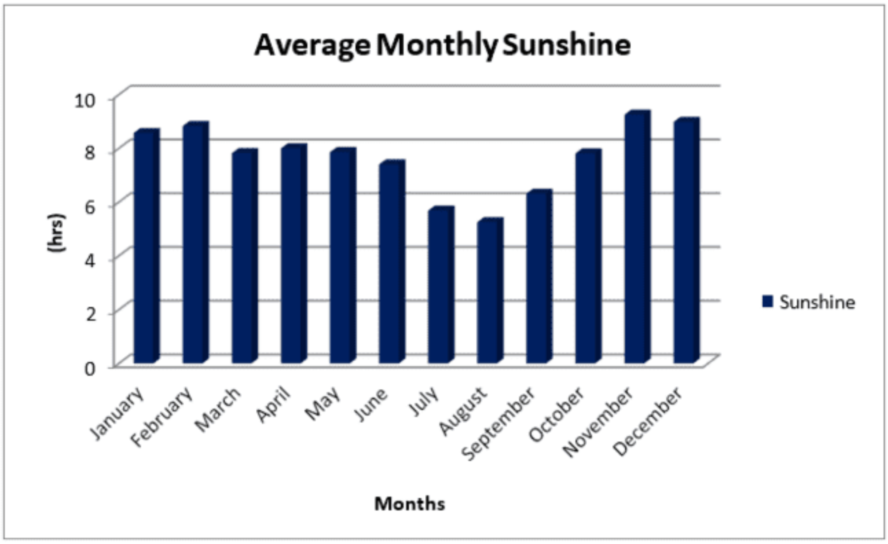


Figure 4.7: Monthly Average of Sunshine Hours for the Project Area (1991-2017)
(Source: NiMet, 2024)

4.2.2 Terrain Characteristics of the Area

The terrain characteristics of the project area were evaluated using Digital Terrain Analysis, contour mapping, and slope modelling techniques. Elevation variations indicate a gently undulating landform with gradual transitions between high and low terrain zones. These terrain characteristics are favourable for electrification infrastructure because they support stable foundation placement, efficient natural drainage, and minimal earthwork. Slope analysis confirms that most areas fall within gentle and moderate slope ranges, which significantly reduces construction complexity and improves long-term infrastructure stability. Aspect orientation further supports natural surface runoff, preventing water accumulation and reducing erosion risk. Overall, terrain stability, manageable slopes, and favourable drainage conditions confirm strong engineering suitability.

The terrain characteristics of all surveyed sites were evaluated using Digital Terrain Analysis, contour mapping, and slope modelling techniques. Elevation variations indicate a gently undulating landform with gradual transitions between high and low terrain zones. These terrain characteristics are favourable for electrification infrastructure because they support stable foundation placement, efficient natural drainage, and minimal earthwork. Slope analysis confirms that most areas fall within gentle and moderate slope ranges, which significantly reduces construction complexity and improves long-term infrastructure stability. Aspect orientation further supports natural surface runoff, preventing water accumulation and reducing erosion risk. Overall, terrain stability, manageable slopes, and favourable drainage conditions confirm strong engineering suitability.

The terrain characteristics of Sites A, B, and C were assessed using Digital Terrain Analysis (DTA), contour mapping, and slope modelling techniques. Across all three locations, elevation data reveal gently undulating landforms with gradual transitions between higher and lower terrain zones. These physiographic conditions are favourable for electrification infrastructure development, as they provide stable ground conditions for foundation placement, promote efficient natural drainage, and minimize the need for extensive earthworks.

Slope modelling indicates that the majority of each site falls within gentle to moderate slope categories, thereby reducing construction complexity and enhancing long-term structural stability. In addition, aspect analysis demonstrates favourable surface orientation that supports natural runoff, limiting the risk of waterlogging and soil erosion. Overall, the combination of terrain stability, manageable slope gradients, and effective drainage patterns confirms that Sites A, B, and C exhibit strong engineering suitability for the proposed development.

The sites are located within the Federal University of Education Zaria. A detailed analysis of the terrain assessment for Site A, Site B, and Site C, including area coverage, elevation range, slope range, engineering assessment, and coordinate tables for each site are described as follows:

Site A Terrain Assessment

The terrain characteristics of Site A, covering an area of approximately 1.31 hectares, were evaluated using Digital Terrain Analysis, contour mapping, and slope modelling techniques. Elevation across the site ranges from approximately 623.24 m to 629.04 m above mean sea level, representing a moderate elevation variation of about 5.80 metres. This elevation pattern indicates a gently undulating landform with gradual transitions between higher and lower terrain zones.

Slope analysis shows gradients ranging from approximately 0.06% to 11.04%, with the majority of the site falling within gentle to moderate slope categories. These slope conditions provide stable terrain for infrastructure placement, minimize earthwork requirements, and support efficient natural drainage. Aspect orientation across the site promotes natural surface runoff, preventing water accumulation and reducing erosion risk. Overall, Site A exhibits stable terrain, favourable slope conditions, and effective drainage characteristics, confirming strong engineering suitability for electrification infrastructure development.

Figure 4.8: Aerial Imagery of Site A of the Proposed Project Area

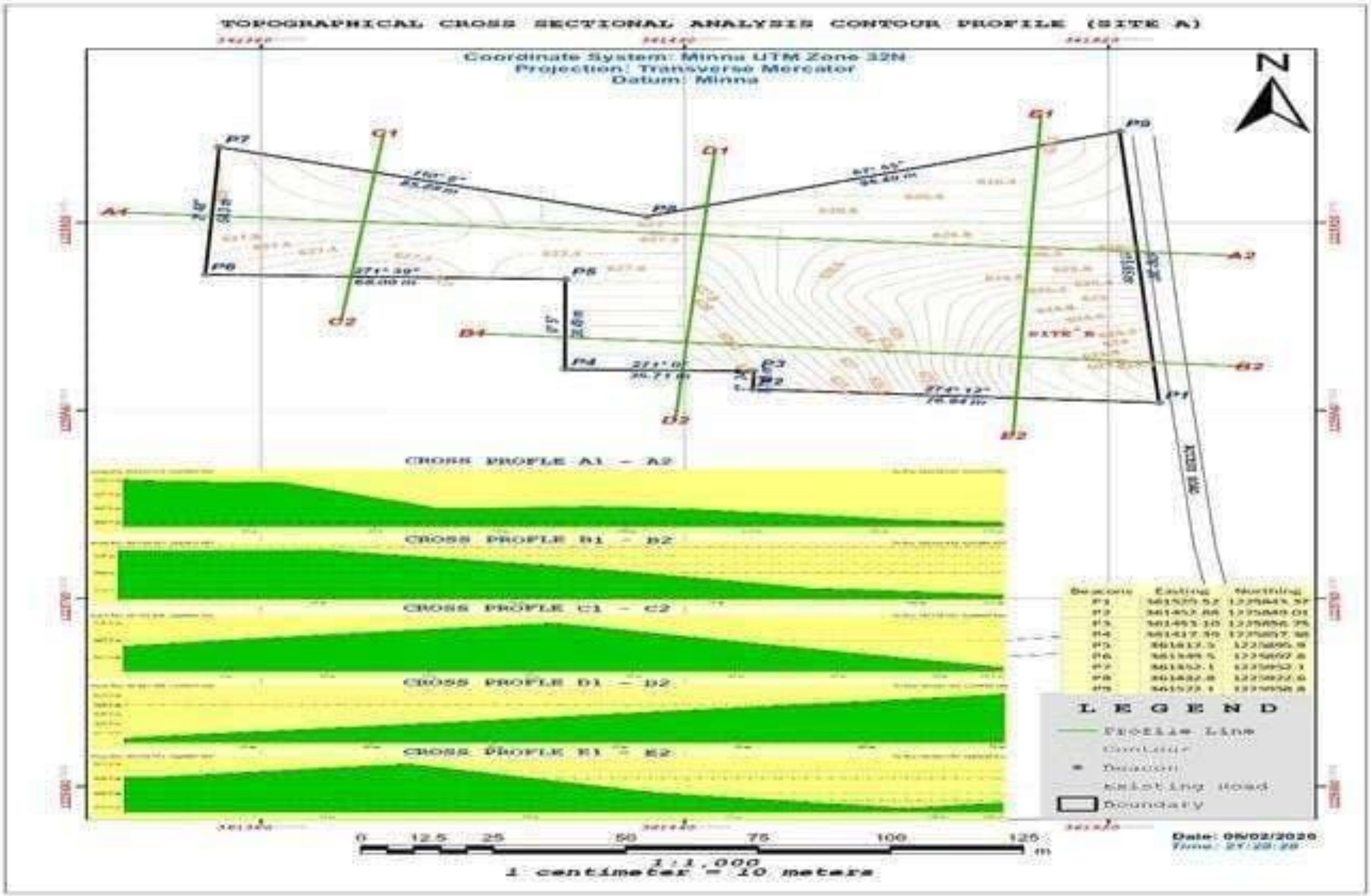


Figure 4.9: Topographic Cross Section Analysis Contour Profile of Site A of the Proposed Project Area

Table 4.2.1: Site A Beacon Coordinates

Beacon	Easting (m)	Northing (m)
P1	361529.52	1225843.37
P2	361452.88	1225849.01
P3	361453.10	1225856.75
P4	361417.39	1225857.38
P5	361417.50	1225895.90
P6	361349.50	1225897.80
P7	361352.10	1225952.10
P8	361432.80	1225922.60
P9	361522.10	1225958.80

Site B Terrain Assessment

Site B covers an area of approximately 7,117.78 square metres (0.71 hectares). Elevation ranges from approximately 616.92 m to 619.94 m above mean sea level, indicating a relatively uniform terrain with a total elevation variation of approximately 3.02 metres. This minimal elevation difference confirms that the site is predominantly flat to gently undulating.

Slope gradients range from approximately 0.03% to 5.56%, with most areas classified as gentle slopes. These terrain conditions provide excellent foundation stability and minimize the need for extensive site preparation. Natural terrain orientation supports effective drainage, preventing water accumulation and ensuring long-term structural stability. Overall, Site B provides highly favourable terrain conditions with minimal engineering constraints, making it particularly suitable for electrification infrastructure installation.

Table 4.3: Site B Beacon Coordinates

Beacon	Easting (m)	Northing (m)
P1	361783.21	1225816.90
P2	361858.21	1225817.10
P3	361855.72	1225905.08
P4	361784.36	1225923.61

Site C Terrain Assessment

Site C covers an area of approximately 1.01 hectares, with elevation ranging from approximately 624.34 m to 629.61 m above mean sea level, representing an elevation difference of approximately 5.27 metres. The terrain exhibits gentle undulations with gradual elevation transitions across the site.

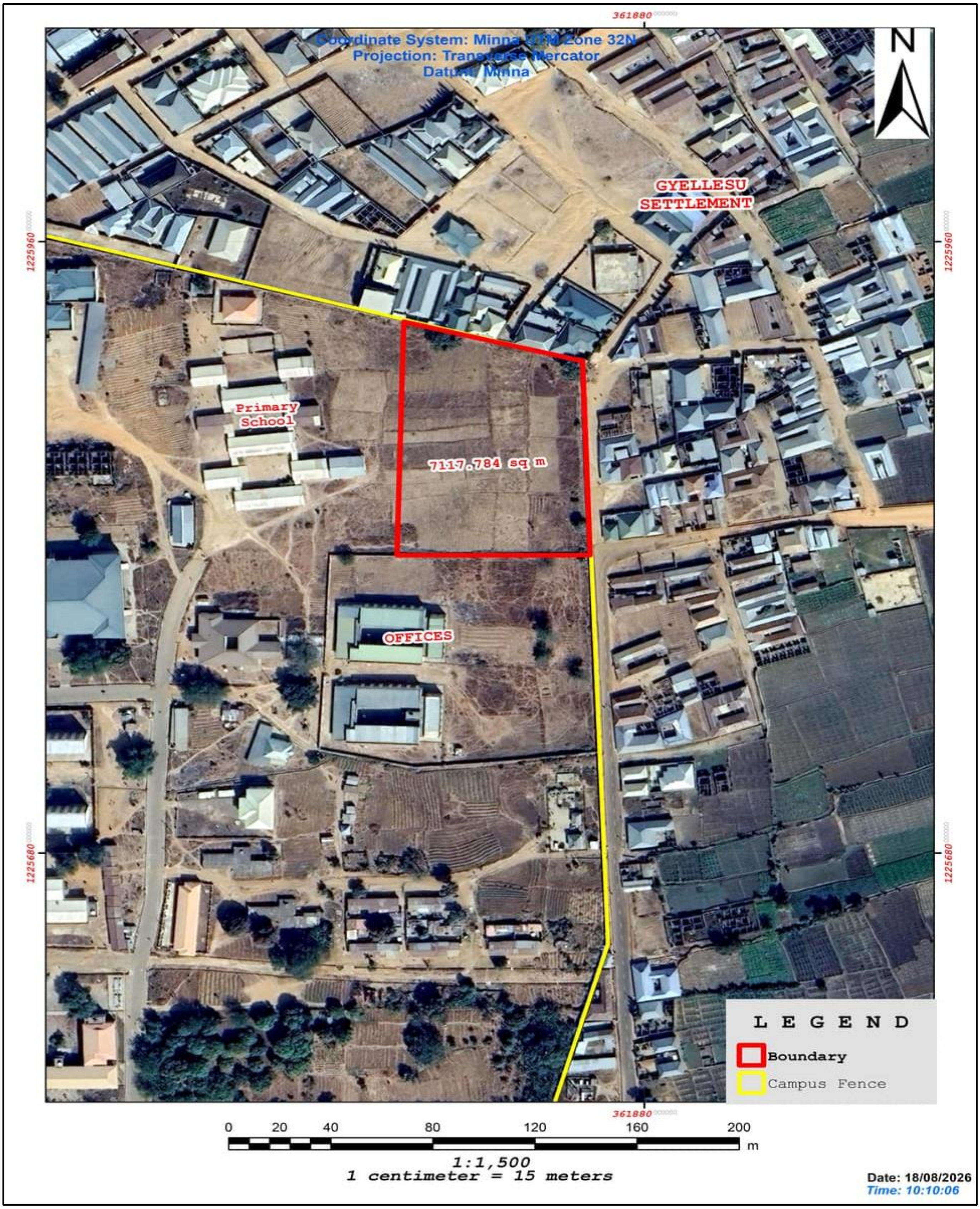


Figure 4.10: Aerial Imagery of Site B of the Proposed Project Area

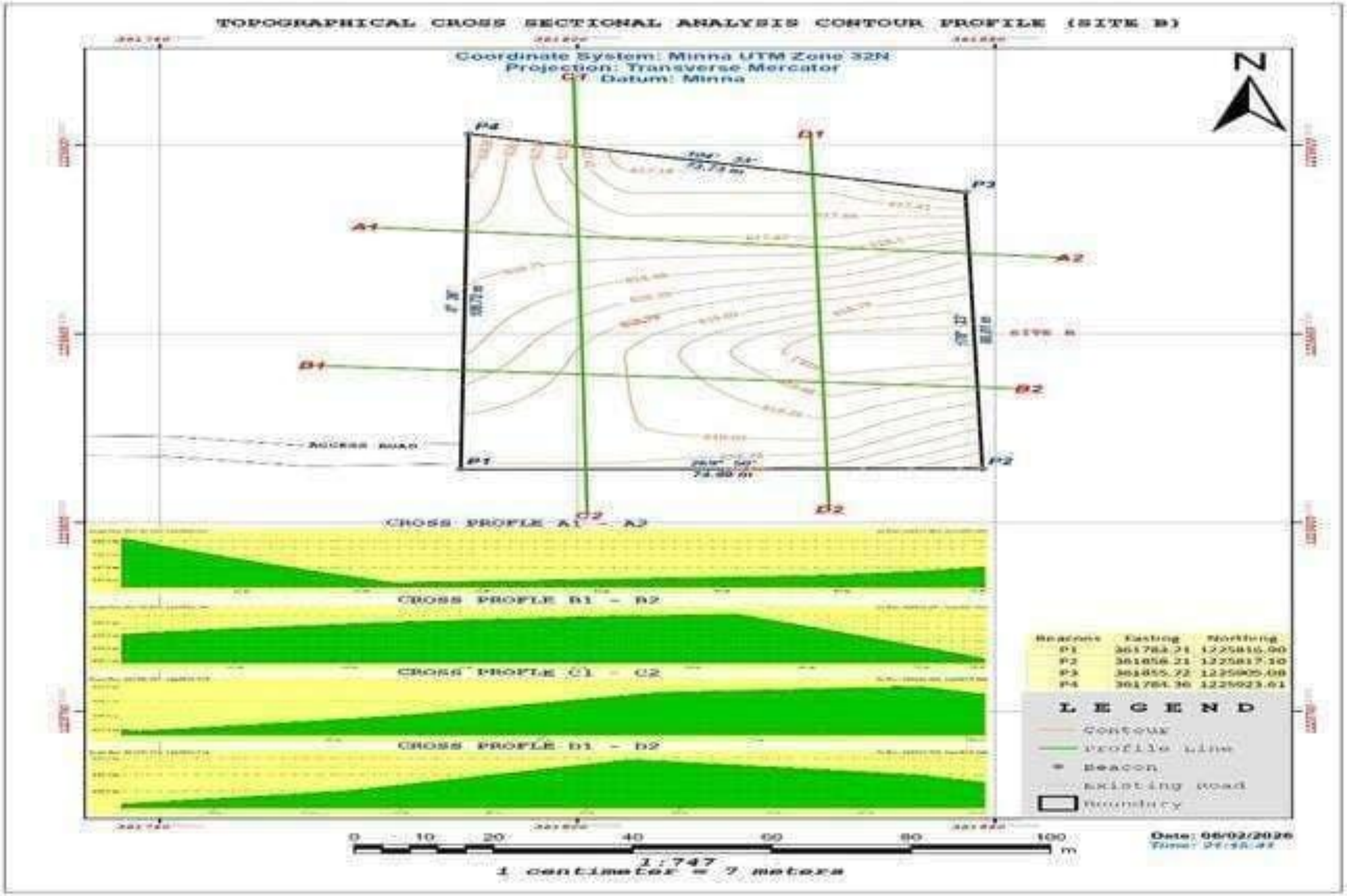


Figure 4.11: Topographic Cross Section Analysis Contour Profile of Site B of the Proposed Project Area

Slope analysis indicates gradients ranging from approximately 0.00% to 10.89%, with most areas falling within gentle and moderate slope categories. These slope conditions support stable infrastructure placement and efficient natural drainage. Aspect orientation allows effective runoff flow toward lower elevations, reducing the risk of erosion or water accumulation. Overall, Site C demonstrates stable terrain, manageable slopes, and favourable drainage characteristics, confirming its suitability for electrification infrastructure development.

Table 4.4: Site C Beacon Coordinates

Beacon	Easting (m)	Northing (m)
P1	361680.56	1225526.18
P2	361627.86	1225525.82
P3	361627.33	1225485.18
P4	361610.14	1225485.07
P5	361609.82	1225447.50
P6	361635.57	1225446.89
P7	361634.07	1225388.07
P8	361692.69	1225363.10
P9	361701.74	1225374.05
P10	361700.47	1225401.57
P11	361692.83	1225443.62
P12	361686.38	1225469.58

Table 4.5: Overall General Assessment of all Sites

Parameter	Site A	Site B	Site C
Area	1.31 ha	0.71 ha	1.01 ha
Elevation Range	623.24–629.04 m	616.92–619.94 m	624.34–629.61 m
Elevation Difference	5.80 m	3.02 m	5.27 m
Slope Range	0.06–11.04%	0.03–5.56%	0.00–10.89%
Terrain Condition	Gentle undulating	Flat to Mostly gentle	Gentle undulating
Engineering Suitability	Highly suitable	Excellent	Highly suitable

Based on Digital Terrain Analysis, slope modelling, elevation assessment, and coordinate surveys, Site A, Site B, and Site C exhibit stable terrain, favourable slope conditions, and efficient natural drainage. All sites are suitable for electrification infrastructure development with minimal engineering constraints. Recommended engineering provisions include minor grading, installation of surface drainage systems, and geotechnical investigation to ensure long-term infrastructure stability.

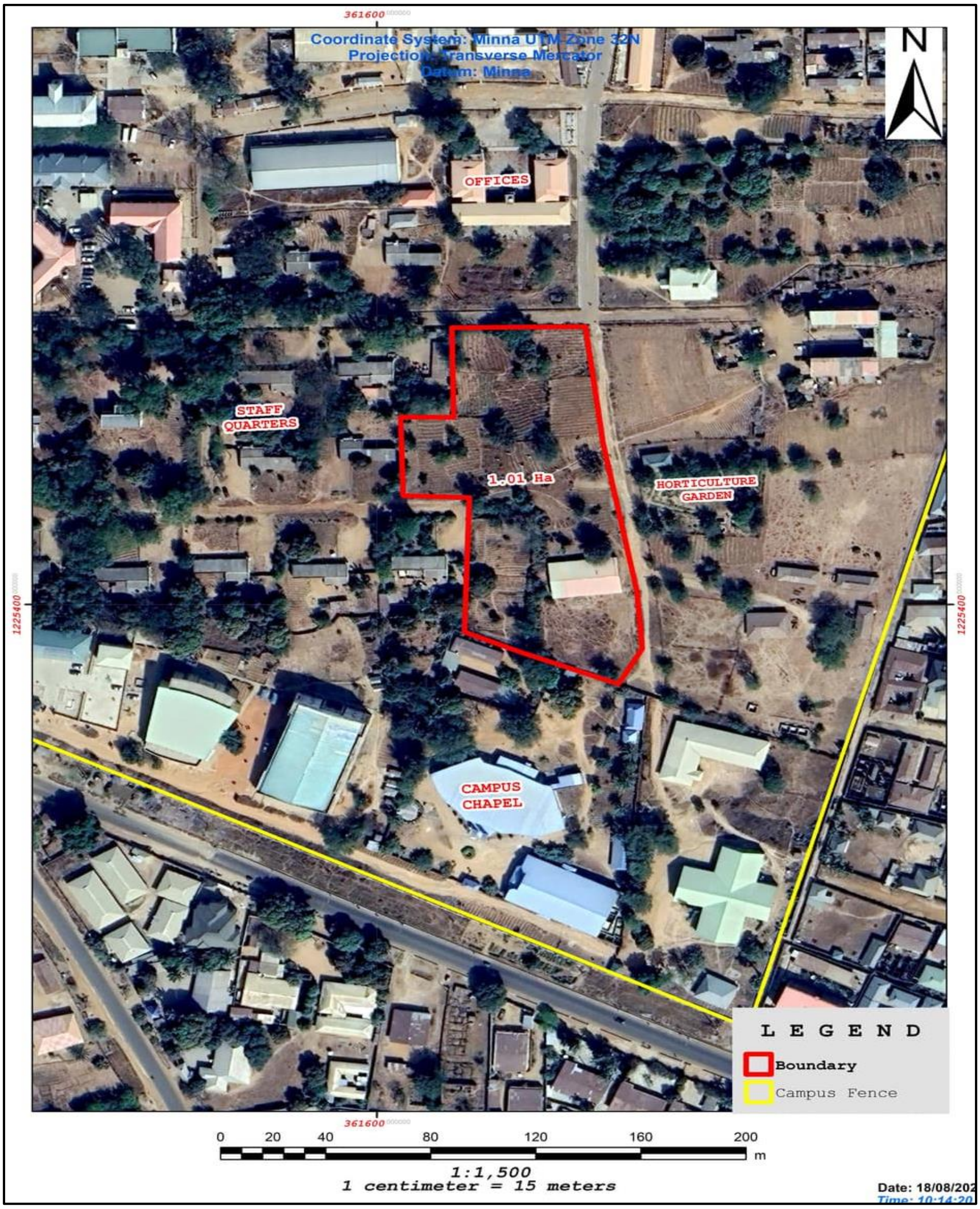


Figure 4.12: Aerial Imagery of Site C of the Proposed Project Area

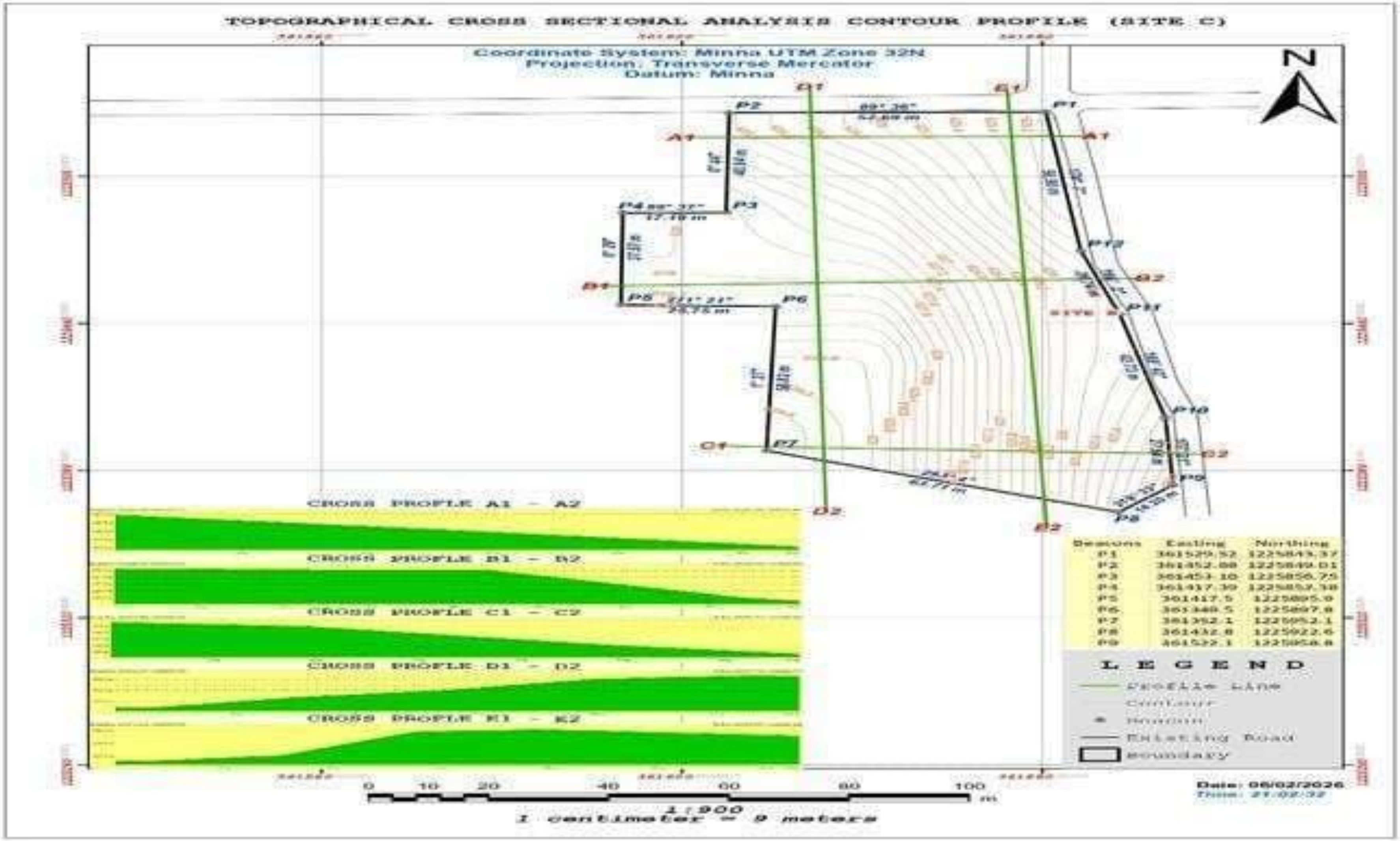


Figure 4.13: Topographic Cross Section Analysis Contour Profile of Site C of the Proposed Project Area

Site Boundary Description

Site A Boundary and Terrain Description: The total site area covers 1.31 hectares, with its boundary demarcated by nine perimeter beacons (P1–P9), established through GPS control points and detailed coordinate surveys.

Site B Boundary and Terrain Description: The total site area measures **7,117.78 square metres (0.71 hectares)**, with its boundary defined by four perimeter beacons (P1–P4) established using GPS and coordinate control points, and the site is accessible through the existing campus road network.

Site C Boundary and Terrain Description: The total site area covers **1.01 hectares**, with its boundary demarcated by twelve perimeter beacons (P1–P12) established using GPS coordinate control points, and the site is accessible via an existing access road along its boundary.

Digital Terrian Methodology

The topographic assessment was conducted using a combination of geospatial and conventional surveying techniques. A GPS control survey was first undertaken to establish accurate coordinate reference points across the study area. This was followed by detailed total station measurements to capture precise horizontal and vertical ground positions. The collected elevation data were processed to generate contour maps and develop a Digital Terrain Model (DTM), which provided a three-dimensional representation of the site's surface. Subsequent slope and aspect analyses were performed to evaluate terrain gradients and directional orientation. Overall, terrain modelling and elevation interpretation were derived from Digital Terrain Analysis (DTA), enabling a comprehensive understanding of site topography and its engineering suitability.

Digital Terrain Model

The Digital Terrain Model (DTM) analysis confirms generally stable terrain conditions across all surveyed sites. Site A exhibits an elevation range from 623.24 m to 629.04 m above mean sea level, resulting in an elevation difference of 5.80 m. Site B shows a narrower elevation range between 616.92 m and 619.94 m, with a total elevation difference of 3.02 m, indicating relatively flatter ground conditions compared to the other sites. Site C records elevations ranging from 624.34 m to 629.61 m above mean sea level, with an elevation difference of 5.27 m. These relatively small elevation variations across all three sites reflect gently undulating topography rather than steep or highly irregular terrain. Such conditions are favourable for electrification infrastructure development, as they support stable foundation placement, reduce the need for extensive earthworks, facilitate efficient surface drainage, and enhance long-term structural integrity. Overall, the terrain characteristics confirm strong engineering suitability for the proposed development.

Elevation Characteristics

Elevation analysis across Sites A, B, and C confirms generally gentle terrain variation and stable ground conditions. The terrain characteristics were assessed using Digital Terrain Analysis (DTA), contour mapping, and slope modelling techniques. Results from the elevation data indicate gently undulating landforms at all three sites, with gradual transitions between higher and lower terrain zones rather than abrupt elevation changes.

Slope modelling further demonstrates that the majority of each site falls within gentle to moderate slope categories. Such slope conditions are advantageous for electrification infrastructure development, as they reduce construction complexity, minimize the need for extensive cut-and-fill earthworks, and enhance long-term structural stability. In addition, aspect analysis shows favourable surface orientation that supports natural runoff patterns, thereby reducing the risk of water accumulation, surface erosion, and localized flooding.

Generally, the combined assessment of elevation range, slope gradient, and aspect orientation confirms that Sites A, B, and C possess stable terrain, manageable slopes, and effective natural drainage conditions. These characteristics collectively indicate strong engineering suitability for the proposed electrification infrastructure development.

Slope Analysis and Colour Interpretation

Slope analysis confirms favourable engineering conditions across Site A, Site B, and Site C. The slope maps use a colour gradient to represent terrain steepness, with colours indicating increasing slope intensity and associated engineering implications.

Site A Slope Analysis: The slope gradient across the site ranges from 0.06% to 11.04%, indicating predominantly gentle to moderate terrain conditions.

Slope map colour interpretation for Site A

Dark Green (0.06% – 2.77%) – Gentle slopes

These areas represent nearly flat to gently sloping terrain and cover a significant portion of the site. They provide excellent stability for infrastructure placement, require minimal grading, and present very low erosion risk.

Light Green to Yellow (2.78% – 5.79%) – Moderate slopes

These zones indicate gradual elevation change and remain highly suitable for electrification infrastructure. Surface runoff is well controlled, and only minor ground preparation is required.

Orange (5.80% – 7.94%) – Moderately sloping terrain

These areas represent slightly steeper terrain but remain suitable for development. Minor grading, drainage control, and foundation preparation may be required.

Light Red to Red (7.95% – 11.04%) – Steeper localized zones

These areas are limited in extent and represent the steepest parts of the site. While still suitable for infrastructure, they may require localized engineering measures such as grading, slope stabilization, and proper drainage installation.

Overall, the dominance of green and yellow zones confirms that Site A has favourable slope conditions with strong engineering suitability.

Site B Slope Analysis: The slope gradient across the site ranges from **0.03% to 5.56%,** reflecting generally gentle terrain conditions.

Slope Map Colour Interpretation for Site B:

Dark Green (0.03% – 0.76%) – Nearly flat terrain

These areas represent very stable ground with minimal slope and excellent suitability for infrastructure installation.

Light Green (0.77% – 1.72%) – Very gentle slopes

These zones provide ideal terrain conditions requiring virtually no grading.

Yellow (1.73% – 3.76%) – Gentle slopes

These areas provide excellent drainage and stable foundation conditions.

Light Orange (3.77% – 5.56%) – Moderate slopes

These areas remain suitable for development with minor engineering preparation.

The predominance of green and yellow colours confirms that Site B provides the most stable and favourable slope conditions among the three sites.

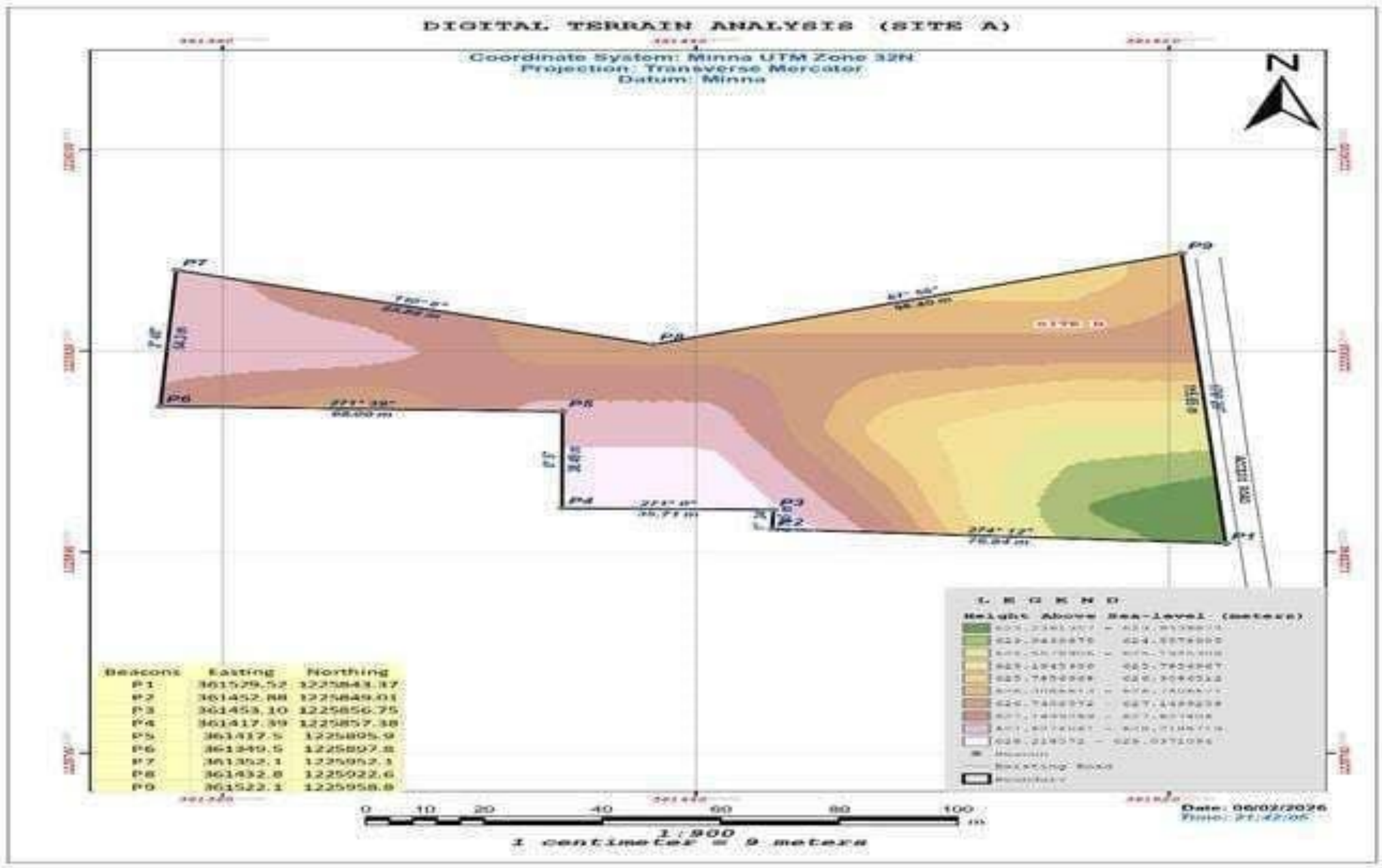


Figure 4.14: Terrain Analysis Map of Site A of the Proposed Project Area

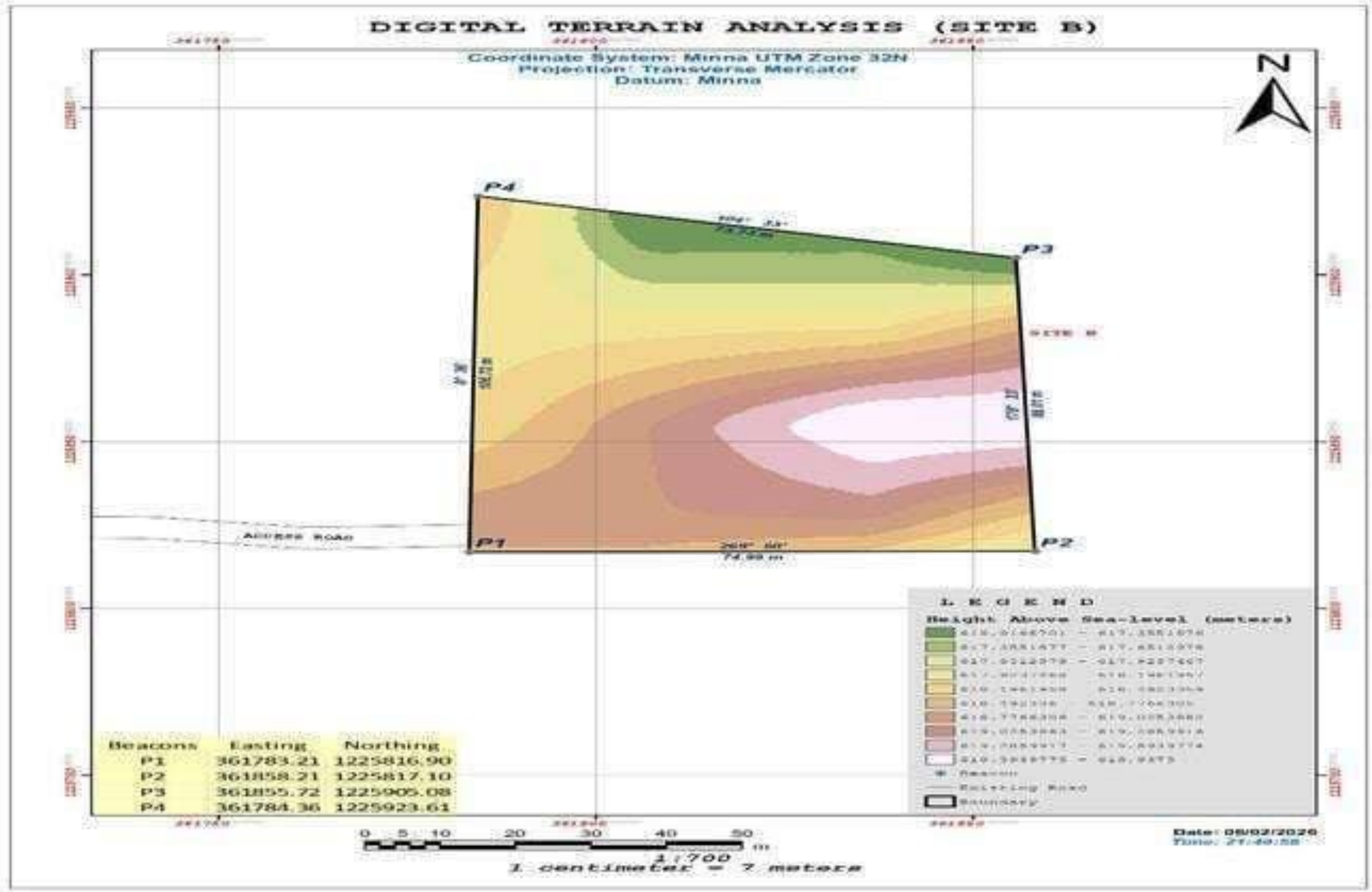


Figure 4.15: Terrain Analysis Map of Site B of the Proposed Project Area

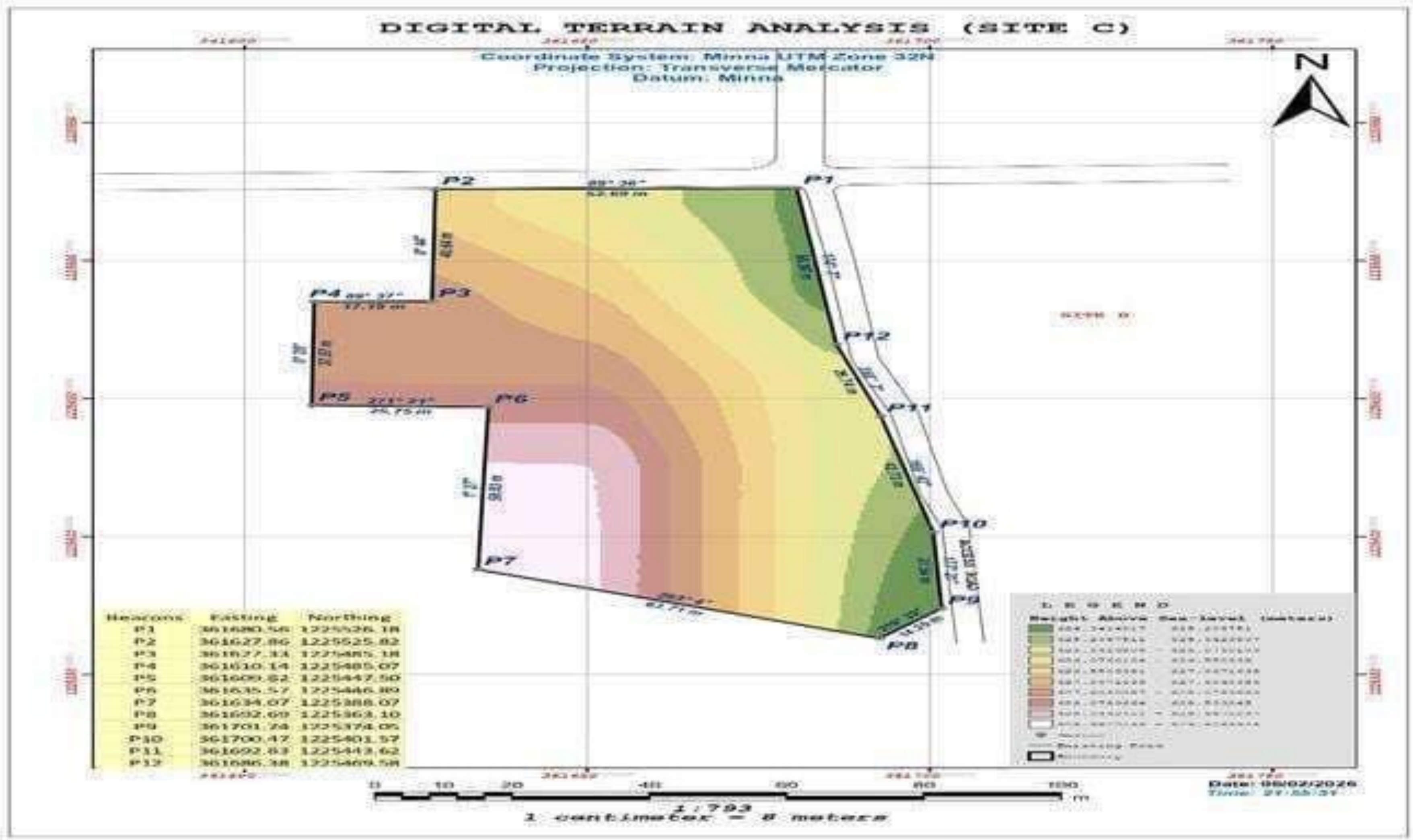


Figure 4.16a: Terrain Analysis Map of Site C of the Proposed Project Area

Site C Slope Analysis: The slope gradient across the site ranges from **0.00% to 10.89%**, indicating predominantly level to moderately sloping terrain.

Slope map colour interpretation for Site C:

Dark Green (0.00% – 2.60%) Gentle slopes

These areas provide highly stable terrain and excellent foundation conditions.

Light Green to Yellow (2.61% – 5.00%) – Moderate slopes

These areas support efficient natural drainage and stable infrastructure placement.

Orange (5.01% – 7.05%) – Moderately sloping terrain

These zones may require minor grading and drainage control but remain suitable for development.

Red (7.06% – 10.89%) – Steeper localized zones

These areas are limited and manageable with standard engineering measures such as grading and erosion control.

Table 4.6: The overall dominance of green and yellow slope range engineering conditions across Site C.

Engineering Significance of Slope Colour Distribution		
Colour		
Dark Green	Nearly flat	Excellent stability, no grading required
Light Green	Gentle slope	Highly suitable, minimal preparation
Yellow	Moderate slope	Suitable, minor grading required
Orange	Moderately sloping	Suitable with standard engineering preparation
Red	Steeper zones	Suitable with localized slope stabilization

In all, the slope maps for Site A, Site B, and Site C are dominated by green and yellow zones, indicating gentle to moderate slopes across most areas. These conditions provide stable terrain, efficient drainage, minimal erosion risk, and favourable engineering conditions. All sites are suitable for electrification infrastructure development with minimal to moderate engineering preparation.

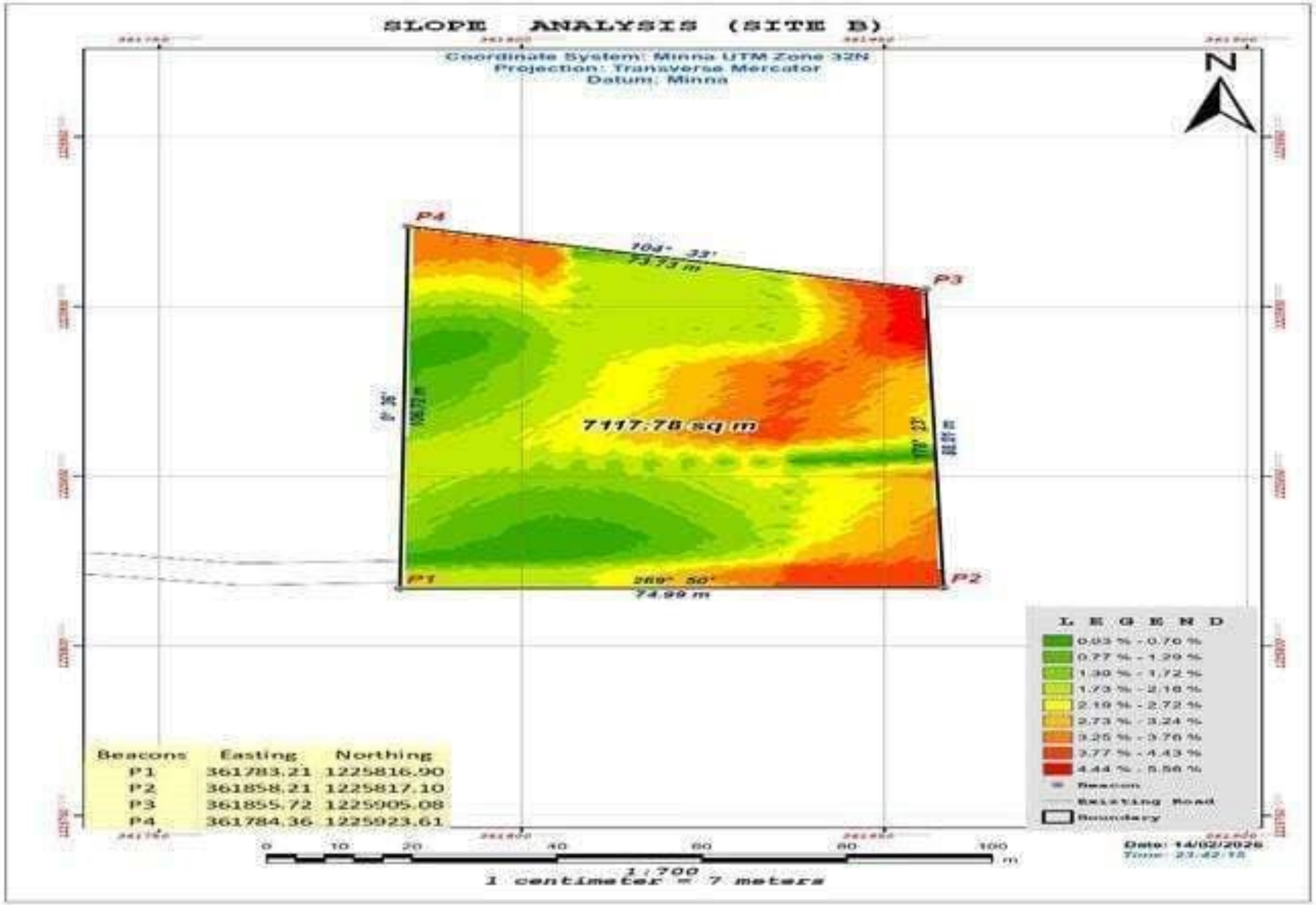


Figure 4.16b: Slope Analysis Map of Site B of the Proposed Project Area

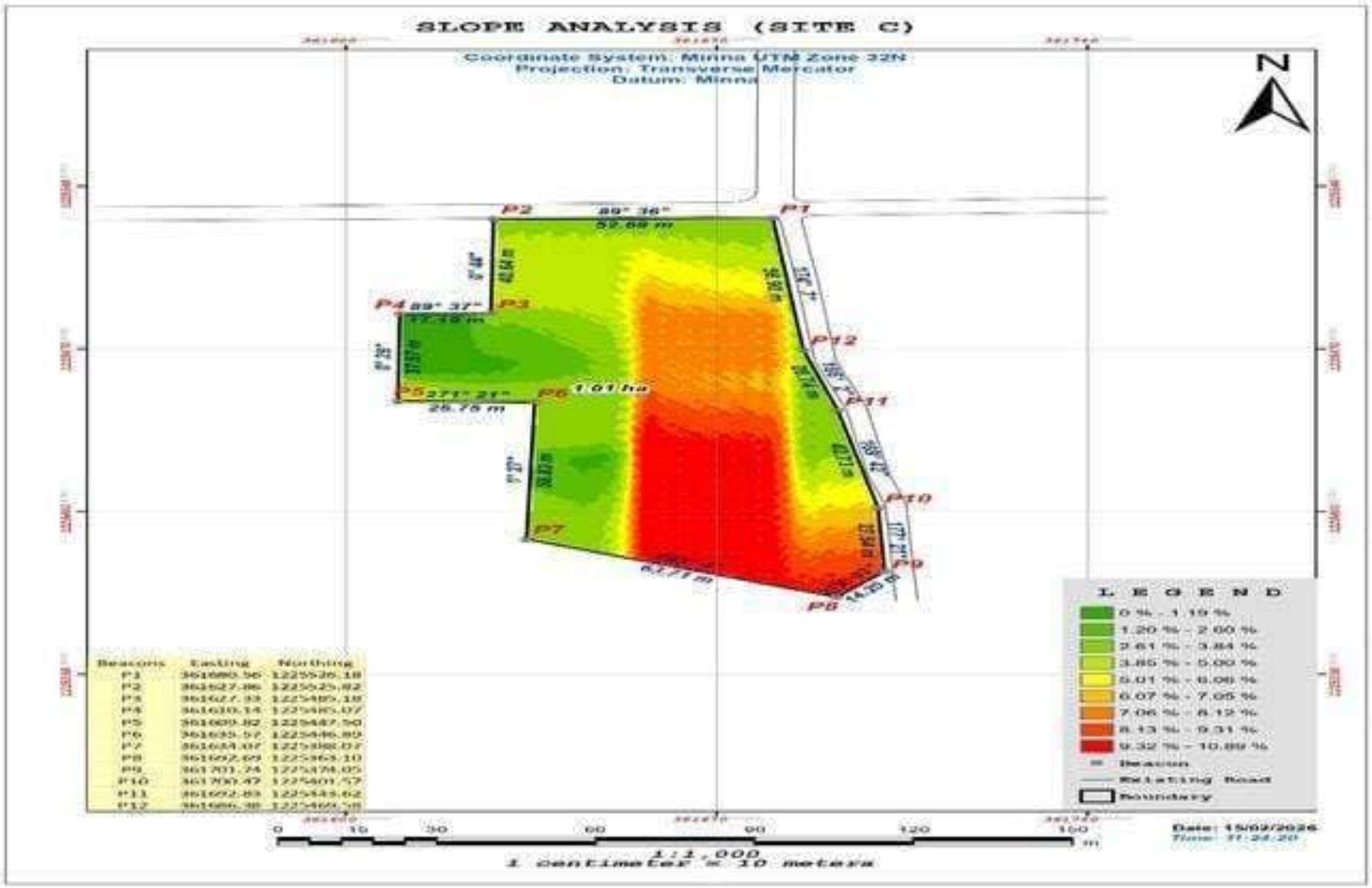


Figure 4.17: Slope Analysis Map of Site C of the Proposed Project Area

Aspect Analysis and Engineering Implications

Aspect analysis evaluates the directional orientation of terrain slopes, measured in degrees from –1° (flat terrain) to 360° (north-facing slopes). Aspect orientation influences natural drainage patterns, surface runoff direction, soil stability, and infrastructure placement suitability. The Digital Terrain Model confirms favourable aspect distribution across Site A, Site B, and Site C, supporting effective drainage and stable engineering conditions.

Site A Aspect Analysis

Aspect Value Range: –1° to 360° Slope directions across Site A include:

- **North:** 0°–22.5° and 337.5°–360°
- **Northeast:** 22.5°–67.5°
- **East:** 67.5°–112.5°
- **Southeast:** 112.5°–157.5°
- **South:** 157.5°–202.5°
- **Southwest:** 202.5°–247.5°
- **West:** 247.5°–292.5°
- **Northwest:** 292.5°–337.5°
- **Flat Areas:** Approximately –1°

Engineering and Drainage Implications doe Site A: Aspect distribution indicates gradual terrain transitions with dominant slope orientations directing runoff toward lower elevation zones. This supports efficient natural drainage, reduces water accumulation, and minimizes erosion risk. These conditions enhance terrain stability and provide favourable foundation conditions for electrification infrastructure development.

Site B Aspect Analysis

Aspect Value Range: –1° to 360°

Slope orientations across Site B include all primary compass directions, with significant portions of the terrain classified as flat or gently sloping.

Engineering and Drainage Implications for Site A: The predominance of flat and gently oriented slopes ensures excellent natural drainage and minimal surface runoff concentration. These conditions provide highly stable terrain, reduce erosion potential, and allow flexible infrastructure placement with minimal site preparation. Site B exhibits the most favourable aspect conditions among the three sites.

Site C Aspect Analysis

Aspect Value Range: –1° to 360° Slope directions across Site C include:

- North, Northeast, East
- Southeast, South, Southwest
- West, Northwest
- Flat areas at approximately –1°

Engineering and Drainage Implications for Site C: The aspect distribution supports natural drainage toward lower terrain zones and prevents water stagnation. The gradual slope orientation ensures stable ground conditions and reduces erosion risk. These conditions are suitable for infrastructure installation and long-term structural stability.

Table 4.7 Overall Aspect Suitability Assessment

Site	Aspect Range	Drainage Suitability	Engineering Implication
Site A	–1° to 360°	Excellent	Stable terrain, favourable infrastructure placement
Site B	–1° to 360°	Excellent	Highly stable terrain, minimal constraints
Site C	–1° to 360°	Very Good	Stable terrain, suitable for development

Aspect analysis confirms that Site A, Site B, and Site C exhibit favourable terrain orientation, supporting natural drainage and stable foundation conditions. The presence of gentle slope orientations and flat terrain areas minimizes erosion risk and enhances infrastructure stability. Overall, aspect conditions across all sites are highly suitable for electrification infrastructure development.

Drainage Assessment

Drainage analysis across Sites A, B, and C confirms generally low flood risk and favourable hydrological conditions. The terrain characteristics of the sites were evaluated using DTA, contour mapping, and slope modelling techniques to assess elevation variability, runoff patterns, and surface water behaviour. Results indicate gently undulating landforms with gradual transitions between higher and lower terrain zones, which promote efficient natural drainage.

Slope modelling demonstrates that most areas across the three sites fall within gentle to moderate gradient ranges, allowing surface runoff to flow naturally without significant water stagnation. Aspect orientation further enhances drainage efficiency by directing runoff away from critical infrastructure zones, thereby reducing the potential for water accumulation and localized flooding.

The absence of steep slopes or pronounced depressions minimizes erosion risk and eliminates the likelihood of concentrated flow paths that could compromise structural integrity.

Overall, the combined assessment of elevation, slope, and aspect confirms stable terrain conditions with effective surface water management characteristics. These features collectively indicate low flood susceptibility and strong engineering suitability for electrification infrastructure development across Sites A, B, and C.

4.2.3 Geology and Hydrogeology

The study area is located within Zaria Local Government Area of Kaduna State. It lies within the northern Nigerian Basement Complex terrain. The area is underlain predominantly by Precambrian crystalline rocks that form part of the extensive Basement Complex of northwestern Nigeria. The dominant lithological units include granites of the Older Granite suite, migmatitic and banded gneisses, schists of metasedimentary origin, and localized quartzites. These rocks are generally hard, compact, and characterized by negligible primary porosity. Structurally, the area has been influenced by Pan-African tectonic events, resulting in the development of fractures, joints, and fault systems that play a critical role in groundwater occurrence.

At the surface, it is characterized by weathered basement rocks overlain by lateritic and sandy-clayey soils derived from in-situ weathering processes. The thickness of the weathered mantle varies spatially depending on topography and degree of rock decomposition, typically ranging from a few meters to over 20 meters in some locations. The terrain is generally gently undulating with occasional rock outcrops, reflecting the structural and lithological control of the underlying crystalline bedrock. The hydrogeological framework is typical of Basement Complex environments, where groundwater occurrence is largely controlled by secondary porosity rather than primary pore spaces. Because crystalline rocks possess minimal primary permeability, groundwater storage and movement occur mainly within the weathered overburden and fractured bedrock zones. This results in a dual aquifer system consisting of a regolith (weathered layer) aquifer and an underlying fractured basement aquifer. The productivity of boreholes in the area depends significantly on the thickness of the weathered mantle and the intensity and connectivity of fracture networks within the bedrock.

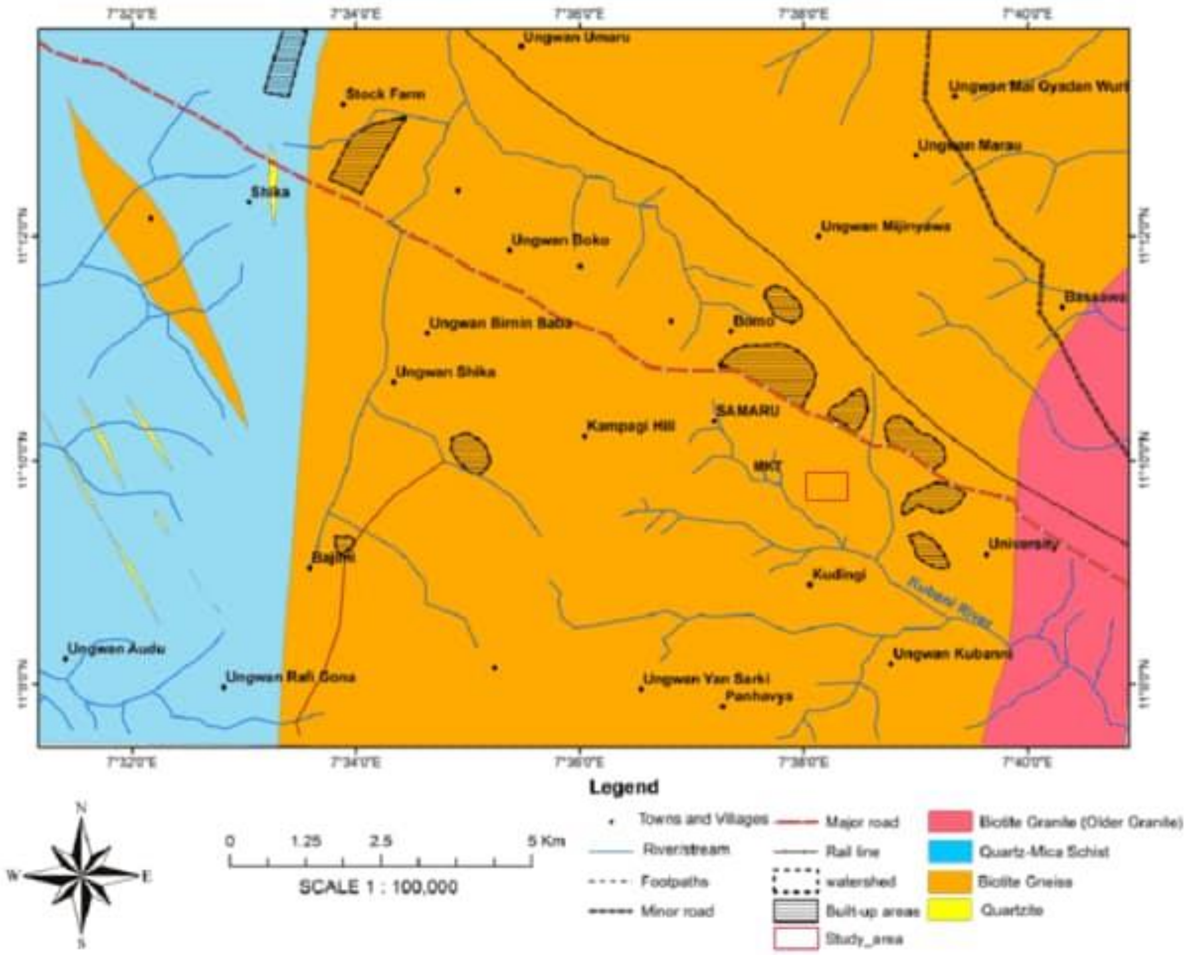


Figure 4.18: Geology of the Zaria showing the study area (Adapted from Abubakar et al., 2020)

Surface hydrology in the area is characterized by seasonal drainage systems that form part of the broader catchment linked to tributaries of the Galma River system. Drainage patterns are typically dendritic, reflecting the homogeneity of the crystalline basement rocks. Streamflow is highly seasonal, with significant runoff occurring during the wet season (April to October), while many minor channels become ephemeral during the dry season. Field investigations confirmed that no permanent surface water bodies occur within the proposed Project footprint across the three development sites. However, a seasonal surface water body associated with the River Kubani tributary serving the irrigational farming area is located outside the area of influence behind the University. This water body supports seasonal agricultural activities and receives runoff during the rainy season. Consequently, the Project design incorporates appropriate stormwater management and pollution prevention measures to prevent sediment transport and accidental contamination of nearby surface water resources during construction and operation. From a project perspective, the hydrogeological conditions suggest moderate groundwater vulnerability, particularly in areas where the weathered layer is shallow. Therefore, appropriate stormwater management, erosion control, and prevention of hazardous material leakage during construction and operation are essential to protect underlying groundwater resource.

4.2.4 Ambient Air Quality and Sound

In-situ air quality measurements were conducted in the Project's area of influence with the use of pre-calibrated digital hand-held monitoring equipment (Aeroqual series 500; Aerocet 531; Graywolf particle counter) for the following parameters: Air Quality Index (AQI), Temperature, HCHO, Total Volatile Organic Compounds (TVOC), Particulate Matter (Pm2.5), Particulate Matter (Pm10). Ambient noise levels were measured using an Integrated Sound Level Meter with a detection range of 30 dB(A) to 130 dB(A). Noise Level measurements were taken at a height of approximately 2m above ground level and the response time was set to slow and read on the 'A' frequency weighting scale in unit decibels. A total of twenty (20) sampling locations were established within and around the Project site for the ambient air quality and noise assessment. These comprised five (5) sampling points at each of three designated monitoring areas within the site, as well as five (5) additional control or buffer points to provide baseline reference conditions (Plate 4.1 and Figure 4.19). The air quality and noise sampling locations map is presented in Figure 4.19.

4.2.4.1 Noise and Air Quality Standards

The concentrations of air quality parameters recorded at the Project area were compared to the Nigerian Ambient Air Quality Standards (NAAQS), World Health Organization (WHO) Air Quality Guidelines noise level guidelines. The summary of these limits is provided in Tables 4.3.

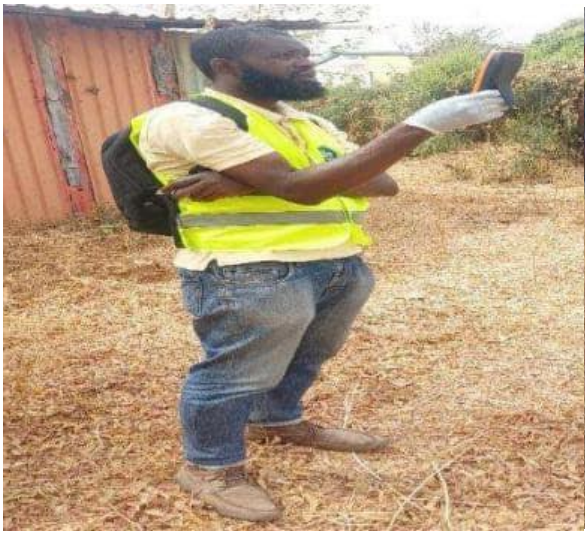



Plate 4.1: Measurements of air quality and noise at the project site

Table 4.8: Noise Exposure Limits for Nigeria

Duration per Day, Hour	Permissible Exposure Limit dB(A)
8	90
6	92
1	105
0.5	110
0.25	115

Source: Guidelines and Standards for Environmental Pollution Control in Nigeria (FEPA {now FMEnv}, 1991)

Table 4.9: Compliance Comparison – Observed Values vs NESREA and WHO Standards

Standard	Recommended Limit
WHO Environmental Noise Guideline	55 dBA (daytime outdoor residential)
NESREA / Nigerian Ambient Noise Limit	55–65 dBA (daytime for institutional areas)

4.2.4.2 Noise Quality Assessment

The sound levels were recorded at twenty monitoring points across Site A, Site B, Site C, and a Control location, with both minimum and maximum readings measured in decibels (dBA) Table 4.10. The environmental noise survey conducted across the study area recorded minimum and maximum sound pressure levels ranging from 38.3 dBA to 88.6 dBA across all monitoring stations.

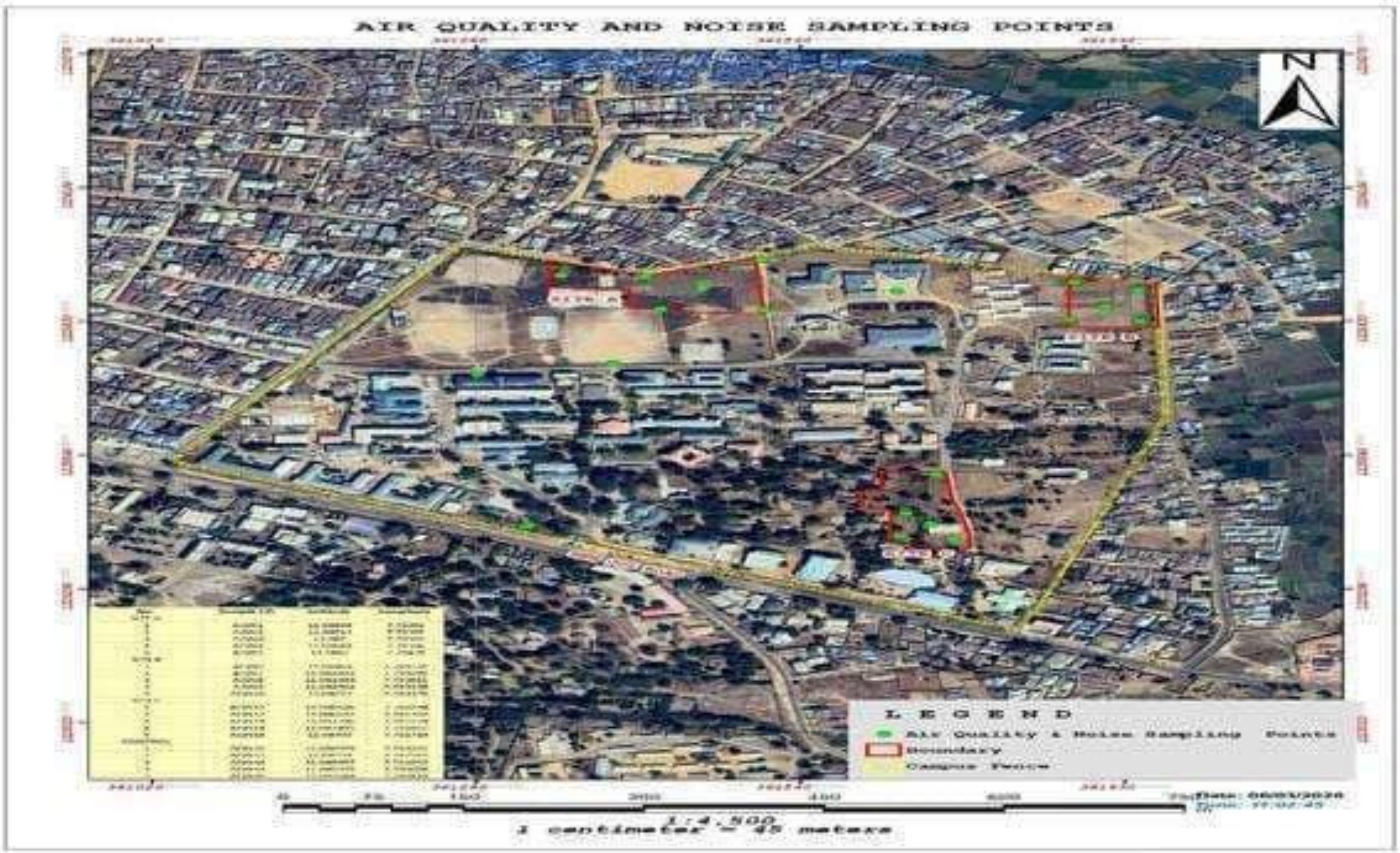


Figure 4.19: Map of Sound Level and Air Quality sampling across the proposed project sites

Minimum background noise levels were generally observed between 38.3 dBA and 52.9 dBA, indicating relatively moderate ambient conditions typical of institutional and semi-urban environments. Maximum instantaneous noise levels ranged between 58.6 dBA and 88.6 dBA, reflecting intermittent noise disturbances associated with human activities, vehicular movement, and localized operational activities within and around the study area (Figure 4.20).

Site A: Noise measurements recorded at Site A showed minimum levels between 40.6 dBA and 48.8 dBA, while maximum levels ranged from 64.7 dBA to 75.9 dBA. The observed sound levels indicate moderate environmental noise typical of institutional environments. Most readings fall within the Nigerian NESREA permissible daytime limit of 55–65 dBA, although some peak values slightly exceed this threshold. These elevated levels may be attributed to vehicular movement, pedestrian activity, and nearby operational activities within the surrounding infrastructure.

Site B: At Site B, background noise levels were relatively lower, with minimum values between 38.5 dBA and 43.1 dBA, indicating relatively quieter baseline conditions. However, maximum levels ranged between 58.6 dBA and 78.0 dBA. The higher peak values suggest temporary noise disturbances likely linked to traffic flow, generator operations, or intermittent mechanical activities within the surrounding environment. Despite these peaks, the majority of the measured values remain within acceptable limits for mixed institutional land use.

Site C: Noise measurements at Site C recorded minimum sound levels ranging from 38.3 dBA to 47.5 dBA, while maximum values ranged between 67.6 dBA and 77.5 dBA. These results indicate a moderately active acoustic environment, where background noise remains relatively stable but occasional spikes occur due to human activity and local traffic movement. Although some peak levels exceed the WHO recommended outdoor guideline of 55 dBA for residential environments, they remain within tolerable limits for institutional and mixed-use environments.

Control Site: The control location outside the campus recorded the highest noise levels among all monitoring sites, with minimum readings between 44.6 dBA and 52.9 dBA and maximum readings ranging from 73.8 dBA to 88.6 dBA. These elevated levels indicate stronger anthropogenic noise influences, possibly due to traffic intensity, nearby commercial activities, or mechanical equipment operations. The peak value of 88.6 dBA significantly exceeds both WHO environmental noise guidelines and NESREA recommended limits, suggesting that the control location is subject to higher environmental noise exposure compared to the project sites.

Table 4.10: Sound Level and Air Quality Analysis of Sites

STATION	SOUND LEVEL METER (DBA)		AIR QUALITY							COORDINATES	
	Minimum Readings	Maximum Readings	AQI	Temperature(^{0}F)	HCHO(mg/m3)	TVOC(mg/m3)	Pm2.5(ug/m3)	Pm10(ug/m3)	No. of particles(per/l)	Latitude	Longitude
SITE A											
AQ1	40.6	65.2	86	102 at 11.8%	0.02	0.08	39.2	76.7	6542	11.086460	7.734520
AQ2	42.2	64.7	76	101 at 16.8%	0.03	0.12	32.9	16.9	1538	11.087140	7.734550
AQ3	48.8	74.0	74	101 at 14.5%	0.01	0.04	27.4	51.7	5581	11.087000	7.735040
AQ4	42.4	75.9	85	98.8 at 13.9%	0.06	0.16	26.6	46.5	5216	11.086440	7.735060
AQ5	45.5	67.7	77	99.2 at 13.2%	0.02	0.10	23.5	36.5	4022	11.086700	7.734790
SITE B											
AQ6	38.6	73.8	90	97.5 at 16.9%	0.02	0.04	32.7	53.6	4503	11.083630	7.733516
AQ7	43.1	78.0	55	96.3 at 12.9%	0.01	0.06	12.6	23.5	2122	11.082922	7.733291
AQ8	38.9	64.7	47	88.67 at 23.6%	0.01	0.03	46.3	78.6	6461	11.082444	7.733651
AQ9	38.5	70.5	66	98.2 at 15.4%	0.01	0.03	20.4	35.5	3213	11.082501	7.733238
AQ10	39.9	58.6	59	98.0 at 12.4%	0.02	0.08	18.2	21.9	2820	11.082720	7.733478
SITE C											
AQ11	38.3	77.5	55	97.2 at 13.5%	0.01	0.05	18.1	31.5	2564	11.086626	7.732194
AQ12	40.8	67.6	37	98.7 at 11.9%	0.02	0.03	6.5	11.7	1192	11.086642	7.731402
AQ13	47.5	69.1	64	95.6 at 12.2	0.01	0.04	18.9	21.8	2688	11.087236	7.731279
AQ14	46	70.5	67	95.3 at 12.0%	0.02	0.04	23	42	4220	11.087455	7.731957
AQ15	44.8	67.6	68	98.7 at 10.0%	0.01	0.05	17.4	31.1	2889	11.087090	7.731714
CONTROL											
AQ16	45.1	88.6	33	103 at 8.0%	0.01	0.06	14.7	26.7	3004	11.086979	7.733201
AQ17	50.7	82.7	39	102 at 8.0%	0.03	0.14	9.7	17.5	1852	11.087540	7.732162
AQ18	45.7	80.1	56	10.5 at 6.7%	0.04	0.15	8.6	13	1226	11.085657	7.731042
AQ19	44.6	73.8	94	101 at 7.1%	0.03	0.16	12.5	21	2258	11.085445	7.730008
AQ20	52.9	74.4	55	97.3 at 11.8%	0.02	0.05	14.6	26.4	3106	11.082684	7.730414

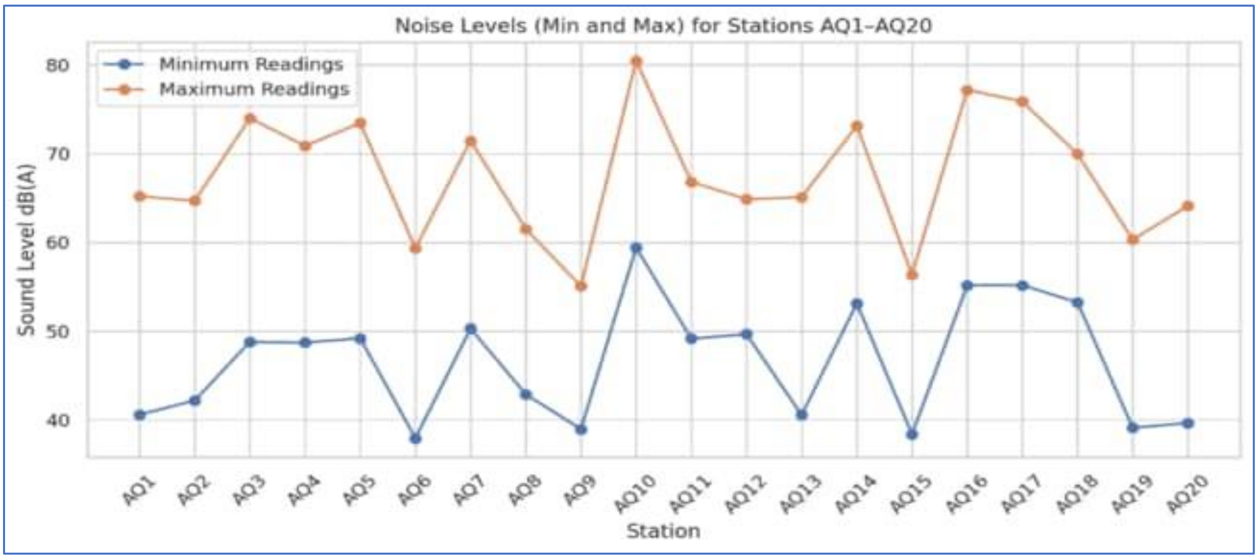


Figure 4.20: Noise Levels for the stations

The ambient air quality assessment focused primarily on particulate matter ($PM_{2.5}$ and PM_{10}), volatile organic compounds (TVOC), formaldehyde (HCHO), and general air quality indicators measured using a portable multi-parameter air quality monitor. These parameters were selected to establish the prevailing ambient air conditions within the proposed Project area. The proposed 2 MW Solar-Hybrid Power Plant is not expected to generate significant gaseous emissions during operation. Potential emissions of criteria pollutants such as carbon monoxide (CO), nitrogen dioxide (NO_2), and sulphur dioxide (SO_2) will be limited to temporary construction equipment and haulage vehicles during the construction phase and have therefore been considered qualitatively in the impact assessment rather than through baseline field monitoring.

4.2.5 Air Quality Assessment

4.2.5.1 Overview of Air Quality Conditions

Ambient air quality measurements were carried out at multiple monitoring stations within the project area to determine baseline atmospheric conditions prior to project implementation (Table 4.10). The parameters analyzed included particulate matter ($PM_{2.5}$ and PM_{10}), formaldehyde (HCHO), and total volatile organic compounds (TVOC), alongside meteorological indicators such as temperature and relative humidity. These parameters are widely used indicators for evaluating atmospheric pollution levels and potential health risks associated with air quality. Overall, the results show that air quality within the study area is generally moderate, with most pollutant concentrations falling within acceptable regulatory limits when compared with the Nigerian

National Ambient Air Quality Standards (NAAQS). However, certain locations exhibited elevated particulate concentrations that may be attributed to localized anthropogenic activities such as vehicular traffic, construction activities, and dust resuspension from unpaved surfaces.

Particulate Matter ($PM_{2.5}$): $PM_{2.5}$ concentrations recorded across the monitoring locations ranged from approximately 6.5 µg/m³ to 46.3 µg/m³ (Figure 4.20). The lowest concentrations were observed at some locations within Site C, while the highest values were recorded at Site B, suggesting localized particulate emission sources within that area. When compared with the World Health Organization (WHO) Air Quality Guideline of 15 µg/m³ (24-hour average) and the Nigerian NAAQS limit of 25 µg/m³, several monitoring points exceeded the WHO guideline and slightly surpassed the national regulatory limit. These elevated values likely result from dust resuspension caused by vehicular movement, soil disturbance, and nearby human activities. Despite these localized increases, the majority of readings remain within or close to regulatory thresholds, indicating moderate particulate pollution levels rather than severe air contamination. From an environmental health perspective, $PM_{2.5}$ is particularly significant because of its ability to penetrate deep into the respiratory system, potentially causing respiratory irritation or long-term cardiovascular effects when exposure is prolonged. Therefore, although the observed concentrations are not critically high, dust control measures should be implemented during project activities to minimize particulate emissions.

Particulate Matter (PM_{10}): The measured PM_{10} concentrations ranged between approximately 11.7 µg/m³ and 78.6 µg/m³ across the sampling locations (Figure 4.21). The highest values were observed at Site B, while relatively lower values were recorded at Site C and some control stations. When compared with the WHO guideline of 45 µg/m³ (24-hour mean) and the Nigerian NAAQS limit of 150 µg/m³, some sampling points exceeded the WHO guideline but remained well below the national standard. This indicates that while coarse particulate matter levels may occasionally rise above ideal health-based thresholds, they remain within acceptable limits for ambient environmental conditions. The elevated PM_{10} values are likely associated with dust generation from exposed soil surfaces, road traffic, and wind-driven particulate transport, particularly during dry conditions. Such particulate matter typically consists of soil particles, road dust, and other coarse aerosols, which can temporarily increase atmospheric turbidity in the immediate environment.

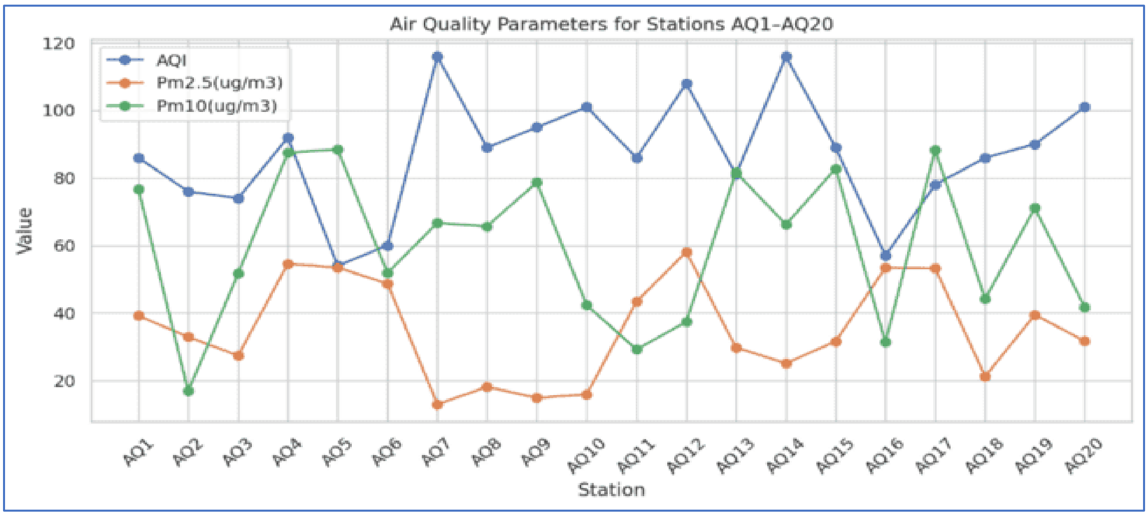


Figure 4.21: Air quality parameter for the stations

Volatile Organic Compounds (TVOC): TVOC concentrations recorded across the study area ranged approximately between 0.03 mg/m³ and 0.16 mg/m³ (Figure 4.22). These values are relatively low and fall within acceptable environmental exposure limits typically associated with outdoor air environments. The observed TVOC concentrations suggest minimal presence of volatile chemical pollutants, indicating that the surrounding environment is not heavily influenced by industrial emissions, fuel combustion activities, or solvent usage. The measured values likely reflect background emissions from vehicles, small generators, and natural organic emissions from surrounding vegetation. Overall, the TVOC results indicate good ambient air quality with minimal chemical contamination.

Formaldehyde (HCHO): Formaldehyde concentrations measured across the Project area ranged between 0.01 mg/m³ and 0.04 mg/m³, which are below the World Health Organization (WHO) guideline value of approximately 0.1 mg/m³ for short-term exposure. Although formaldehyde is not considered a primary pollutant of concern for the proposed solar PV Project, it was measured as part of the multi-parameter ambient air quality assessment used to characterize existing environmental conditions. The low concentrations recorded indicate the absence of significant local combustion or industrial sources that could adversely influence baseline air quality.

Meteorological Conditions: Temperature readings across the sampling locations ranged from approximately 38°C to 52°C, while relative humidity levels ranged between about 88% and 103%. These meteorological conditions influence the dispersion and accumulation of airborne pollutants.

Higher temperatures can enhance dust suspension and pollutant dispersion, while elevated humidity levels may contribute to particulate aggregation and atmospheric deposition. These factors partly explain the observed variability in particulate concentrations across different monitoring points.

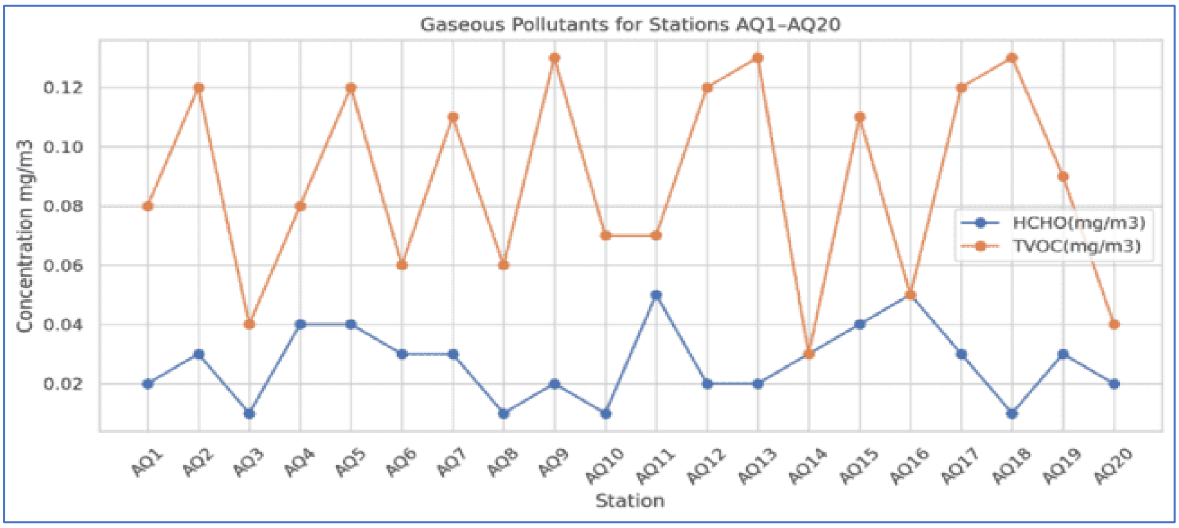


Figure 4.22: Gaseous pollutants for the stations

Environmental Significance: The baseline air quality conditions across the study area indicate that: Particulate matter ($PM_{2.5}$ and PM_{10}) represents the most significant air quality parameter, primarily influenced by dust and local anthropogenic activities. Chemical pollutants such as TVOC and formaldehyde remain within safe environmental limits, indicating minimal industrial pollution. Air quality conditions are typical of semi-urban institutional environments, where dust and traffic emissions represent the dominant pollution sources. Although some particulate concentrations slightly exceed WHO health-based guidelines, the levels remain within Nigerian regulatory limits, suggesting moderate environmental air quality with manageable pollution levels.

4.2.6 Soil and Ground Investigation

4.2.6.1 Soil Sampling, Characteristics and Quality

A total of eighteen (18) soil sampling stations were established in the Project area. At each of the sampling station, both top soil (0-15cm) and sub-soil (15-30cm) were collected (Plate 4.2). Soil sampling was carried out using a stainless-steel auger. The soil samples collected were homogenized in plastic bucket lined with aluminum foil sheet, and from the homogenized soil samples, sub samples were taken for physico-chemical analysis. All samples collected were preserved and transported to the laboratory for analysis. The geographical coordinates of the soil sampling locations are presented in Table 4.11 while the soil sampling locations map is depicted in Figure 4.23.

Plate 4.2: Soil sampling and ground investigation activities at the project site

Soil Cations and Anions:

The soil samples analyzed for major anions including phosphate (PO_4^{3-}), sulphate (SO_4^{2-}), carbonate (CO_3^{2-}), chloride (Cl^-), and nitrate (NO_3^-) show moderate variability across the sampling locations and depths (Table 4.11 and Figure 4.24). Phosphate concentrations ranged approximately between 5.89 mg/kg and 24.03 mg/kg, indicating relatively low to moderate nutrient availability. These values are typical for natural soils and do not indicate excessive fertilizer or anthropogenic nutrient enrichment. Sulphate concentrations varied between 22.25 mg/kg and 56.03 mg/kg, suggesting moderate sulphur presence which may originate from natural mineral weathering or organic matter decomposition. Carbonate concentrations ranged between 126 mg/kg and 246 mg/kg, indicating the presence of carbonate minerals which can contribute to buffering soil acidity and stabilizing soil pH conditions. Chloride concentrations were recorded between 177.5 mg/kg and 221.88 mg/kg, values that are consistent with natural soil salinity levels in semi-arid environments and are not indicative of contamination from industrial sources.

Figure 4.23: Soil sampling across the proposed project sites

Table 4.11: Soil Cations and Anions for all stations

S ID	PO4 (mg/kg)	SO4 (mg/kg)	CO3 (mg/kg)	Cl (mg/kg)	NO3 (mg/kg)	Regulatory/ Reference Limit
SS7 - B	7.50268	26.27346	246	221.875	8.406	NS*
SS7 -T	5.894962	56.03217	138	177.5	14.01	NS*
SS8 - B	24.02644	22.25201	126	177.5	2.802	NS*
SS8 - T	8.931761	10.72386	96	310.625	11.208	NS*
SS9 - B	7.234727	12.86863	162	310.625	2.802	NS*
SS9 - T	8.21722	11.79625	84	488.125	2.802	NS*
SS6 - B	8.574491	13.80697	78	399.375	8.406	NS*
SS6 - T	6.609503	16.08579	216	2041.25	11.208	NS*
SS5 - B	8.485173	14.07507	246	221.875	8.406	NS*
SS5 - T	5.716327	10.99196	90	177.5	11.208	NS*
SS4 - B	10.6288	24.26273	138	798.75	5.604	NS*
SS4 - T	7.681315	14.34316	120	355	5.604	NS*
SS1 - B	5.894962	11.93029	60	177.5	8.406	NS*
SS1 - T	8.038585	15.81769	72	221.875	5.604	NS*
SS2 - B	4.912469	11.12601	114	177.5	8.406	NS*
SS2 - T	7.056091	18.76676	84	266.25	2.802	NS*
SS3 - B	9.646302	11.93029	36	133.125	2.802	NS*
SS3 - T	5.62701	11.6622	150	266.25	8.406	NS*

NS = No specific FMEnv/NESREA regulatory limit was identified for PO_4, SO_4, CO_3, Cl and NO_3 in soil. Results are therefore interpreted as baseline soil chemistry/nutrient conditions and compared qualitatively with typical background/agronomic soil conditions.

Nitrate concentrations ranged from 2.80 mg/kg to 14.01 mg/kg, reflecting relatively low nitrogen availability typical of undisturbed soils. Overall, the anion composition suggests that the soils are nutrient-poor to moderately fertile with no indication of excessive nutrient loading or chemical contamination. The observed levels are consistent with natural geochemical conditions and background soil chemistry, indicating minimal anthropogenic influence on soil ionic composition.

The exchangeable cations measured in the soil samples include calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+), and sodium (Na^+) (Figure 4.24). These base cations are essential indicators of soil fertility, nutrient availability, and soil chemical balance. Their concentrations also provide insight into the soil's capacity to support plant growth and maintain structural stability. The results show that calcium (Ca^{2+}) is the most dominant exchangeable cation in the soil samples, with concentrations ranging from approximately 1.75 to 5.31 cmol(+)/kg. Calcium plays an important role in soil structure formation by promoting the aggregation of soil particles, which improves soil porosity, aeration, and water infiltration. The relatively higher calcium concentrations observed in several sampling stations indicate that the soils possess moderate base saturation and favorable structural stability. The variability observed between sampling locations likely reflects differences in soil mineral composition and organic matter distribution within the study area.

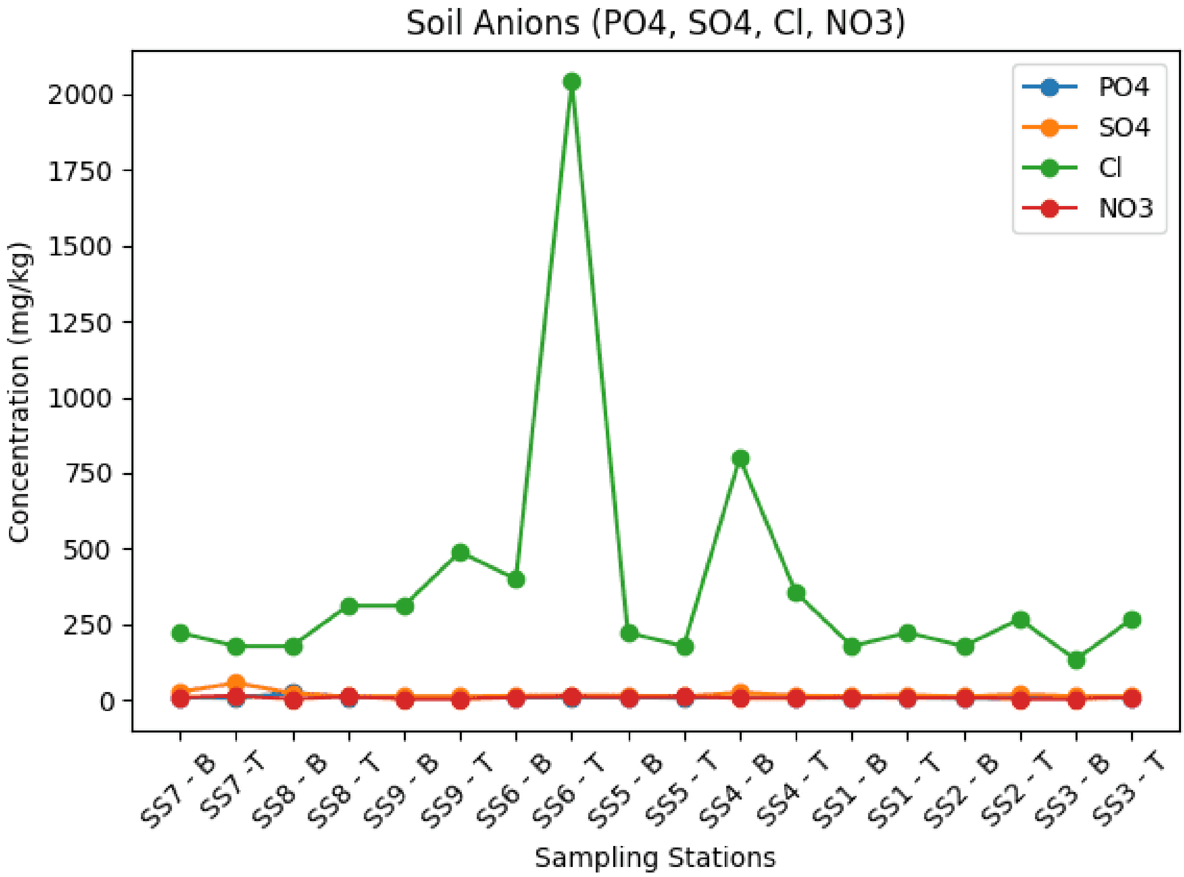


Figure 4.24: Soil Anions for the stations

Magnesium (Mg^{2+}) concentrations range between approximately 0.60 and 1.15 cmol(+)/kg, indicating moderate magnesium availability across the sampling sites. Magnesium is a key component of chlorophyll and plays a crucial role in plant metabolic processes and enzyme activation. The recorded values suggest that the soils contain adequate magnesium levels for plant nutrition, although slightly lower concentrations compared with calcium are typical due to the natural geochemical balance of exchangeable bases in tropical soils. The concentration of potassium (K^{+}) varies from approximately 0.13 to 0.37 cmol(+)/kg, indicating relatively low to moderate potassium availability. Potassium is a vital plant nutrient involved in water regulation, enzyme activation, and stress resistance in plants. The moderate levels observed in the study area may reflect the leaching tendency of potassium in sandy soils, particularly in regions with high rainfall or well-drained soil profiles. Despite this, the values remain within the range typical for natural soils and indicate sufficient potassium reserves to support vegetation growth.

Sodium (Na^+) concentrations recorded in the soil samples range from approximately 0.06 to 0.13 cmol(+)/kg, representing the lowest among the measured exchangeable cations. Low sodium levels are generally desirable in soils because excessive sodium accumulation can lead to soil dispersion, poor drainage, and reduced soil permeability. The relatively low sodium concentrations observed therefore indicate good soil quality with no evidence of sodicity or salinity-related degradation. Overall, the distribution of exchangeable cations follows the typical order Ca^{2+} > Mg^{2+} > K^+ > Na^+, which is characteristic of well-balanced and naturally fertile soils. This pattern reflects a stable soil chemical environment where beneficial base cations dominate over potentially harmful sodium ions. The moderate concentrations of calcium and magnesium contribute positively to soil structure and nutrient availability, while the presence of potassium supports plant physiological functions.

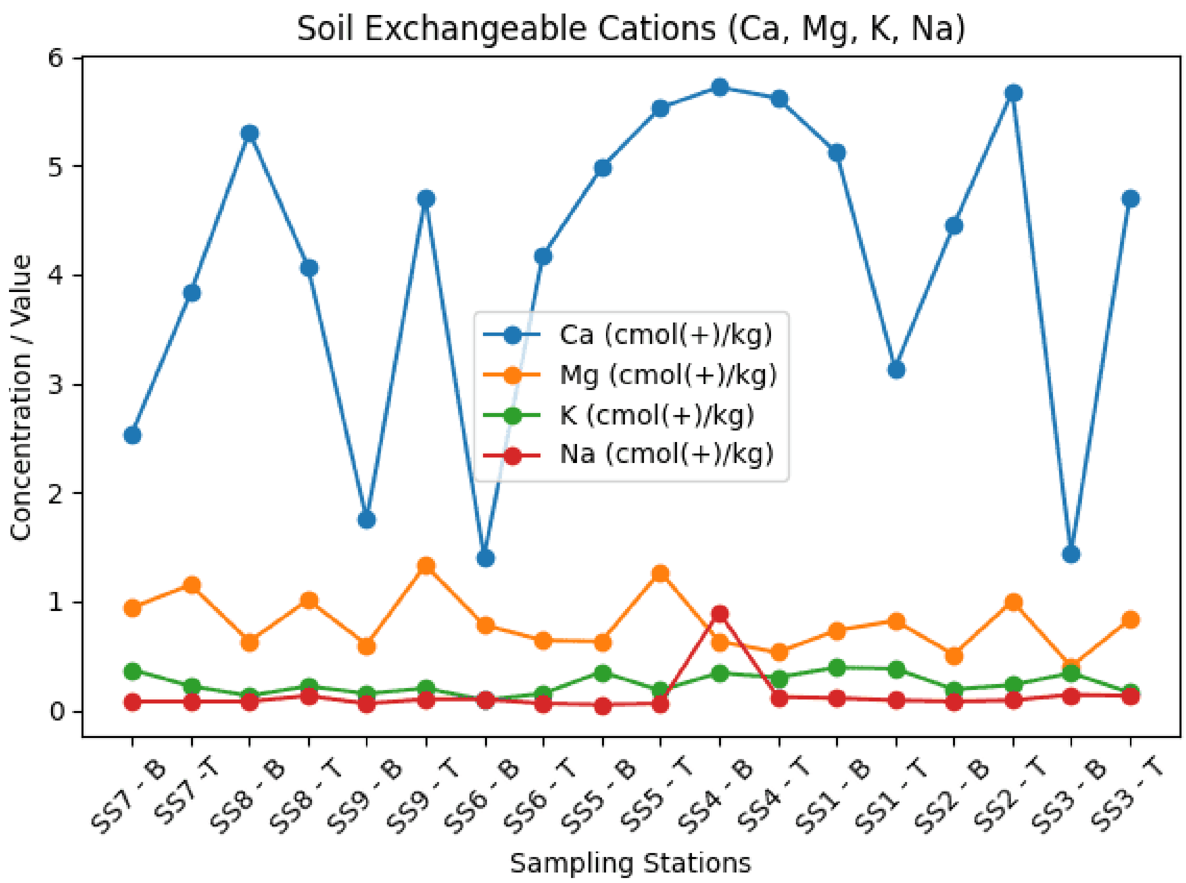


Figure 4.25: Soil cations for the stations

From an environmental assessment perspective, the cation composition suggests that the soils within the study area possess moderate fertility and stable chemical conditions, with no indication of salinity or sodicity problems. The observed cation levels are consistent with natural soil geochemistry and indicate that the soils are suitable for vegetation growth and infrastructure development, provided that appropriate soil management practices are maintained during project implementation.

Soil Physicochemical Properties

The physicochemical analysis provides important information regarding soil texture, chemical fertility, and structural stability (Table 4.12 and Figure 4.26). Soil pH values across the sampling locations ranged from 5.89 to 6.95, indicating slightly acidic to near-neutral soil conditions. This pH range is favorable for plant nutrient availability and microbial activity, suggesting that the soils maintain balanced chemical conditions suitable for vegetation growth.

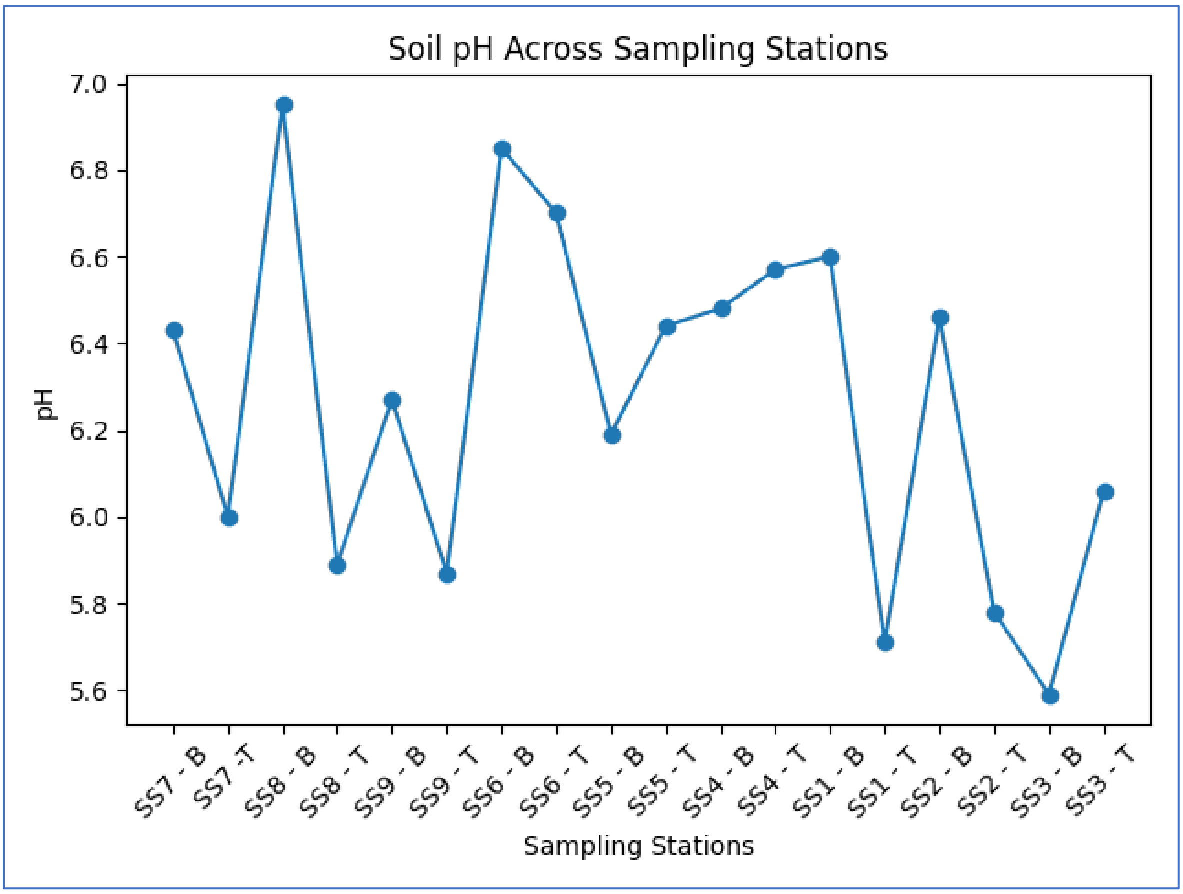


Figure 4.26: Soil pH for the stations

Electrical conductivity values ranged from 547 µS/cm to 1011 µS/cm, indicating low to moderate salinity levels. These values are well below typical salinity thresholds that could negatively affect plant growth, suggesting that the soils are not affected by salinization or chemical pollution. Texture analysis shows that the soils are predominantly sandy, with sand content ranging between 60.42% and 77.14%, while clay content varies between 10.08% and 23.95%, and silt between 7.57% and 25.64%. This indicates that the soils can be classified as sandy loam to sandy clay loam, which generally exhibit good drainage characteristics but relatively low nutrient retention capacity. Organic carbon values ranged between 0.50% and 1.39%, indicating moderate organic matter content. Total nitrogen concentrations ranged from 0.02% to 0.09%, reflecting relatively low nitrogen availability, which is common in tropical soils due to rapid organic matter decomposition and nutrient leaching (Figure 4.27). Available phosphorus values ranged between 3.05 mg/kg and 10.23 mg/kg, suggesting moderate phosphorus availability within the soil profile (Figure 4.27).

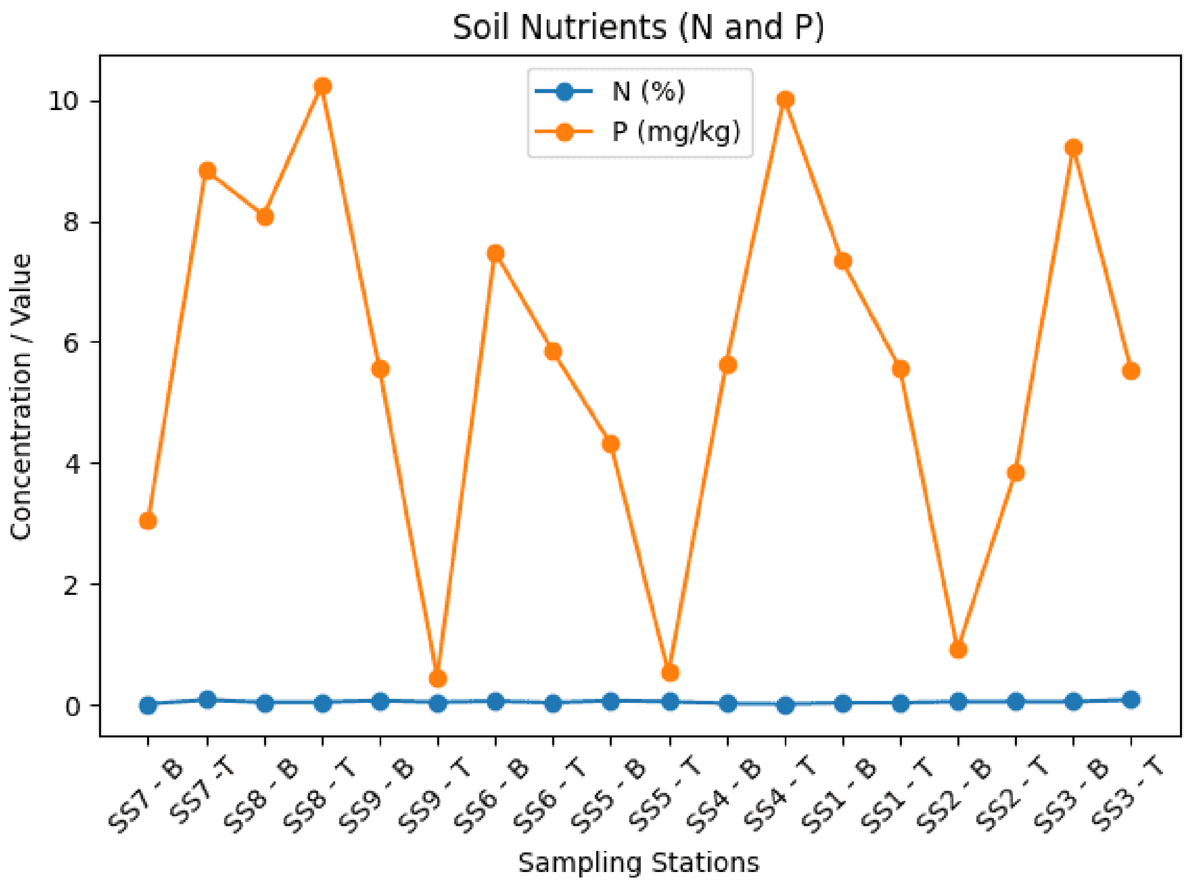


Figure 4.27: Soil cations for the stations

Exchangeable base cations including calcium, magnesium, potassium, and sodium showed moderate concentrations, with calcium ranging from 1.75 to 5.31 cmol(+)/kg, magnesium from

0.60 to 1.15 cmol(+)/kg, potassium from 0.13 to 0.37 cmol(+)/kg, and sodium from 0.06 to 0.13 cmol(+)/kg. The effective cation exchange capacity (ECEC) ranged between 2.56 and 6.16 cmol(+)/kg, indicating moderate nutrient retention capacity.

Trace Elements and Heavy Metals

The trace element composition of the soil samples was evaluated using the concentrations of zinc (Zn), copper (Cu), manganese (Mn), and iron (Fe) recorded in the physicochemical analysis (Figure 4.28). These elements are important micronutrients in soils and also serve as indicators of potential heavy-metal contamination when present at elevated concentrations. The results indicate that iron (Fe) is the most abundant trace element, with concentrations ranging approximately from 113.00 mg/kg to 321.73 mg/kg across the sampling stations. Such concentrations are typical of tropical soils formed from highly weathered parent materials, particularly ferruginous or lateritic soils common in many parts of West Africa. The elevated iron is therefore attributed primarily to natural geochemical processes such as mineral weathering and oxidation of iron-bearing minerals, rather than anthropogenic contamination. Iron plays an important role in soil formation and nutrient cycling and, at the observed levels, does not pose any environmental concern.

Manganese (Mn) concentrations vary between approximately 15.93 mg/kg and 55.15 mg/kg. Manganese is another essential micronutrient involved in plant metabolic processes, including photosynthesis and enzyme activation. The values recorded fall within the typical background range for natural soils and indicate moderate manganese availability. The spatial variation observed among sampling locations likely reflects differences in soil mineralogy, organic matter content, and local weathering intensity rather than pollution sources. Zinc (Zn) ranges from approximately 5.91 mg/kg to 18.36 mg/kg. Zinc is an essential trace nutrient required for plant growth and microbial activity, and the measured levels suggest adequate micronutrient availability within the soil system. These concentrations remain well below internationally recognized soil contamination thresholds, indicating that zinc enrichment from anthropogenic activities such as industrial discharge or waste disposal is not evident in the study area.

Similarly, copper (Cu) concentrations range from approximately 1.85 mg/kg to 4.13 mg/kg, which are considered relatively low and consistent with natural background levels in most tropical soils. Copper is required in small quantities for plant physiological processes, and the measured values indicate sufficient but not excessive copper presence within the soil profile. Overall, the distribution of trace elements across the sampling stations shows moderate variability but remains within acceptable natural background ranges for uncontaminated soils. No unusually elevated concentrations of zinc, copper, manganese, or iron were detected that would suggest contamination from industrial, agricultural, or petroleum-related activities. The trace element profile therefore reflects natural geochemical characteristics of the soil rather than anthropogenic pollution.

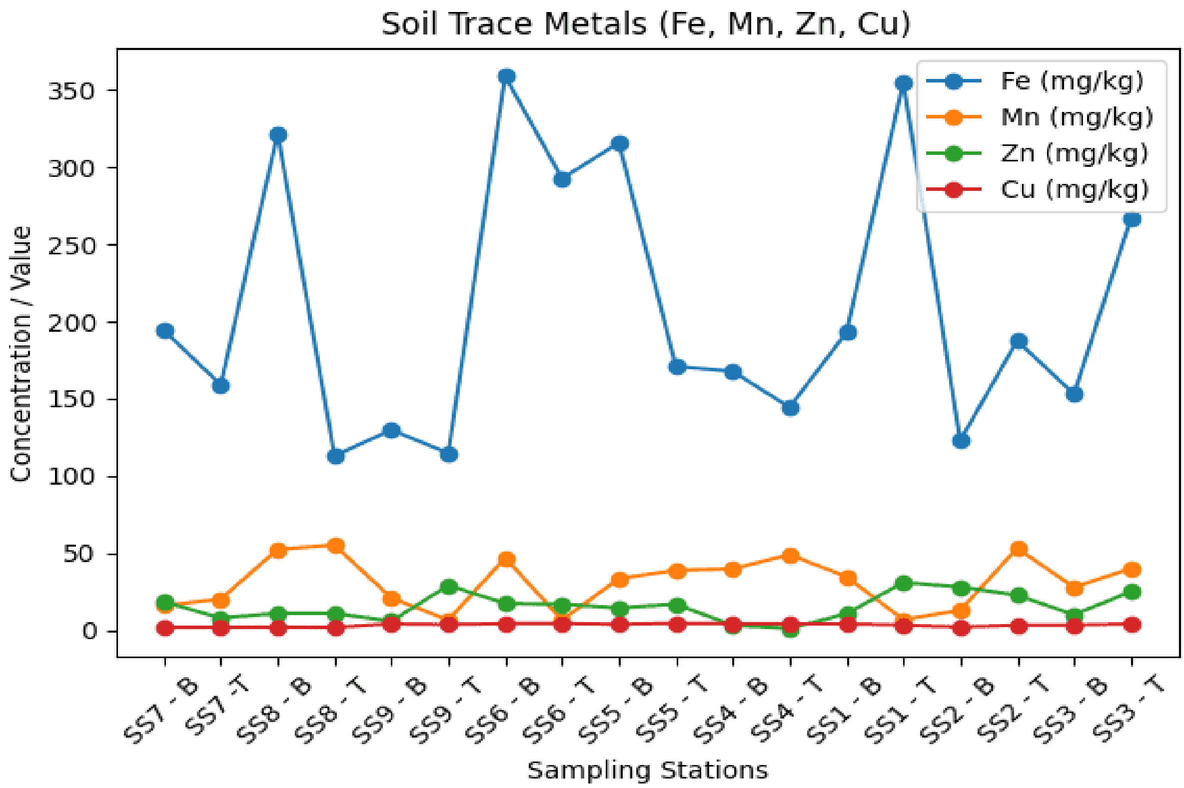


Figure 4.28: Soil trace and heavy metals for the stations

From an environmental assessment perspective, the trace element concentrations indicate that the soils within the study area are chemically stable and environmentally suitable for infrastructure development, with no evidence of heavy-metal contamination that could pose ecological or human health risks. The presence of these elements at moderate levels may also contribute positively to soil fertility and microbial activity, supporting natural ecosystem processes.

Table 4.12a: Soil physiochemical assessment for all stations

Sample ID	pH (1:1)	Conductivity (µs/cm)	Colour (TCU)	Sand (%)	Clay (%)	Silt (%)	O.C (%)	N (%)	P (mg/kg)	Ca (cmol(+)/kg)
SS7 - B	6.43	996	Brownish	60.42	16.95	22.63	1.02	0.02	3.05	2.54
SS7 -T	6.00	547	Brownish	66.57	15.42	18.00	1.39	0.09	8.84	3.83
SS8 - B	6.95	693	Brownish	77.14	15.29	7.57	0.50	0.05	8.09	5.31
SS8 - T	5.89	1011	Brownish	63.93	23.95	12.12	1.28	0.05	10.23	4.07
SS9 - B	6.27	757	Brownish	64.29	10.08	25.64	1.35	0.08	5.57	1.75
SS9 - T	5.87	605	Brownish	48.55	9.95	41.50	0.42	0.05	0.47	4.70
SS6 - B	6.85	883	Brownish	58.95	24.33	16.72	0.86	0.07	7.49	1.41
SS6 - T	6.70	471	Brownish	66.11	12.25	21.65	1.33	0.04	5.85	4.17
SS5 - B	6.19	589	Brownish	67.43	21.05	11.52	0.55	0.08	4.32	4.98
SS5 - T	6.44	603	Brownish	53.15	30.18	16.68	0.36	0.06	0.54	5.53
SS4 - B	6.48	1004	Brownish	69.32	19.43	11.56	0.93	0.03	5.65	5.72
SS4 - T	6.57	985	Brownish	71.31	18.97	9.72	1.19	0.02	10.03	5.62
SS1 - B	6.60	762	Brownish	68.81	16.21	14.99	0.71	0.04	7.35	5.12
SS1 - T	5.71	664	Brownish	56.32	18.33	25.35	1.42	0.04	5.57	3.14
SS2 - B	6.46	892	Brownish	60.71	26.57	12.72	1.36	0.06	0.92	4.45
SS2 - T	5.78	763	Brownish	55.13	19.48	25.39	0.59	0.06	3.85	5.68
SS3 - B	5.59	1012	Brownish	58.30	21.79	19.91	0.44	0.06	9.22	1.44
SS3 - T	6.06	970	Brownish	59.82	9.28	30.90	0.42	0.09	5.55	4.71

Table 4.12b: Soil physiochemical assessment for all stations

Sample ID	Mg (cmol(+)/kg)	K (cmol(+)/kg)	Na (cmol(+)/kg)	ECEC (cmol(+)/kg)	EA (cmol(+)/kg)	Zn (mg/kg)	Cu (mg/kg)	Mn (mg/kg)	Fe (mg/kg)
SS7 - B	0.94	0.37	0.08	3.93	0.46	18.36	1.85	15.93	194.26
SS7 -T	1.15	0.22	0.08	5.27	0.50	7.93	1.93	20.20	158.97
SS8 - B	0.63	0.13	0.08	6.16	0.61	10.95	1.98	52.39	321.73
SS8 - T	1.01	0.22	0.13	5.44	0.34	10.89	1.86	55.15	113.00
SS9 - B	0.60	0.15	0.06	2.56	0.39	5.91	4.13	20.86	129.75
SS9 - T	1.33	0.20	0.10	6.33	0.15	28.99	3.69	6.56	114.73
SS6 - B	0.78	0.09	0.10	2.38	0.85	17.38	4.30	46.93	358.79
SS6 - T	0.64	0.15	0.06	5.02	0.12	16.85	4.38	6.59	292.56
SS5 - B	0.63	0.35	0.05	6.02	0.46	14.51	3.88	33.52	315.77
SS5 - T	1.27	0.18	0.06	7.04	0.84	16.87	4.55	38.76	170.92
SS4 - B	0.63	0.34	0.90	6.87	0.10	3.25	4.26	39.74	167.74
SS4 - T	0.53	0.30	0.12	6.57	0.08	1.19	4.17	48.94	144.36
SS1 - B	0.73	0.39	0.11	6.35	1.45	10.67	4.17	34.64	192.93
SS1 - T	0.82	0.38	0.09	4.43	0.02	30.94	3.31	6.91	355.11
SS2 - B	0.51	0.19	0.08	5.23	1.45	27.99	2.03	12.93	122.84
SS2 - T	1.00	0.23	0.09	7.00	0.62	22.68	3.31	53.08	187.55
SS3 - B	0.40	0.34	0.14	2.32	1.64	10.10	3.29	27.90	152.99
SS3 - T	0.83	0.16	0.13	5.83	0.82	24.97	4.16	39.93	266.66
Limits	NS*	NS*	NS*	NS*	NS*	300	100	NS*	NS*

Organic and Microbiological Properties

The organic and microbiological analysis provides insights into soil biological activity and potential contamination from petroleum hydrocarbons or microbial pollutants (Table 4.13). The results show that oil and grease concentrations were below detection limits (BDL) across all sampling locations. This indicates that the soils are not contaminated by petroleum hydrocarbons or lubricating oils, suggesting minimal industrial or mechanical pollution within the study area.

Table 4.13: Organic and Microbiological Properties for all stations

Sample ID	Oil & Grease	THB (CFU/G)	THF (CFU/G)	Total Coliform
SS7 - B	BDL	1.04X106	6.2X105	Nil
SS7 -T	BDL	7.35X105	4.7X105	Nil
SS8 - B	BDL	5.55X105	1.35X105	Nil
SS8 - T	BDL	6.7X105	5.15X105	Nil
SS9 - B	BDL	3.71X106	1.295X106	Nil
SS9 - T	BDL	2.6X106	1.75X106	Nil
SS6 - B	BDL	3.0X105	2.9X105	Nil
SS6 - T	BDL	8.7X105	4.2X105	Nil
SS5 - B	BDL	1.1X106	5.15X105	Nil
SS5 - T	BDL	2.3X105	4X104	Nil
SS4 - B	BDL	3.67X106	1.25X106	Nil
SS4 - T	BDL	1.6X106	3.8X105	Nil
SS1 - B	BDL	9X105	7.15X105	Nil
SS1 - T	BDL	3.9X105	3.25X105	Nil
SS2 - B	BDL	2.85X105	1.05X105	Nil
SS2 - T	BDL	1.8X105	3X104	Nil
SS3 - B	BDL	3.35X105	1.35X105	Nil
SS3 - T	BDL	1.04X106	7X104	Nil

Microbiological analysis revealed the presence of Total Heterotrophic Bacteria (THB) ranging approximately between 5.55×10^5 and 3.71×10^6 CFU/g, and Total Heterotrophic Fungi (THF) ranging between 1.35×10^5 and 1.295×10^6 CFU/g. These microbial populations are typical of healthy soils and reflect active microbial communities involved in organic matter decomposition and nutrient cycling.

The presence of these microorganisms indicates that the soil ecosystem remains biologically active and environmentally stable. Importantly, total coliform bacteria were absent (Nil) in all samples, indicating that the soils are not contaminated by fecal matter or pathogenic microorganisms. The microbiological profile therefore suggests that the soils maintain good ecological health with active microbial processes supporting soil fertility and natural biogeochemical cycling.

4.2.6.2 Ground (Subsurface) Interpretation

The subsurface conditions beneath the proposed 2 MW Solar-Hybrid Power Plant and Associated Infrastructure at the Federal University of Education (FUE), Zaria, Kaduna State were evaluated using Electrical Resistivity Tomography (ERT) along a 108 m traverse with a unit electrode spacing of 1.5 m. The interpreted resistivity section (Figure 4.29) provides a generalized representation of the subsurface stratification to a depth of approximately 6 m.

The inversion model produced an absolute error of about 3.9%, indicating a satisfactory correlation between the measured field data and the computed resistivity model. The resistivity values within the profile range approximately from below 100 Ωm to over 1000 Ωm, reflecting variations in soil composition, moisture content, and degree of weathering. The subsurface profile generally exhibits a layered but laterally consistent structure, which is typical of the savannah-derived soils within the northern Guinea Savannah belt of Kaduna State.

The uppermost layer, extending from the ground surface to an average depth of about 1.0–2.0 m, is characterized by moderate to high resistivity values (approximately 789–1076 Ωm) represented by orange, red, and purple zones in the resistivity section. This layer corresponds to dry sandy to sandy-loam soils with lateritic influence, which commonly develop under alternating wet and dry climatic conditions typical of the Zaria area. The relatively high resistivity values indicate low moisture content, good drainage characteristics, and limited clay enrichment within the near-surface materials.

Field observations and geophysical response suggest that this layer is composed predominantly of:

- Well-drained sandy to sandy-loam soils
- Ferruginous or lateritic soil materials common in savannah terrains
- Low to moderate organic matter content
- Low natural moisture due to high evapotranspiration rates

This horizon represents the primary engineering layer where most construction activities such as solar panel mounting structures, cable trenching, and shallow foundation installations will occur. Beneath the surface layer, between approximately 2 m and 4 m depth, the resistivity values decrease to about 326–789 Ωm, represented by green to yellow zones on the geoelectric section. This intermediate layer is interpreted as a moderately weathered sandy-clay or silty sand horizon.

The reduced resistivity relative to the upper layer indicates slightly higher moisture retention and increased clay content within the soil matrix.

Geologically, this horizon represents a transition zone between the dry lateritic surface soils and deeper weathered materials. The resistivity distribution across this layer is relatively uniform and laterally continuous, suggesting consistent subsurface conditions across the project site. No abrupt resistivity contrasts or localized anomalies were observed, indicating homogeneous geotechnical properties within this depth range.

At greater depths, approximately 4 m to 6 m, the resistivity values further decrease to 134–326 Ωm, represented by cyan to blue zones in the lower portion of the section. This deeper horizon is interpreted to consist of moist clayey or highly weathered fine-grained materials. The lower resistivity values reflect increased moisture content and finer soil particles, which are characteristic of deeper weathered formations within tropical savannah environments.

Importantly, the conductive zone observed in the deeper section is broad and gradational rather than sharply defined, indicating a natural weathered formation rather than localized groundwater accumulation or subsurface structural disturbance. The ERT profile does not reveal vertical conductive plumes, cavities, fractures, or fault structures, and no shallow bedrock outcrops were detected within the depth of investigation. Overall, the geoelectric section reveals a stable and laterally consistent subsurface profile, with gradual transitions between soil horizons and no evidence of geophysical anomalies that would pose significant engineering constraints to the proposed development.

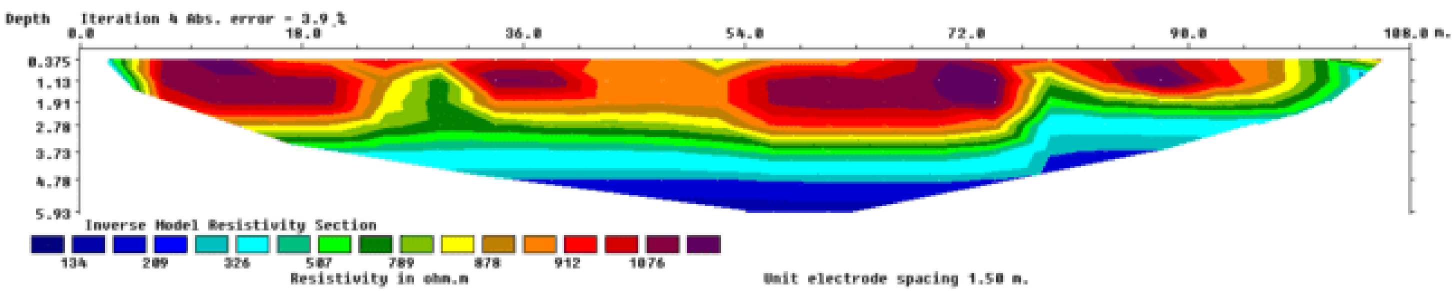


Figure 4.29: Ground (Subsurface) Image of the Site

Groundwater Implications for the Proposed Project

The hydrogeological setting of Zaria, Kaduna State, falls within the northern Guinea savannah climatic zone, where groundwater occurrence is influenced by seasonal rainfall patterns, weathered soil formations, and underlying geological structures. Recharge of groundwater typically occurs during the rainy season through infiltration of precipitation into permeable surface soils and weathered subsurface materials.

Interpretation of the ERT section to a depth of approximately 6 m indicates no evidence of shallow groundwater occurrence within the investigated depth range. The resistivity distribution does not display any laterally continuous low-resistivity layer near the surface that would normally indicate a perched water table. In addition, there are no vertical conductive anomalies that would suggest fracture-controlled groundwater flow or localized seepage pathways.

The lower resistivity values observed within the deeper portion of the profile (approximately 4–6 m depth) are interpreted as naturally moist weathered clayey materials, rather than a saturated aquifer horizon. The gradual transition in resistivity values suggests increased moisture retention within deeper soil layers, which is typical of weathered tropical soil profiles.

In many parts of Zaria and surrounding areas of Kaduna State, productive groundwater is commonly encountered at significantly greater depths, typically:

- Within weathered or fractured basement formations between approximately 20 m and 60 m depth, or
- Within deeper sedimentary aquifer systems, depending on the local geological setting.

The resistivity profile therefore supports the interpretation of a relatively deep groundwater table beneath the project site.

This hydrogeological condition has several important engineering implications for the proposed project:

- Low likelihood of capillary rise affecting near-surface soil stability
- Minimal risk of foundation weakening due to groundwater saturation
- No anticipated groundwater interference during shallow excavation or trenching activities
- Reduced risk of hydrostatic pressure beneath foundation structures

Consequently, groundwater conditions at the project site are not expected to adversely affect foundation performance or structural stability of the proposed solar-hybrid power infrastructure. The absence of shallow groundwater also reduces the need for groundwater dewatering measures during construction, thereby simplifying engineering design and construction operations.

Ground Environmental and Engineering Condition of the Project Site

The Electrical Resistivity Tomography (ERT) results indicate that the subsurface conditions at the proposed FUE Zaria Solar-Hybrid Power Plant site are environmentally stable and consistent with naturally occurring savannah soil formations. The resistivity values across the profile do not reveal any anomalous ultra-low resistivity zones that would normally indicate contamination from industrial effluents, leachates, or saline intrusion. Furthermore, there is no geophysical signature suggestive of hydrocarbon contamination, such as localized conductive plumes or irregular pockets of very low resistivity associated with subsurface leakage. The resistivity distribution is generally continuous and gradational, which strongly indicates that the subsurface conditions reflect natural pedogenic and weathering processes rather than anthropogenic disturbances.

The subsurface stratification identified during the investigation consists of a lateritic sandy-loam surface layer, underlain by moderately weathered sandy-clay materials, and deeper moist clayey horizons. These soil profiles are typical of the northern Guinea savannah soils of Kaduna State, which develop under alternating wet and dry climatic conditions.

The subsurface conditions therefore demonstrate:

- Uniform and laterally consistent soil stratification
- Absence of subsurface voids or cavities
- No evidence of fractures, faults, or structural discontinuities
- Stable geotechnical characteristics suitable for infrastructure development

From an engineering perspective, the soil profile is considered competent for the proposed solar-hybrid power infrastructure. The soil conditions can adequately support:

- Shallow reinforced concrete foundations for inverter and control structures
- Driven or pile-mounted foundations for solar panel arrays
- Cable trenching and underground electrical conduits
- Ancillary facilities such as battery storage units and service buildings

Overall, the subsurface conditions confirm the environmental integrity and geotechnical suitability of the project site for the proposed solar-hybrid power development.

Table 4.14: Summary of Interpreted Subsurface Geoelectric Layers

Layer	Depth Range (m)	Resistivity Range (Ωm)	Interpreted Material	Engineering Significance
Layer 1	0 – 2	789 – 1076	Dry sandy to sandy-loam lateritic soil	Suitable for shallow foundations, cable trenching, and mounting structures
Layer 2	2 – 4	326 – 789	Moderately weathered sandy-clay / silty sand	Transition layer with moderate moisture retention
Layer 3	4 – 6	134 – 326	Moist clayey or highly weathered fine-grained materials	Stable deeper weathered horizon with increased moisture

4.2.7 Surface and Groundwater Quality Assessment

A total of five water samples, comprising three groundwater samples collected from existing boreholes within the Project area and two surface water samples collected from the seasonal surface water body associated with the River Kubani tributary serving the irrigational farming area behind the University (Plate 4.3 and Figure 4.30). The surface water sampling locations are situated outside the Project Area of Influence (AoI); however, the samples were collected to provide baseline information on the water quality and condition of nearby surface water resources, although these resources are not influenced by Project activities.

Groundwater samples were collected into 2-litre polyethylene containers for physicochemical analyses, while oil and grease samples were collected in 1-litre glass bottles and preserved with concentrated sulphuric acid. Samples for heavy metals were preserved with concentrated nitric acid, whereas microbiological samples were collected in pre-sterilized McCartney bottles. In-situ measurements of pH, Electrical Conductivity, Total Dissolved Solids (TDS), Temperature and Dissolved Oxygen (DO) were undertaken at each sampling location using an Extech DO700 meter. Groundwater and surface water results are presented and interpreted separately using their respective applicable assessment criteria.

Plate 4.3: Surface and Groundwater sampling activities at the project site

Table 4.15: Regulatory Standard for Physico-chemical and microbial characteristics of groundwater samples from the Project area

Parameter / Unit	WHO Drinking Water Guideline (2022)	NSDWQ (Nigeria, 2015)
pH	6.5–8.5	6.5–8.5
Temperature (°C)	NS	Ambient
Electrical Conductivity (µS/cm)	1,000	1,000
Total Dissolved Solids (mg/L)	500	500
Turbidity (NTU)	5	5
Total Hardness (mg/L)	500	150
Chloride (mg/L)	250	250
Nitrate (mg/L)	50	50
Sulphate (mg/L)	500	100
Total Coliform	0/100 mL	0/100 mL
E. coli	0/100 mL	0/100 mL

Table 4.16: Regulatory Standard for Physico-chemical and microbial characteristics of surface water samples from the Project area

Parameter / Unit	FMEnv / NESREA Surface Water Standard
pH	6.5–8.5
Temperature (°C)	<40
Dissolved Oxygen (mg/L)	≥5.0
BOD_5 (mg/L)	≤4.0
Total Suspended Solids (mg/L)	30
Turbidity (NTU)	5
Electrical Conductivity (µS/cm)	—
Total Dissolved Solids (mg/L)	500
Chloride (mg/L)	250
Nitrate (mg/L)	20
Sulphate (mg/L)	500
Phosphate (mg/L)	5
Oil & Grease (mg/L)	10
Total Coliform	As applicable for designated use

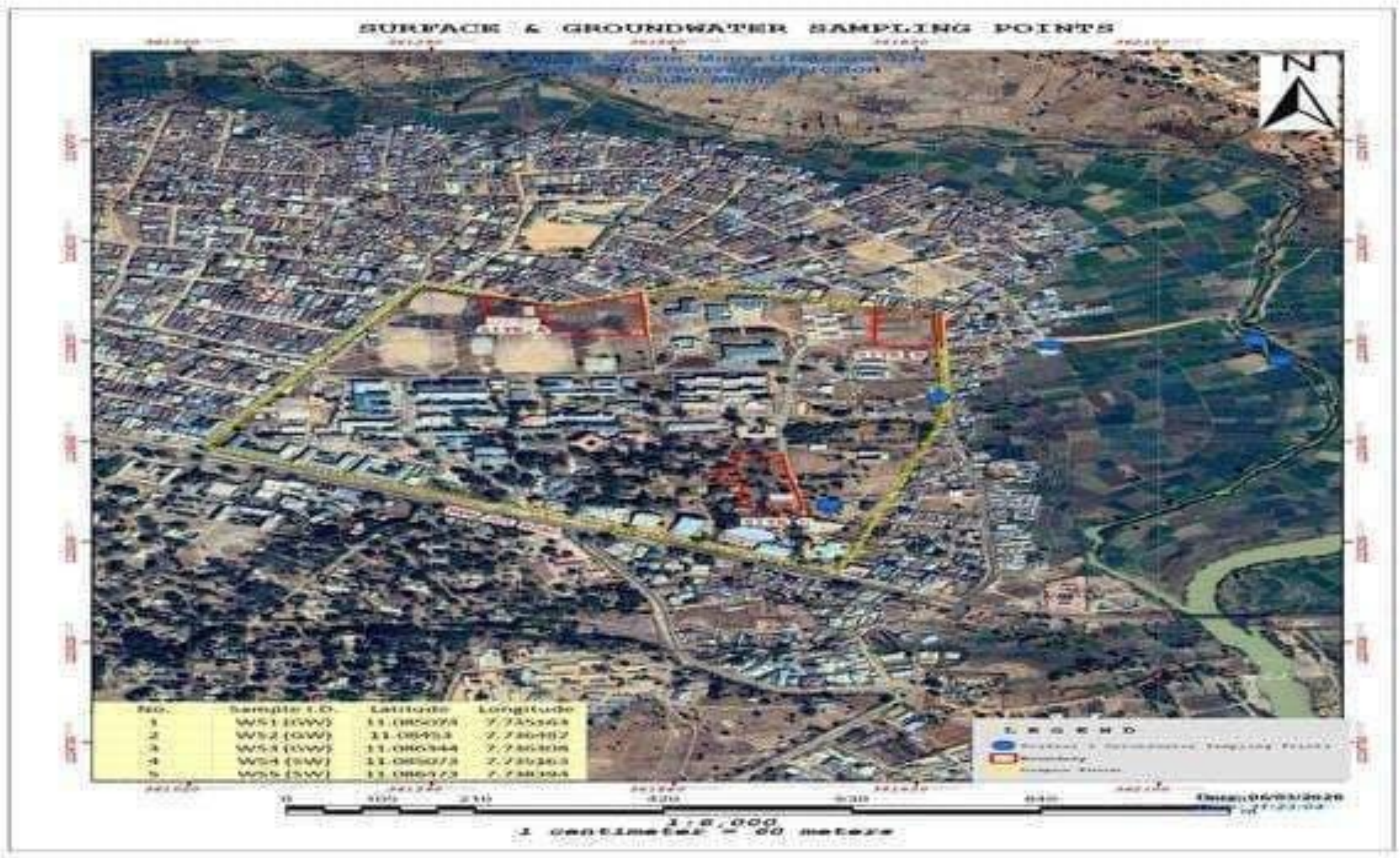


Figure 4.30: Surface and Groundwater sampling across the proposed project sites

Cations and Anions

The ionic composition of the groundwater and surface water samples was evaluated using major anions including phosphate (PO_4^{3-}), sulphate (SO_4^{2-}), carbonate (CO_3^{2-}), chloride (Cl^-), and nitrate (NO_3^-) (Table 4.17). These ions are important indicators of water chemistry, mineral dissolution processes, and potential anthropogenic influences.

Table 4.17: Cations and Anions for water samples

Sample ID	PO4 (mg/l)	SO4 (mg/l)	CO3 (mg/l)	Cl (mg/l)	NO3 (mg/l)
WS1 (GW)	0.893176	12.33244	30	257.375	8.406
WS2 (GW)	0.74006	21.71582	18	284	5.604
WS3 (GW)	0.75282	21.58177	48	434.875	8.406
WS4 (SW)	1.212168	8.44504	66	124.25	11.208
WS5 (SW)	0.880416	7.640751	66	284	47.634

Phosphate concentrations in the water samples ranged approximately between 0.74 mg/L and 1.21 mg/L. The slightly higher value recorded in the surface water sample (WS4) suggests the possible influence of organic matter decomposition or surface runoff carrying nutrients from surrounding land surfaces. However, the concentrations remain relatively low and are not indicative of significant nutrient pollution.

Sulphate concentrations varied from about 7.64 mg/L to 21.72 mg/L across the sampling locations. These values are considerably lower than the WHO drinking water guideline value of 250 mg/L, indicating that sulphate levels in both groundwater and surface water are within safe limits. The observed sulphate likely originates from natural dissolution of sulphate-bearing minerals within the aquifer or soil layers.

Carbonate concentrations ranged between 18 mg/L and 66 mg/L, reflecting moderate alkalinity within the water samples. The relatively higher carbonate levels observed in surface water samples indicate the influence of atmospheric carbon dioxide dissolution and interactions with carbonate minerals in the surrounding soils.

Chloride concentrations ranged from approximately 124.25 mg/L to 434.88 mg/L. The highest concentration was observed in one groundwater sample (WS3). Elevated chloride levels may result from natural mineral dissolution, evaporative concentration, or localized anthropogenic inputs such as domestic wastewater or agricultural runoff. Although the highest value approaches the WHO guideline limit of 250 mg/L, most of the samples remain within acceptable ranges.

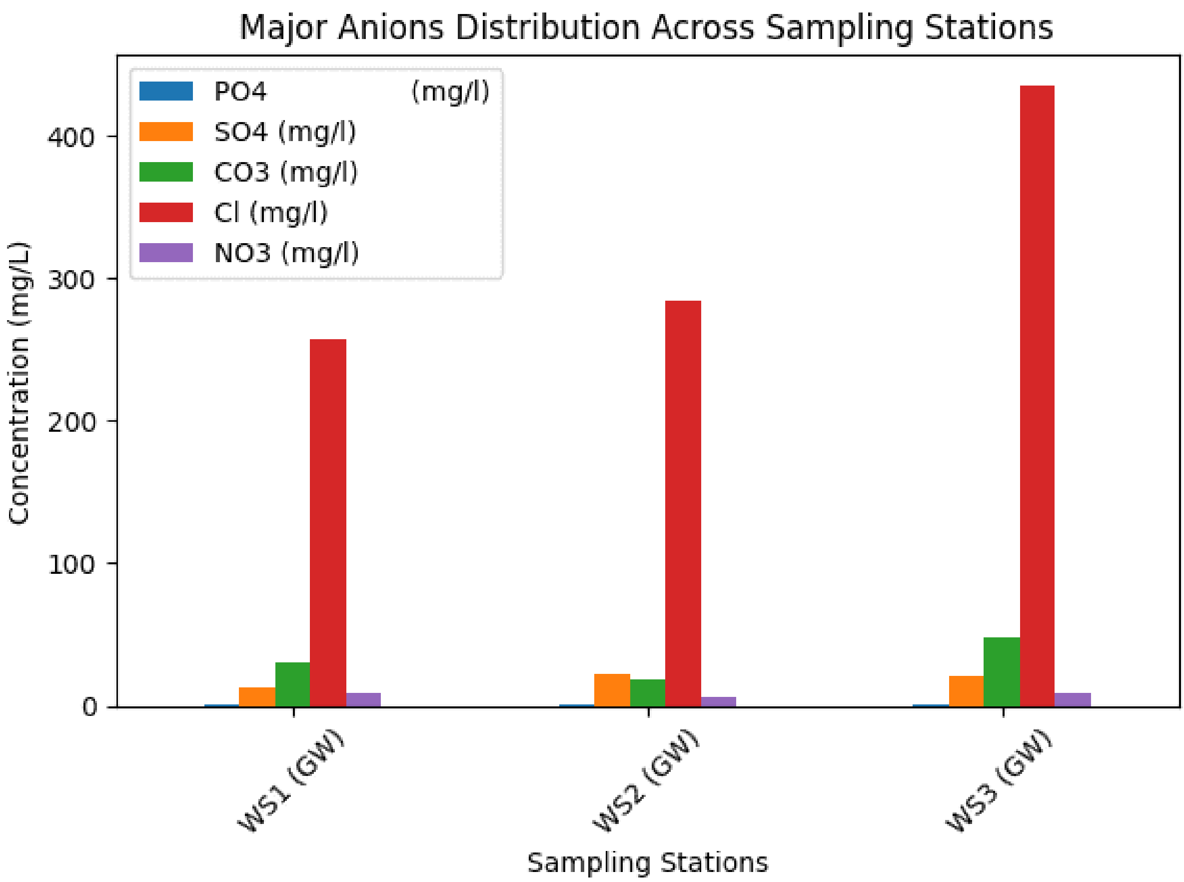


Figure 4.31: Cations and Anions of water sample

Nitrate concentrations ranged between 5.60 mg/L and 47.63 mg/L. The highest value was recorded in surface water (WS5), which may indicate surface contamination from organic matter, fertilizers, or runoff from nearby land uses. Although most samples remain below the WHO maximum permissible limit of 50 mg/L, the elevated nitrate level in the surface water sample suggests possible nutrient enrichment from surface activities. Overall, the ionic composition indicates that natural geochemical processes and limited surface inputs control the water chemistry, with no strong evidence of severe chemical contamination.

Physicochemical Properties

The physicochemical characteristics of the groundwater and surface water samples provide insight into the overall quality, suitability for domestic use, and environmental condition of the water bodies (Table 4.18).

Table 4.18: Physiochemical Properties for water samples

Sample ID	pH	Temp. °C	ORP (MV)	Conductivity (µs/cm)	Appearance	TDS (mg/l)	Salinity (%)	DO (mg/dm3)	BOD (mg/dm3)
WS1 (GW)	7.2	30.2	282	393	Clear	196	0.01	6	5.3
WS2 (GW)	5.28	28.5	290	416	Clear	208	0.02	5.6	0.4
WS3 (GW)	6.75	28.1	265	152	Clear	76	0	6	1
WS4 (SW)	7.18	26.6	255	154	Turbid	77	0	5.6	2.4
WS5 (SW)	4.73	27.8	237	580	Turbid	288	0.02	9	2.3

The pH values range between 5.28 and 7.20, indicating slightly acidic to neutral water conditions. Most samples fall within the WHO recommended drinking water pH range of 6.5–8.5, although the slightly acidic groundwater sample (WS2) may reflect the influence of dissolved carbon dioxide or organic acids in the subsurface environment.

Water temperature ranged between 26.6°C and 30.2°C, which is typical for tropical environmental conditions. Temperature influences chemical reactions and biological activity in water but does not indicate pollution when within natural environmental ranges

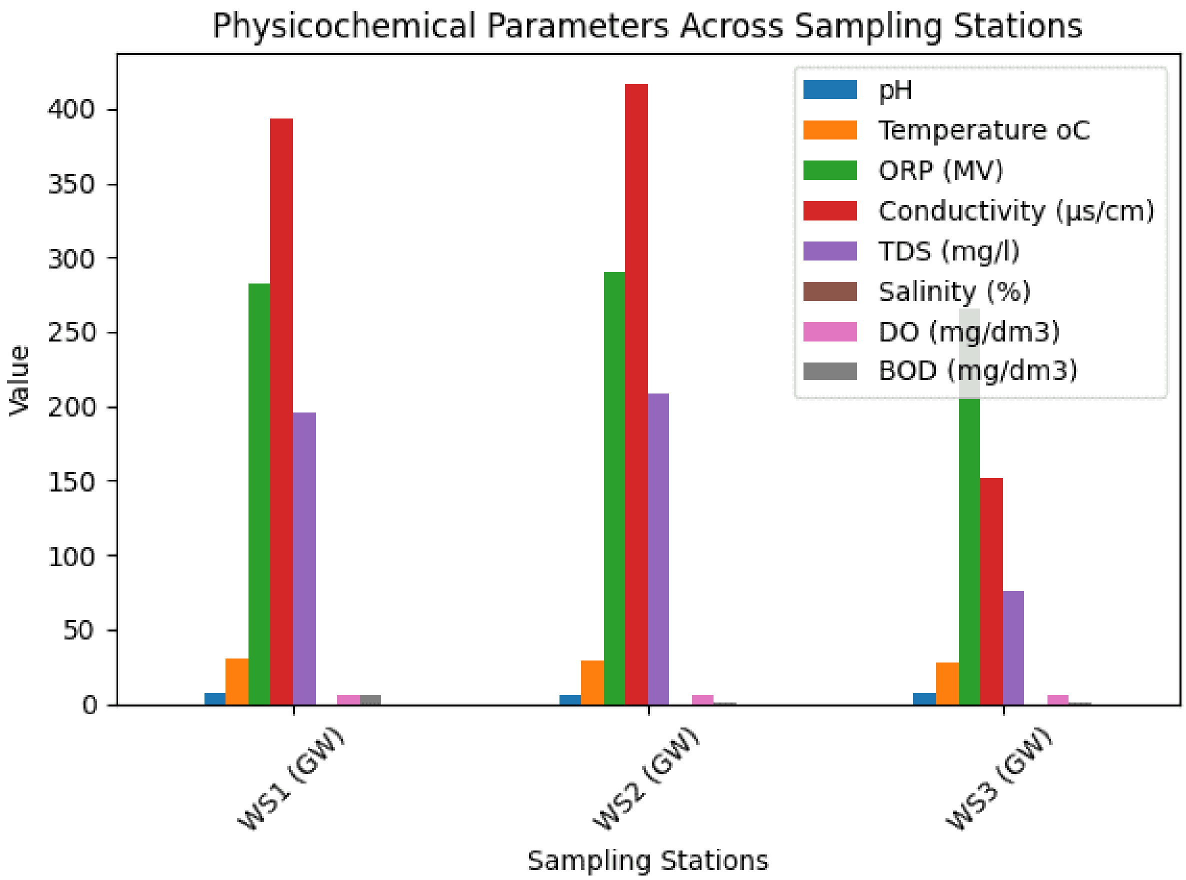


Figure 4.32: Physiochemical parameters for water samples

Electrical conductivity values ranged from 152 µS/cm to 416 µS/cm, indicating moderate mineralization of dissolved salts. These values are well below the WHO guideline threshold of 1000 µS/cm, suggesting that the waters contain relatively low concentrations of dissolved ions and are suitable for domestic use.

Total Dissolved Solids (TDS) concentrations ranged between 76 mg/L and 208 mg/L, which are significantly below the WHO recommended limit of 500 mg/L. Low TDS values indicate that the water is fresh and not heavily mineralized.

Dissolved Oxygen (DO) values ranged between 5.6 mg/L and 6.0 mg/L, indicating well-oxygenated water conditions (Figure 4.32). Adequate dissolved oxygen levels are important for maintaining aquatic life and preventing anaerobic water conditions.

Biochemical Oxygen Demand (BOD) values ranged between 0.4 mg/L and 5.3 mg/L. Low BOD values in most samples indicate minimal organic pollution, while slightly higher values in some groundwater samples may reflect natural organic matter decomposition.

Overall, the physicochemical parameters suggest that the groundwater and surface water in the study area are generally of good quality with low levels of dissolved pollutants.

Organics and Microbiological Properties

The organic and microbiological analysis was conducted to evaluate the presence of hydrocarbon contaminants and microbial indicators of water quality (Table 4.19).

Table 4.19: Organics and Microbiological Properties for water samples

Sample ID	Oil & Grease	THB (CFU/G)	THF (CFU/G)	Total Coliform
WS1 (GW)	BDL	8.5X104	6.2X104	Nil
WS2 (GW)	BDL	4X105	3.2X106	Nil
WS3 (GW)	BDL	7X104	5.1X104	Nil
WS1 (SW)	BDL	4.48X106	6.21X106	21
WS2 (SW)	BDL	4.45X105	3.72X104	15

The analysis shows that oil and grease concentrations were below detection limits (BDL) in all water samples. This result indicates no detectable petroleum hydrocarbon contamination, suggesting that the water bodies have not been impacted by oil spills, fuel leakage, or industrial discharge.

Microbial analysis shows the presence of Total Heterotrophic Bacteria (THB) ranging from approximately 7.0×10^4 to 4.48×10^6 CFU/mL and Total Heterotrophic Fungi (THF) ranging from about 5.1×10^4 to 6.21×10^6 CFU/mL. These microorganisms are commonly present in natural aquatic environments and play important roles in organic matter decomposition and nutrient cycling.

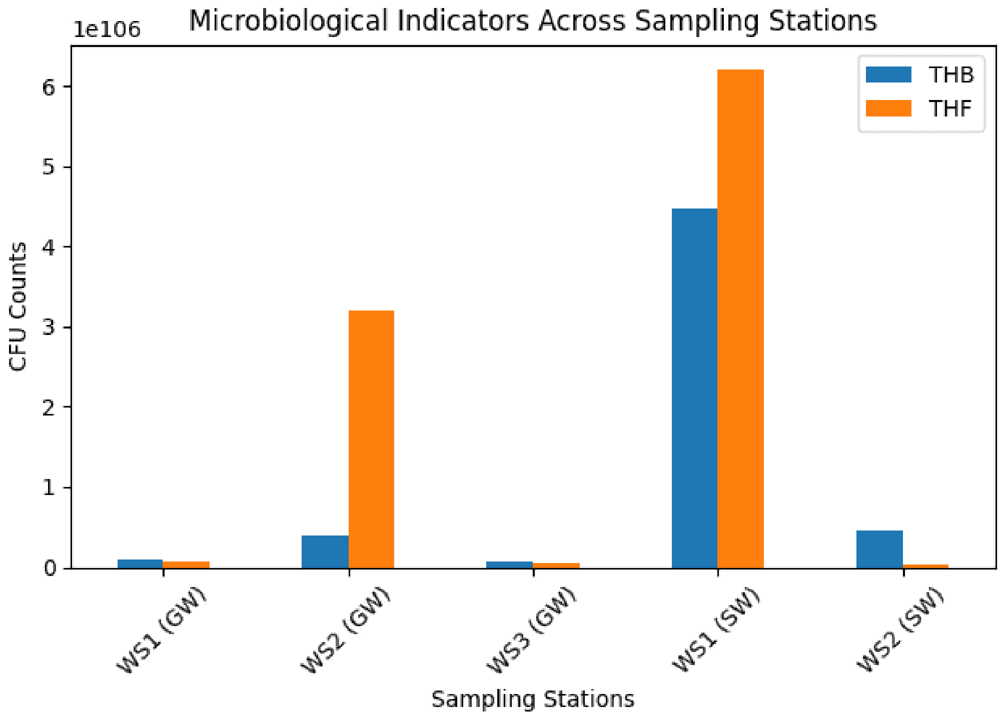


Figure 4.33: Organics and Microbiological Properties for Water Samples

Importantly, total coliform bacteria were absent (Nil) in all groundwater samples, indicating that the groundwater sources are not contaminated by fecal matter and are microbiologically safe for potential domestic use after minimal treatment.

However, surface water samples recorded total coliform counts of approximately 15–21 CFU/100 mL, indicating some level of microbial contamination likely resulting from surface runoff, animal activities, or human interactions with the water body. This suggests that surface water sources may require adequate treatment before being used for drinking purposes.

Environmental Implication

The combined analysis of ionic composition, physicochemical parameters, and microbiological characteristics indicates that the groundwater sources generally exhibit good chemical and microbiological quality, making them potentially suitable for domestic use with minimal treatment. Surface water samples, although chemically acceptable, show slightly elevated nitrate levels and the presence of coliform bacteria, indicating moderate susceptibility to surface contamination. From an environmental assessment perspective:

- Groundwater quality is generally good and relatively protected from contamination.

- Surface water is more vulnerable to environmental influences and microbial contamination.
- No evidence of hydrocarbon pollution or severe chemical contamination was detected in any of the samples.

Overall, the water resources within the study area are considered environmentally stable and suitable for domestic and institutional use, provided that appropriate water management and treatment practices are implemented.

4.2.8 Terrestrial Flora and Fauna

Terrestrial Flora

Flora refers to all plant life forms that are found within a specific region at a particular period of time. Plants provide valuable information about site environmental conditions. By their occurrence and relative abundance, certain plant species serve as environmental indicators, through which inferences can be drawn about the state of the environment in that area. Thus, the physiological state and ecological response of plants provide evidence of changes in the environmental conditions of a project site. The array of information derived from the flora composition and vegetation structure of a site is of importance for understanding the nature of the site, potential human health and ecological risk, and the feasibility of different mitigation approaches.

The field assessment of the Project site and surrounding area was done via on-site field observations. The identification of flora specimen was done both in situ (field) and ex situ using appropriate manuals and monographs. Photographs were taken during survey to record relevant plant species, habitat characteristics and other features.

Figure 4.34: Terrestrial Flora in the area

The results of the vegetation assessment are presented as follows:

- Habitat characterization
- Physiognomy, Floristic composition, and Biodiversity status
- *Habitat characterization*

The vegetation of Kaduna comprises of low land forests which have become secondary rainforests or forest re-growth because of the increase in land use and exposure. The natural vegetation within the Project site was observed to have been modified habitat as a result of human interference; mainly crop farm plots as shown in Figure 4.35 a, b, and c below. The dominant vegetation observed on the site can be classified as secondary vegetation dominated by grasses, shrubs, and a few trees.

- *Physiognomy, Floristic composition, and Biodiversity assessment*

Species composition, distribution and structure of the vegetation of Project site as well as the physiognomic view show few trees and grasses. A few plants and their families were identified and within and around the Project site.

In terms of biodiversity assessment, the IUCN (International Union of Conservation of Nature) Red List of Threatened Species was employed. The IUCN Red List of Threatened Species provides taxonomic, conservation status and distribution information on plants, fungi and animals that have been globally evaluated using the IUCN Red List Categories and Criteria. This system is designed to determine the relative risk of extinction, and the main purpose of the IUCN Red List is to catalogue and highlight those plants and animals that are facing a higher risk of global extinction (i.e. those listed as Critically Endangered, Endangered and Vulnerable).

Figure 4.35a: Natural vegetation and land use within the proposed project sites (Site A)

Figure 4.35b: Natural vegetation and land use within the proposed project sites (Site B)

Figure 4.35c: Natural vegetation and land use within the proposed project sites (Site C)

The IUCN Red List also includes information on plants, fungi and animals that are categorized as Extinct or Extinct in the Wild; on taxa that cannot be evaluated because of insufficient information (i.e., are Data Deficient); and on plants, fungi and animals that are either close to meeting the threatened thresholds or that would be threatened were it not for an ongoing taxon-specific conservation programme (i.e., are Near Threatened).

None of the plant species recorded in the Project area belongs to the endangered status. In addition, there are no known protected species on the Project site under the Nigerian legislation. The IUCN status of the plant species encountered in the Project area is highlighted in Table 4.20.

Table 4.20: Plant inventory and Conservation Status

Dominant Species Encountered	Family Name	Common Name (Local name)	Plant Forms	IUCN Status
Azadirachta indica	Meliaceae	Neem tree	Tree	NA
Ageratum conyzoides	Asteraceae	Goat Weed	Herb	NA
Arachis hypogaea	Fabaceae	Groundnut	Herb	NA
Zea Mays	Poaceae	Maize	Shrub	NA
Manihot esculenta	Euphorbiaceae	Cassava	Shrub	NA
Psidium guajava	Mayrtaceae	Guava	Shrub	NA
Colocasia esclulenta	Araceae	Cocoyam	Shrub	NA
Ipomoea batatas	Convolvulaceae	Potato	Climber	NA
Mangifera indica	Anacardaceae	Mango	Tree	NA
Nauclea latifolia	Rubiaceae	African Peach	Tree	NA
Dioscorea rotundata	Dioscoreaceae	White yam	Climber	NA
Panicum maximum	Poaceae	Guinea Grass	Grass	NA
Tridax procumbens	Compositae	Tridax	Herb	NA
	Fabaceae	African locust bean	Tree	NA
Pennisetum spp.	Poaceae	Elephant grass	Grass	NA
Paspalum spp	Poaceae	Crown grass	Grass	NA
Cajanus cajan	Fabaceae	Pigeon pea	Shrub	NA
Solanum lycopersicum	Solanaceae	Tomato	Shrub	NA
Cucumis sativus	Cucurbitaceae	Cucumber	Vine	NA
Ipomoea involucrata	Convolvulaceae	Morning glory	Vine	NA
Synedrella nodiflora	Asteraceae	Node weed	Shrub	NA
Sida acuta	Malvaceae	Broom weed	Shrub	NA
Luffa cylindrical	Cucurbitaceae	Sponge gourd	Vine	NA
Dactyloctenium Aegyptium	Poaceae	Cow foot grass	Grass	NA
Oryza Sativa	Poaceae	Rice	Herb	NA

NE= Not Evaluated

IUCN – International Union for Conservation of Nature

Fauna Species

The methodology used in identifying the terrestrial fauna species in the study area includes direct sighting, sound, nest type, and foot prints. The fauna characteristics of the Project site and the Project area of influence are discussed in the section below.

The fauna species observed at the site were generally few and restricted to small invertebrates such as earthworms, insects, Grasshoppers, Butterflies, spiders. Also, vertebrates such as Lizards, birds and rodents were sighted within the Project site and AoI. Table 4.21 presents a list of some fauna species encountered in the Project area.

Table 4.21: List of Fauna Species Encountered in the Project Area

Common (Local) Names	Species	Family	Group	IUCN status
Millipede	*Archispirostreptus gigas*	Spirostretidae	Arthropoda	Not evaluated
Black ant	*Lasius niger*	Formicidae	Insecta	Not evaluated
Black Kite	*Muluus migrans*	Accipitridae	Aves	Least concern
Bush fowl	*Francolinus bicalcaratus*	Phasianidae	Aves	Not evaluated

Common (Local) Names	Species	Family	Group	IUCN status
Earthworm	*Lumbricus terrestris*	Acanthodrilidae	Annelida	Not evaluated
Giant African mantis	*Sphodromantis viridis*	Mantidae	Insecta	Not evaluated
Green fruit Pigeon	*Treron australis*	Columbidae	Aves	Least concern

4.3 Description of Socio-economic Environment of the Project Area

The proposed Project is located within the Federal University of Education (FUE), Zaria, in Zaria Local Government Area of Kaduna State. The Project Area of Influence (AoI) includes the University community and its immediate host communities, particularly Gyallesu Community, which is contiguous with the University. This section presents the baseline socio-economic and public health conditions of the Project Area based on field surveys, stakeholder consultations, Focus Group Discussions (FGDs), Key Informant Interviews (KIIs), and questionnaire administration. Photographs taken during the field survey are presented in Appendices 1 and 2.

4.3.1 Study Approach and Methodology

Study Area

The socio-economic survey was undertaken within the Federal University of Education (FUE), Zaria, and its immediate host community of Gyallesu in Zaria Local Government Area, Kaduna State. The study area comprises the University community, staff residential quarters, students, nearby residents, local businesses, and members of the adjoining host community who may be directly or indirectly influenced by the proposed Project. Zaria is one of the major urban centres in Kaduna State and serves as an important educational, commercial, and administrative hub. The dominant economic activities include education, commerce, agriculture, public service, and small-scale enterprises.

Study Population

The study population comprised adults (18 years and above) residing or working within the Federal University of Education (FUE), Zaria, and its immediate host community. Respondents included University staff, students, residents of the Federal Low-Cost Housing Estate, community leaders, healthcare practitioners, youth representatives, women groups, traders, and other relevant stakeholders.

Study Design

The study adopted a mixed-methods approach involving both quantitative and qualitative techniques. Primary data were collected through questionnaire administration, while qualitative information was obtained through Key Informant Interviews (KIIs), Focus Group Discussions (FGDs), and stakeholder consultations. The survey was conducted in February 2026. Information obtained from the different sources was triangulated to ensure consistency, reliability, and validity of the socio-economic baseline.

Sample Size and Sampling Techniques

The study population is relatively homogeneous with respect to the characteristics relevant to the proposed Project. A total of 100 questionnaires were administered using a systematic sampling technique across the University community and the adjoining host community to ensure adequate representation of the various stakeholder groups. Of these, 72 questionnaires were successfully completed and found suitable for analysis, representing a 72% response rate. Variations in the number of responses presented for some variables resulted from non-response or incomplete responses to individual questions. For the qualitative assessment, three (3) Focus Group Discussions (FGDs) comprising two male groups and one female group were conducted. Each FGD consisted of between 6 and 15 participants, representing youths, adults, women, persons living with disabilities, educated and non-educated residents, and other relevant stakeholder groups. In addition, Key Informant Interviews (KIIs) were conducted with community leaders and experienced healthcare practitioners to obtain in-depth information on community characteristics, existing infrastructure, healthcare access, and perceptions of the proposed Project.

Data Collection, Analysis and Reporting

Primary data were collected through structured questionnaires administered electronically using SurveyCTO on smartphones by trained enumerators. The survey was complemented by personal interviews, Focus Group Discussions, and Key Informant Interviews. The data were subsequently collated, cleaned, analysed using appropriate descriptive statistical methods, and presented in tables, charts, and narrative form to establish the socio-economic baseline of the Project Area.

Plate 4.4: Administration of Questionnaires and Interview activities at the project site

4.3.2 The Socio-Economic Baseline Report Structure

This study adopted the Social Framework Model for reporting the socio-economic baseline. Consistent with the framework developed by Smyth and Vanclay (2017), the baseline assessment presents information on the socio-demographic characteristics, socio-economic conditions, access to social infrastructure and services, public health, livelihoods, community perceptions, and other relevant social indicators within the Project Area of Influence (AoI):

4.3.2.1 Socio-demographic Profile of the Study Area

Gender

A total of 72 valid respondents participated in the socio-economic survey. Of these, 45 respondents (62.5%) were male, while 27 respondents (37.5%) were female (Figure 4.36). The survey achieved representation from both male and female members of the University and host community, providing a balanced basis for assessing the potential social impacts of the proposed Project. The participation of both genders ensures that the views and concerns of different stakeholder groups were adequately captured during the baseline assessment.

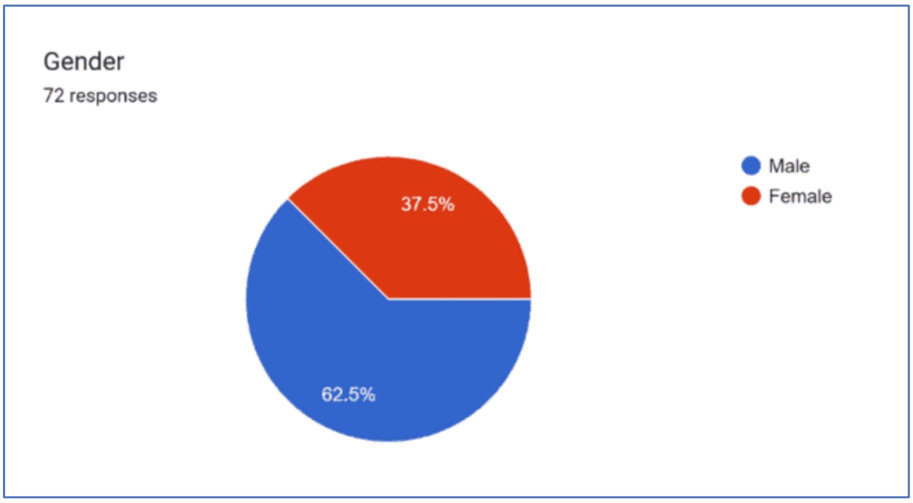


Figure 4.36: Gender Distribution

Age

A total of 71 respondents provided information on their age. The results show that the majority of respondents (52.1%) were within the 18–30 years age group (Figure 4.37). Respondents aged 31–45 years accounted for 28.2%, while those within the 46–54 years age bracket constituted 14.1%. Respondents aged 55 years and above represented the smallest proportion, accounting for approximately 5.6% of the valid responses. The age distribution indicates that the study area is predominantly youthful, reflecting the educational setting of the Project Area. This demographic profile is expected to influence stakeholder interests, particularly with respect to improved infrastructure, employment opportunities during Project implementation, and skills development associated with the proposed Project.

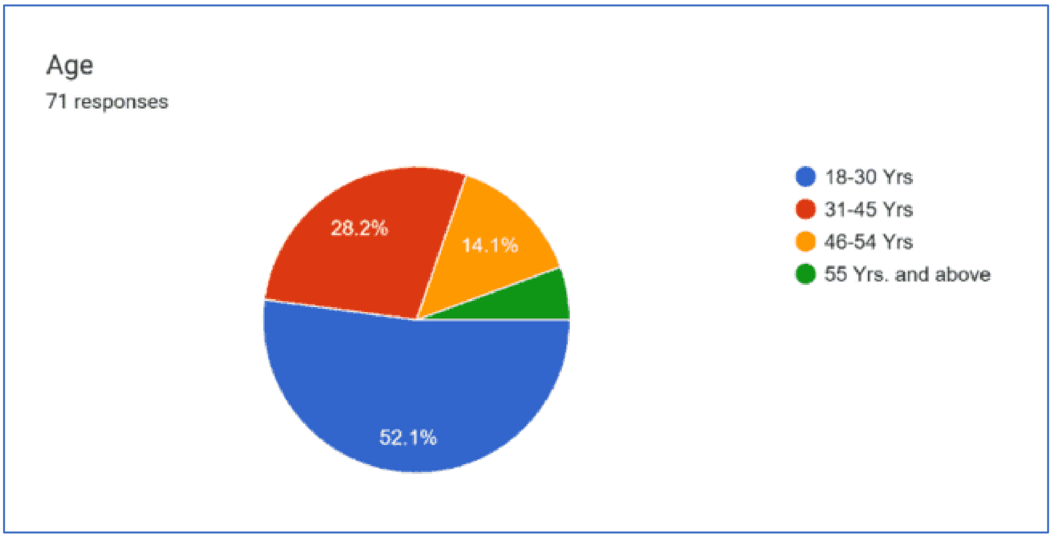


Figure 4.37: Age Distribution

Marital Status

A total of 72 respondents provided information on their marital status. The results indicate that 50.0% of the respondents were married, while 47.2% were single (Figure 4.38). The remaining respondents (2.8%) were widowed, with no respondents indicating that they were separated or divorced. The distribution reflects a mix of household types within the Project Area, comprising both established family households and unmarried individuals. This diversity provides a representative basis for assessing the potential social impacts of the proposed Project across different segments of the population.

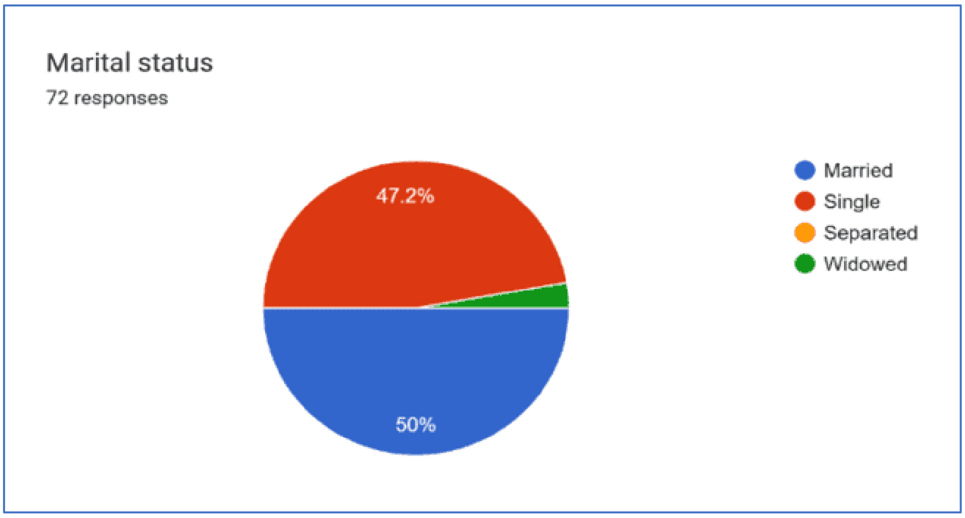


Figure 4.38: Marital Status

Family Pattern

A total of 70 respondents provided information on their family pattern. The results indicate that 58.6% of the respondents belong to nuclear families, making this the predominant household structure within the Project Area (Figure 4.39). Respondents living in joint or extended family arrangements accounted for 30.0%, while 11.4% reported living independently.

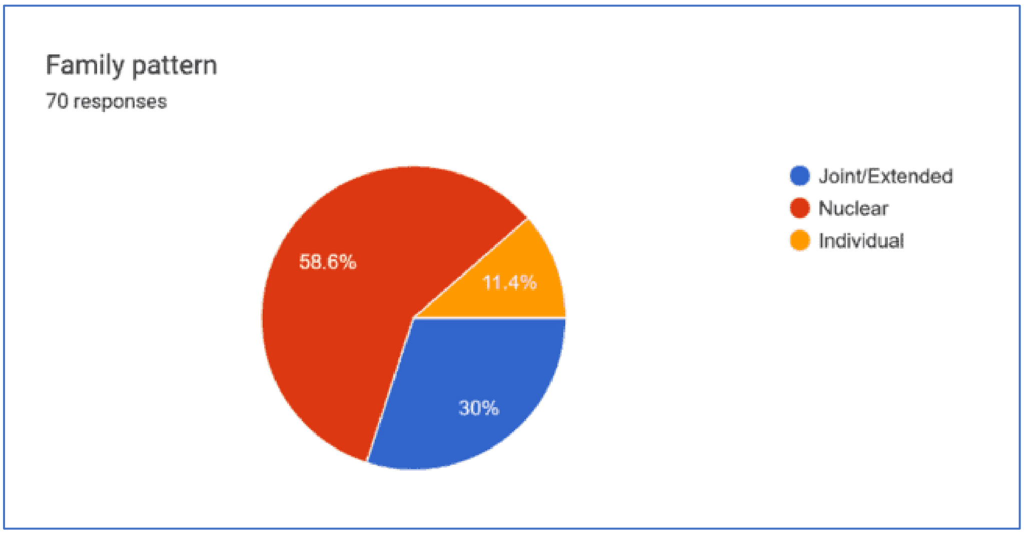


Figure 4.39: Distribution of Respondents by Family Pattern in the Project Area

The predominance of nuclear families suggests that smaller household units are common within the Project Area, reflecting the influence of the University environment and the surrounding semi-urban setting. Nevertheless, the substantial proportion of respondents living in joint or extended family arrangements demonstrates that traditional family structures remain an important feature of the host community. This mixture of household types indicates a socially diverse population with varying household needs and priorities. From a socio-economic perspective, the household structure is relevant in understanding the potential social implications of the proposed Project, particularly in relation to community engagement, service demand, livelihood considerations, and the distribution of Project benefits. The presence of both nuclear and extended family systems suggests that Project information dissemination and stakeholder engagement should be designed to effectively reach different household groups within the Project Area.

Household Size

A total of 71 respondents provided information on their household size. The results indicate that 45.1% of the respondents belong to medium-sized households (5–8 members), making this the most common household category within the Project Area (Figure 4.40). This is followed by 32.4% of respondents living in large households (more than 9 members), while 22.5% reside in small households (2–4 members). The findings indicate that medium- to large-sized households are prevalent within the Project Area, reflecting the family structure and living arrangements of both the University community and the adjoining host community. Larger household sizes may translate into higher demand for essential services such as electricity, potable water, healthcare, waste management, and other social amenities. Conversely, the presence of smaller households reflects the diversity of the study population, including nuclear families and individual households.

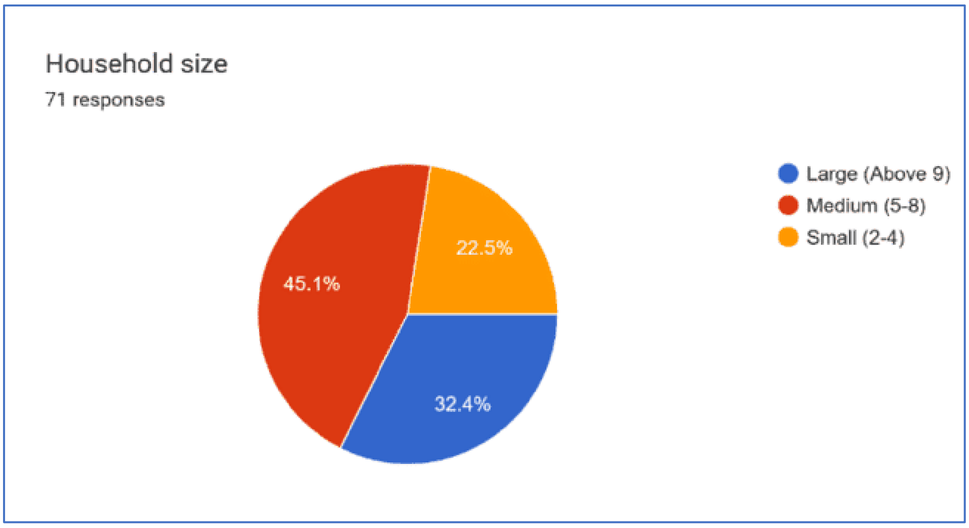


Figure 4.40: Distribution of Respondents by Household Size in the Project Area

From a socio-economic perspective, the household size distribution provides an important baseline for understanding community service demand and the potential beneficiaries of the proposed Project. The improved electricity supply expected from the Project is anticipated to enhance the quality and reliability of services available to households within the University community and the surrounding host communities.

Religion

A total of 72 respondents provided information on their religious affiliation. The results show that 70.8% of the respondents are Muslims, while 29.2% are Christians. No respondents identified with traditional religion (Figure 4.41). The findings indicate that the Project Area is predominantly Islamic, which is consistent with the general religious composition of Zaria and much of northern Nigeria. Nevertheless, the presence of a sizeable Christian population reflects the diversity associated with the University community and its host environment. This religious diversity underscores the importance of implementing inclusive stakeholder engagement, consultation, and information dissemination processes that respect the beliefs and practices of all religious groups throughout the Project lifecycle. Overall, the religious composition of the Project Area provides a sound basis for planning culturally sensitive engagement and ensuring equitable participation in Project-related activities.

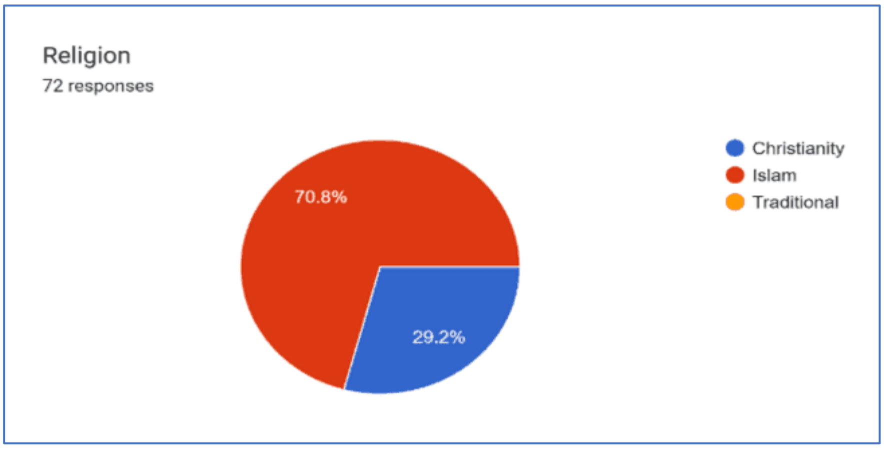


Figure 4.41: Distribution of Respondents by Religious Affiliation in the Project Area

Education

A total of 72 respondents provided information on their highest educational qualification. The results indicate that the study population is relatively well educated, with 47.2% of the respondents possessing NCE/ND qualifications and another 47.2% holding HND/B.Sc degrees (Figure 4.42).

Respondents with secondary education and primary or informal education accounted for only a small proportion of the total responses.

The predominance of respondents with tertiary-level qualifications reflects the educational setting of the Project Area, which is centred around the Federal University of Education (FUE), Zaria. This educational profile is expected to facilitate effective stakeholder engagement, communication, and dissemination of Project-related information, as well as enhance community understanding of the Project's objectives, potential impacts, and proposed mitigation measures. Furthermore, the relatively high level of educational attainment provides a favourable basis for local participation in skilled employment, capacity-building initiatives, and the long-term sustainability of the proposed Project.

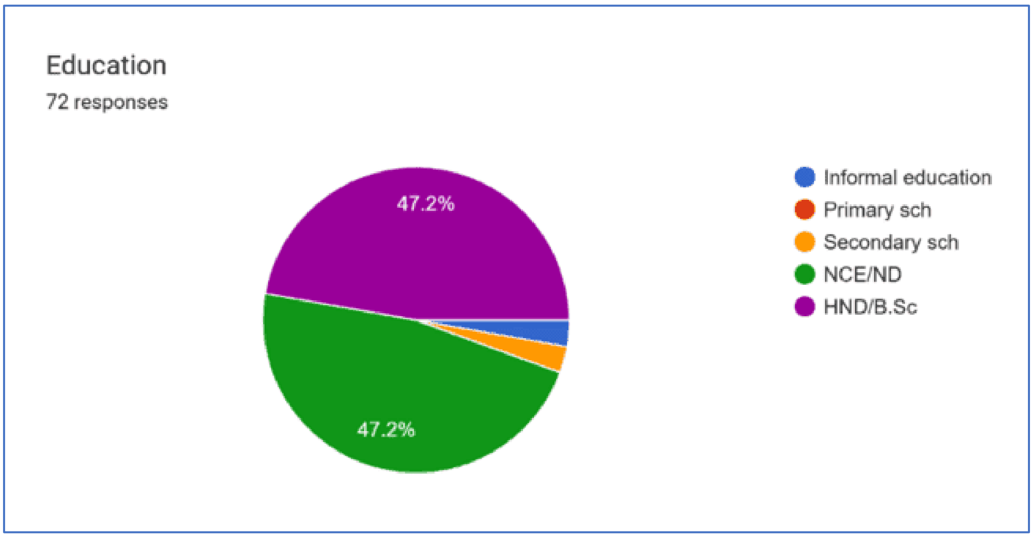


Figure 4.42: Distribution of Respondents by Educational Qualification in the Project Area

Occupation and Monthly Income

A total of 72 respondents provided information on their occupation. The results indicate that civil servants constitute the largest occupational group, accounting for 45.8% (33 respondents) of the study population (Figure 4.43). This is followed by students, who represent 36.1% (26 respondents). Respondents engaged in farming account for 13.9% (10 respondents), while trading and consultancy services represent 2.8% (2 respondents) and 1.4% (1 respondent), respectively. The occupational profile reflects the educational and administrative setting of the Project Area, where employment within the public sector and academic activities predominate. The substantial proportion of students further underscores the influence of the Federal University of Education

(FUE), Zaria, on the socio-economic characteristics of the area. Although farming and trading account for a smaller proportion of respondents, they remain important livelihood activities within the adjoining host community and contribute to the local economy.

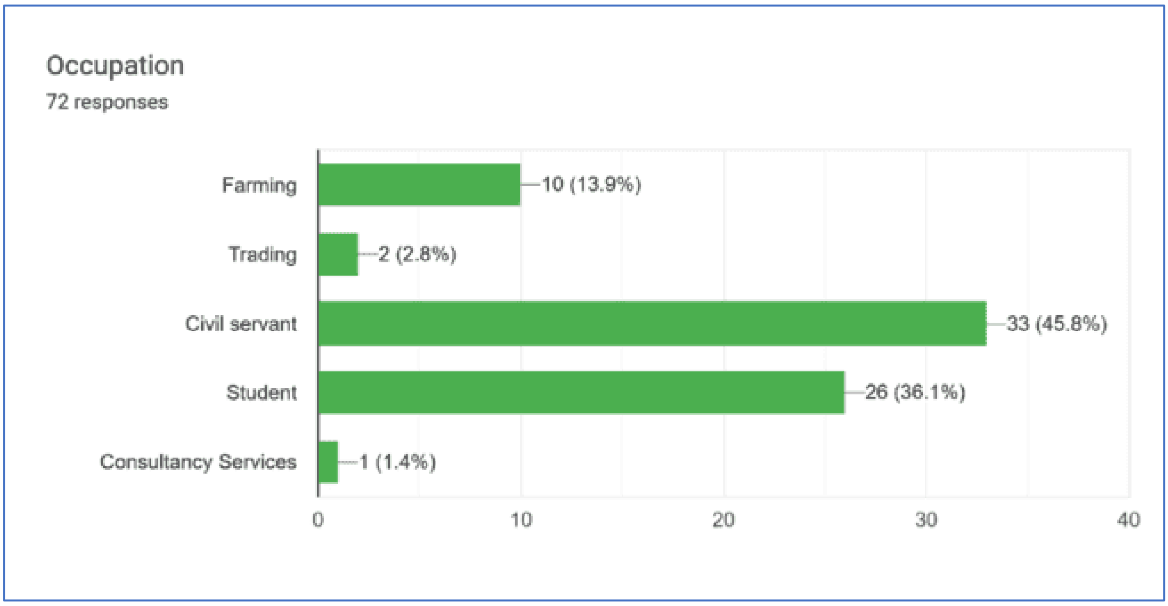


Figure 4.43: Distribution of Respondents by Occupation in the Project Area

From a socio-economic perspective, the occupational structure indicates that the proposed Project is expected to benefit a diverse group of stakeholders. During the construction phase, temporary employment and business opportunities may be created for both skilled and unskilled labour, while the improved electricity supply during operation is expected to enhance institutional productivity, support commercial activities, and improve the overall socio-economic wellbeing of the University community and its host environment. .

Monthly Income

A total of 70 respondents provided information on their monthly income. The results show that 40.0% of the respondents earn between ₦0–₦30,000 per month, while 38.6% earn ₦120,000 and above (Figure 4.44). Respondents earning between ₦31,000–₦60,000 accounted for 10.0%, whereas 11.4% reported monthly incomes ranging from ₦60,001–₦90,000. The income distribution indicates that the Project Area comprises respondents with varying economic backgrounds, reflecting the diverse composition of the University community and its adjoining host community. The relatively high proportion of respondents in the upper income category is consistent with the presence of salaried public sector employees and professionals, while respondents in the lower income category are likely to include students, small-scale traders, and other low-income earners. This variation in income levels demonstrates the socio-economic diversity of the Project Area and provides an important baseline for assessing the distribution of Project benefits and potential socio-economic impacts.

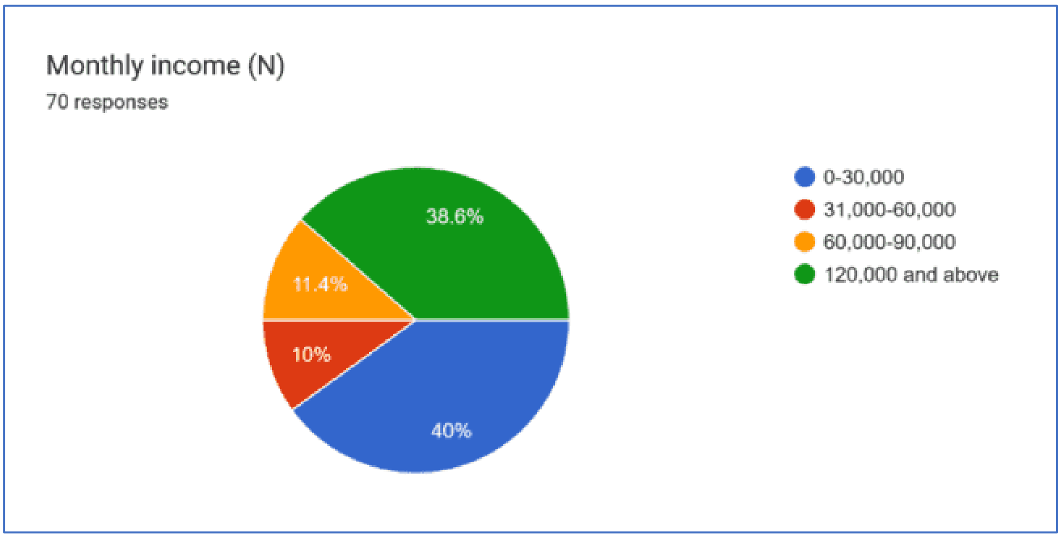


Figure 4.44: Distribution of Respondents by Monthly Income Level in the Project Area

From a Project perspective, improved and reliable electricity supply is expected to support educational activities, institutional operations, and small-scale commercial enterprises, thereby contributing to enhanced productivity and improved socio-economic conditions within the University community and the surrounding host communities.

Duration of stay in the community or institution

A total of 70 respondents provided information on the duration of their stay within the community or institution. The results indicate that 48.6% of the respondents have resided in the area for 1–5 years, representing the largest proportion of the study population (Figure 4.45). Respondents who had lived in the area for 11–19 years accounted for 25.7%, while 14.3% reported a duration of stay of 20 years and above. Those who had resided in the area for 6–10 years constituted 11.4% of the respondents. The findings indicate that the Project Area comprises both relatively recent and long-term residents. The predominance of respondents who have lived in the area for 1–5 years is consistent with the dynamic nature of the University environment, where student enrolment and staff mobility contribute to periodic changes in the resident population. At the same time, the presence of a substantial proportion of long-term residents provides valuable local knowledge of the community, existing infrastructure, environmental conditions, and historical development trends.

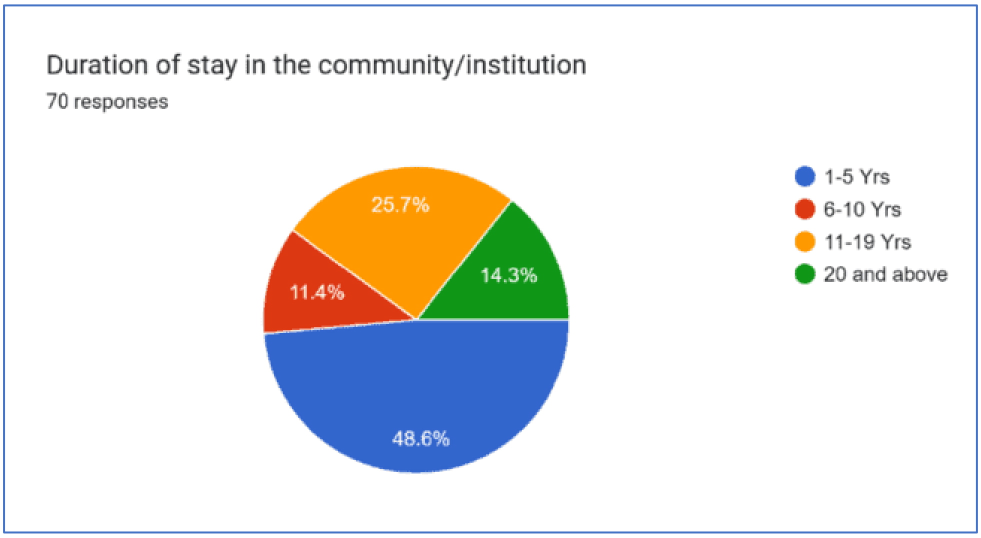


Figure 4.45: Distribution of Respondents by Duration of Stay in the Community/Institution

From the perspective of the proposed Project, the combination of newer and long-term residents provides a balanced basis for assessing stakeholder perceptions, identifying community priorities, and evaluating the potential social impacts and benefits associated with the Project.

Language Distribution

A total of 72 respondents provided information on the primary language spoken within the community. The results indicate that Hausa is the predominant language, spoken by 55.6% of the respondents, followed by English at 33.3% (Figure 4.46). Zarma/Dendi accounts for 8.3%, while C'lela/Fulfulde represents 2.8% of the respondents. No respondents reported Reshe/Chishingini as their primary language. The predominance of Hausa is consistent with the linguistic profile of Zaria and the wider northern region of Nigeria, where it serves as the principal language of communication. The relatively high proportion of English speakers reflects the educational environment of the Federal University of Education (FUE), Zaria, where English is the official language of instruction and administration. The presence of other indigenous languages further demonstrates the multicultural nature of the Project Area.

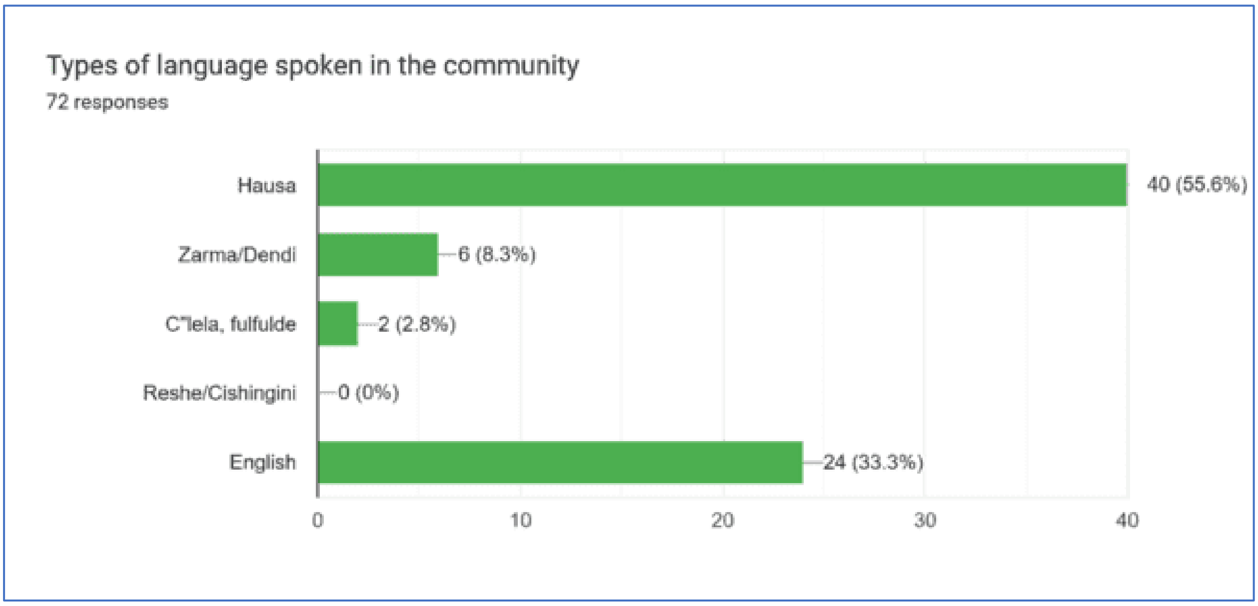


Figure 4.46: Distribution of Respondents by Primary Language Spoken in the Community

From a stakeholder engagement perspective, the language profile indicates that Hausa and English should be adopted as the primary languages for community consultations, public awareness campaigns, grievance redress, and dissemination of Project information. This approach will promote effective communication, enhance stakeholder participation, and ensure that Project information is accessible to the diverse groups within the Project Area.

Access to Health Facilities

A total of 71 respondents provided information on their access to healthcare facilities within the Federal University of Education (FUE), Zaria, and its immediate surroundings. The results indicate that 52.1% of the respondents primarily access healthcare services through the Primary Health Centre, making it the most accessible healthcare facility within the Project Area (Figure 4.47). In addition, 21.1% reported access to the University sick bay, while 12.7% indicated access to a General Hospital and another 12.7% reported access to private hospitals. Only 1.4% of the respondents indicated access to all categories of healthcare facilities. The findings demonstrate that respondents generally have adequate access to primary healthcare services, with the Primary Health Centre and the University sick bay serving as the principal healthcare providers within the Project Area. Access to secondary and private healthcare facilities is also available, although these facilities are generally located outside the immediate University environment. This indicates that while routine healthcare needs can largely be met within or close to the campus, specialized medical services may require referral to higher-level healthcare facilities.

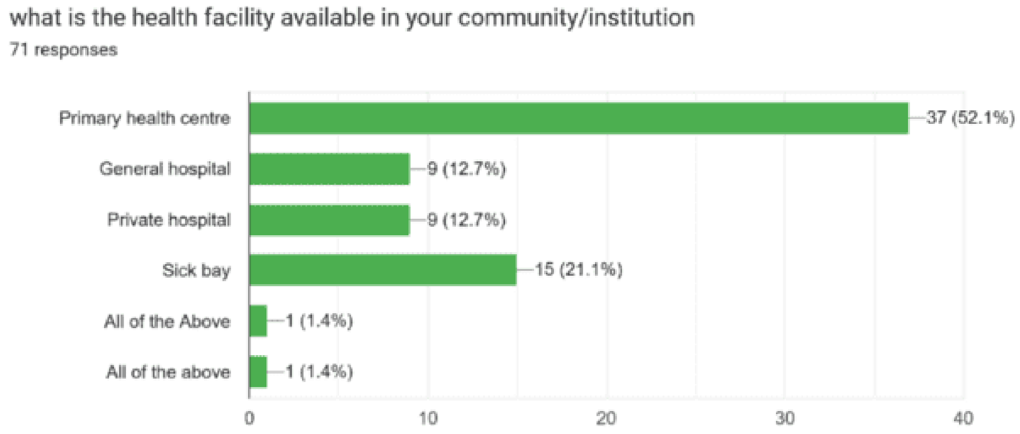


Figure 4.47: Types of Health Facilities Available in the Community/Institution

From the perspective of the proposed Project, the existing healthcare infrastructure provides an adequate baseline for addressing routine occupational and community health needs during Project implementation. Nevertheless, emergency response arrangements and referral mechanisms to higher-level healthcare facilities should form part of the Project's Health, Safety, and Emergency Response Plan.

Condition of Health Facilities

A total of 71 respondents assessed the condition of the healthcare facilities they access within the Federal University of Education (FUE), Zaria, and its immediate surroundings. The results show that 59.2% of the respondents rated the condition of the available health facilities as good, while 21.1% considered them to be very good (Figure 4.48). In contrast, 16.9% rated the facilities as fair, and only a small proportion considered them to be poor. The findings indicate that respondents generally perceive the available healthcare facilities to be functional and capable of providing routine healthcare services. The high proportion of respondents rating the facilities as good or very good suggests that the existing healthcare infrastructure provides an adequate level of service for the University community and the adjoining host community. However, the responses indicating fair or poor conditions highlight opportunities for continued improvement in healthcare service delivery and facility maintenance.

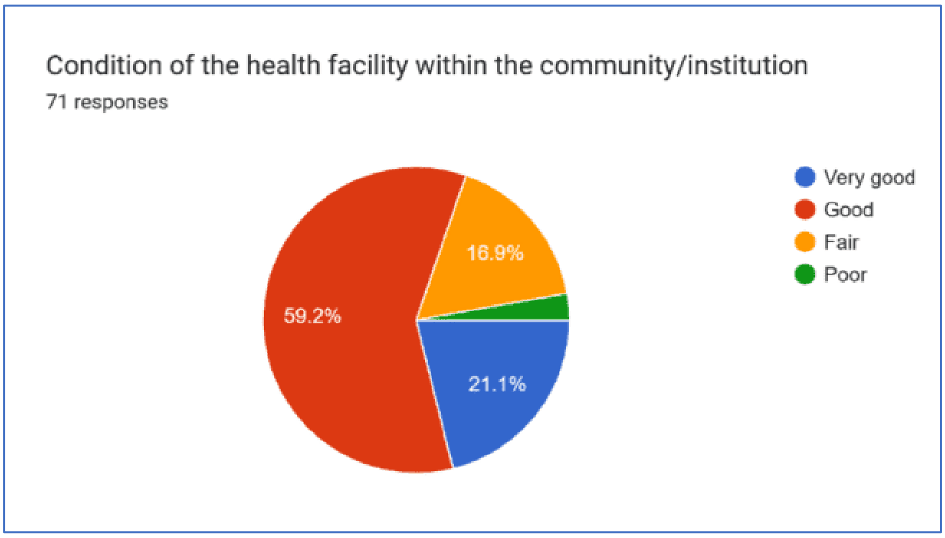


Figure 4.48: Condition of Health Facilities within the Community/Institution

From the perspective of the proposed Project, the availability of functional healthcare facilities within and around the University provides an important support system for occupational and community health management during Project implementation. Where specialized medical care or emergency treatment is required, established referral arrangements with higher-level healthcare facilities will complement the existing healthcare services.

Management of Health Conditions When Sick

A total of 67 respondents provided information on how they manage their health conditions when ill. The results indicate that the majority (73.1%; 49 respondents) seek treatment at a clinic or hospital, making formal healthcare facilities the preferred option for managing illness within the Project Area (Figure 4.49). In addition, 25.4% (17 respondents) reported purchasing medicines from nearby chemists or pharmacies, while only 1.5% (1 respondent) indicated reliance on traditional medicine. No respondents selected other treatment options. The findings demonstrate that respondents have good access to formal healthcare services within the University community and its immediate surroundings and generally utilize these facilities when medical attention is required. The proportion of respondents who obtain medicines from chemists or pharmacies suggests that self-medication is also practiced, particularly for minor ailments. However, the very low reliance on traditional medicine indicates a strong preference for conventional healthcare services among the study population. Overall, the results reflect a community with relatively good healthcare-seeking behaviour and access to formal medical services.

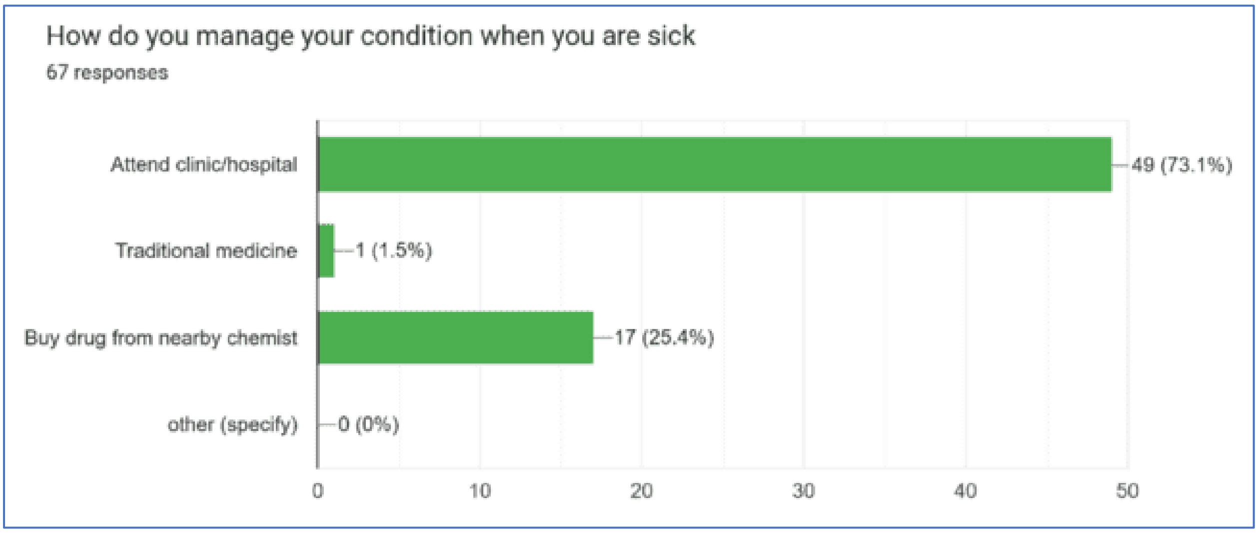


Figure 4.49: Methods Adopted by Respondents in Managing Illness within the Community/Institution

Health Conditions

Regarding prevalent health conditions (n = 68), malaria was identified as the most common illness, affecting 58.8% (40 respondents), followed by typhoid fever at 35.3% (24 respondents) (Figure 4.50). Other reported conditions include hypertension (5.9%)**,** asthma (4.4%)**,** rheumatism (2.9%)**,** and pneumonia and meningitis (1.5% each), while no cases were reported for cholera, tuberculosis, or rashes. The predominance of malaria and typhoid fever reflects typical public health challenges in tropical environments, often associated with environmental sanitation and water quality issues.

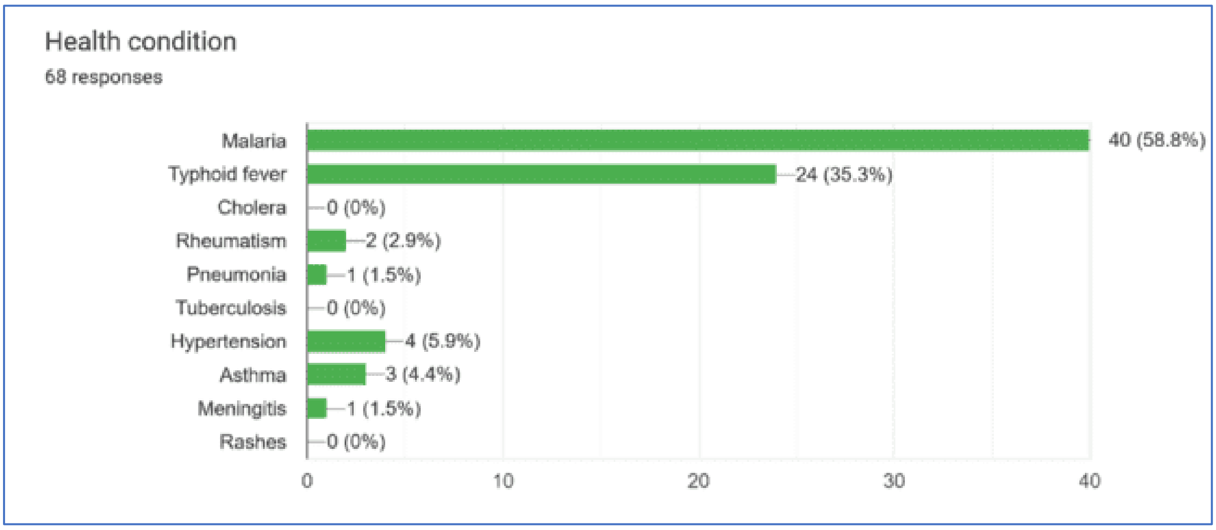


Figure 4.50: Prevalent Health Conditions Reported by Respondents in the Community/Institution

The relatively low occurrence of chronic and communicable diseases such as tuberculosis suggests manageable public health risks. Overall, the findings highlight the importance of sustained public health awareness, improved sanitation, and access to quality healthcare services within the community.

Negative Impact on Health or the Environment

The responses to whether the proposed project would have a negative impact on health or the environment (n = 71) indicate that a clear majority, 78.9%, do not believe the project will have negative effects, while 21.1% expressed concerns that it may have adverse impacts (Figure 4.51). This distribution suggests generally strong community support for the project and confidence in its environmental sustainability. The high proportion of respondents who do not anticipate negative impacts may reflect awareness of the project's renewable energy nature and its perceived benefits, such as improved electricity supply and reduced reliance on fossil fuels. However, the presence of over one-fifth of respondents expressing concerns highlights the need for continued stakeholder engagement and transparent communication regarding environmental safeguards.

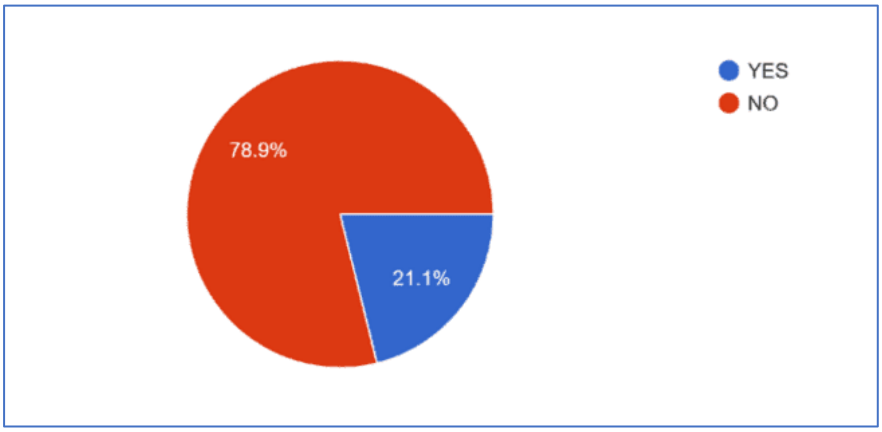


Figure 4.51: Respondents' Perception on Whether the Proposed Project Will Have Negative Impacts on Health/Environment

Source of Negative Impact

Among the 20 respondents who expressed concerns, 45% identified air pollution as a potential impact, followed by 35% who cited noise pollution (Figure 4.52). Additionally, 10% mentioned groundwater contamination, while another 10% were concerned about surface water contamination. These responses suggest that perceived risks are largely associated with construction-phase activities rather than operational impacts of the solar facility. Concerns about air and noise pollution may relate to dust generation, equipment use, and vehicular movement during installation. The relatively smaller proportion worried about water contamination indicates moderate awareness of environmental protection issues. Overall, while the majority perception is positive, the expressed concerns underscore the importance of implementing and communicating effective mitigation measures outlined in the Environmental and Social Management Plan (ESMP).

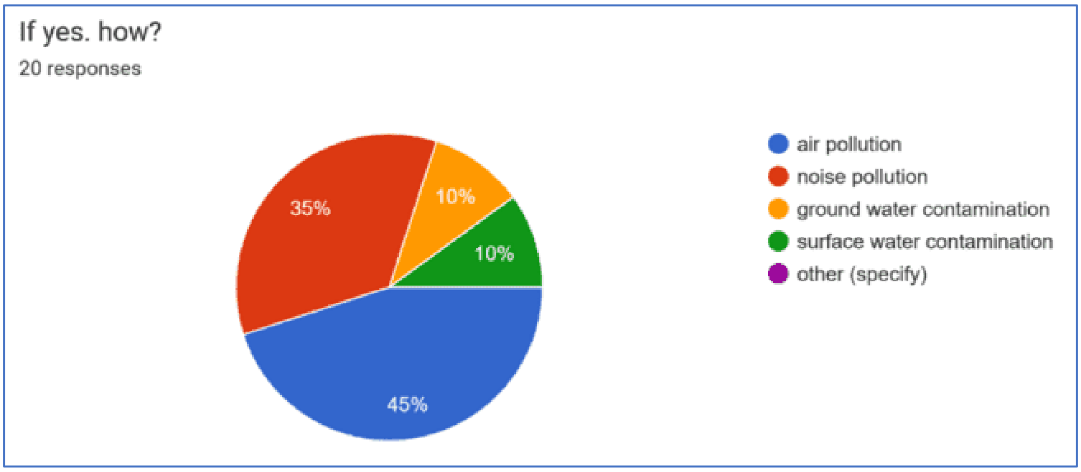


Figure 4.52: Perceived Types of Negative Impacts of the Proposed Project

Impact Aversion

The responses on how perceived negative impacts can be averted indicate that respondents suggested practical mitigation measures focused on environmental management and public health protection (Figure 4.53). The identified measures include ensuring proper maintenance of facilities, regular use of pesticides and mosquito nets, and implementing adequate measures to prevent water contamination. Each of these suggestions reflects community awareness of potential environmental and health risks and highlights preventive strategies rather than reactive solutions. The emphasis on proper maintenance suggests concern about infrastructure sustainability and operational oversight, while the recommendation for mosquito control measures aligns with the high prevalence of malaria previously reported. Additionally, the call for protecting water sources underscores sensitivity to potential groundwater or surface water contamination. Overall, the responses demonstrate proactive community thinking and support for implementing effective mitigation strategies to safeguard public health and environmental quality throughout the project lifecycle.

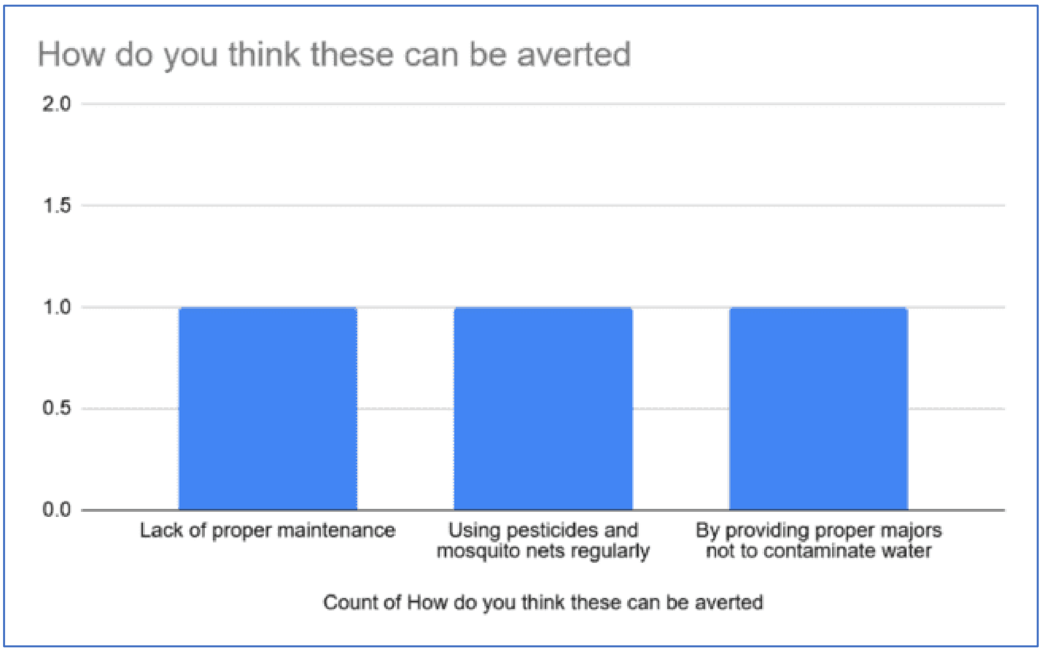


Figure 4.53: Suggested Measures by Respondents for Averting Potential Negative Health and Environmental Impacts

Gender-Based Violence (GBV)

According to Nigeria Demographic and Health Survey, the percentage of women who have experienced physical, sexual, or emotional violence committed by their current or most recent husband/partner in Kaduna State was 59.4% which is high compared to some other states in Nigeria (Nigeria DHS, 2018) (Figure 4.54). The responses on gender-based violence (GBV) with a total of 72 indicate that 29.2% of respondents reported that they or someone in their household had experienced gender-based violence**,** while 70.8% stated that they had not (Figure 4.54)**.**

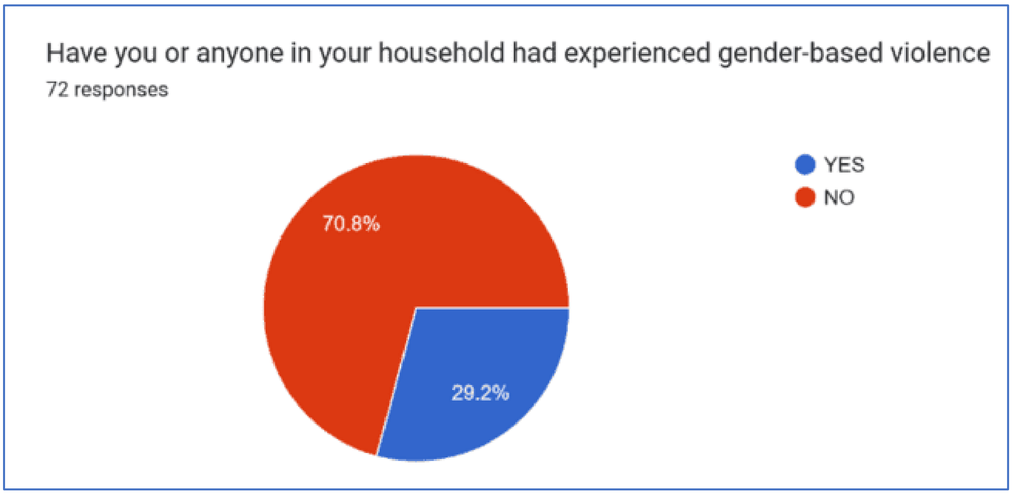


Figure 4.54: Respondents' Experience of Gender-Based Violence within Households

Although the majority reported no experience of GBV, the proportion indicating exposure, nearly one-third of respondents, is significant and highlights that gender-based violence remains a concern within the community. This finding underscores the importance of integrating gender-sensitive measures and grievance redress mechanisms into project planning and implementation, particularly in line with environmental and social safeguard requirements.

Equal Access to Economic Opportunities

Regarding perceptions of equal access to economic opportunities with a total of 70, 65.7% of respondents believe that men and women have equal access, while 34.3% disagree (Figure 4.55). The majority perception suggests progress toward gender inclusivity within the community, likely influenced by the educational and institutional environment. However, the fact that over one-third of respondents perceive inequality indicates that gender disparities may still exist in certain sectors or at household levels. These findings highlight the need for continued efforts to promote gender equity, ensure inclusive participation, and provide equal access to employment and economic benefits associated with the proposed project.

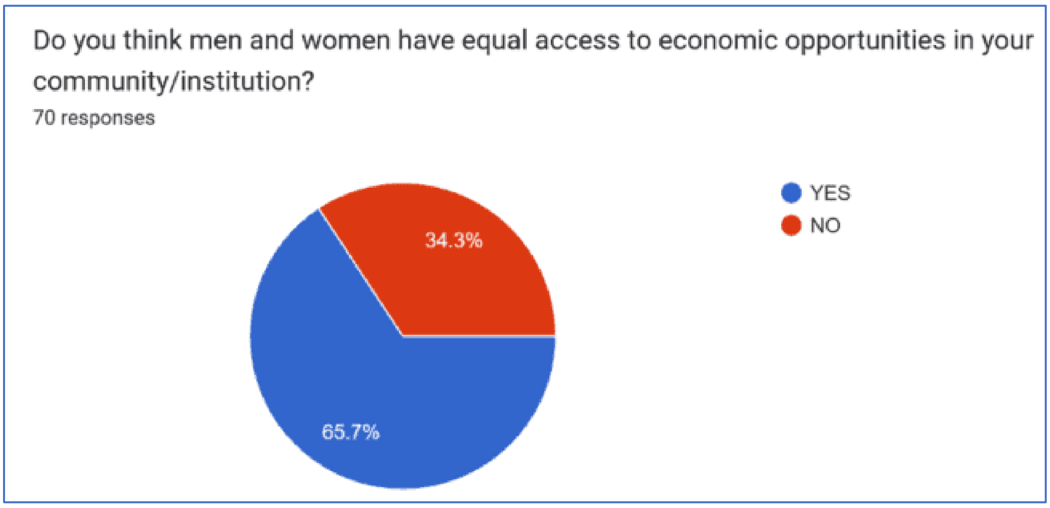


Figure 4.55: Respondents' Perception of Equal Access to Economic Opportunities for Men and Women

Influence of Cultural Norms on the Prevalence of Gender-Based Violence (GBV)

The responses to whether cultural norms influence the prevalence of gender-based violence (GBV) with total of 55 respondents indicate that 52.7% of respondents believe that cultural norms do influence GBV, while 47.3% do not share this view (Figure 4.56). The slight majority perception suggests that more than half of the respondents recognize a link between entrenched cultural practices and the occurrence of gender-based violence within the community. This finding highlights the role that social attitudes, traditional beliefs, and gender expectations may play in shaping behaviors and power dynamics. However, the relatively close distribution between "Yes" and "No" responses also reflect differing perspectives on the root causes of GBV, suggesting that the issue may be influenced by a combination of cultural, economic, and social factors. Overall, the result underscores the importance of community sensitization, gender awareness programs, and culturally responsive interventions to address and mitigate GBV within the project area.

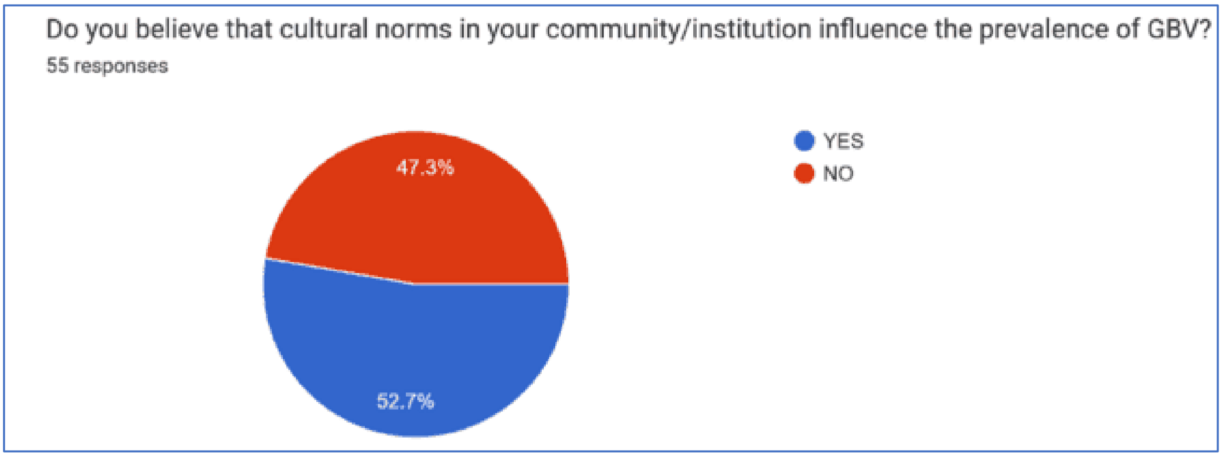


Figure 4.56: Respondents' Perception of the Influence of Cultural Norms on the Prevalence of Gender-Based Violence (GBV)

Availability of Support Services for Survivors of Gender-Based Violence (GBV)

The responses regarding the availability of adequate support services for survivors of gender-based violence (GBV) (n = 55) indicate that 58.2% of respondents believe that adequate support services are available**,** while 41.8% disagree (Figure 4.57). The majority perception suggests that more than half of the community members are aware of or confident in the existence of support mechanisms, which may include health facilities, counseling services, legal assistance, or institutional reporting channels. However, the relatively high proportion of respondents who feel that support services are inadequate highlights potential gaps in accessibility, awareness, or effectiveness of these services. This near-balanced distribution suggests that while some structures may be in place, there is a need for strengthening GBV response systems, improving visibility of available services, and enhancing trust in institutional mechanisms to ensure comprehensive support for survivors within the community.

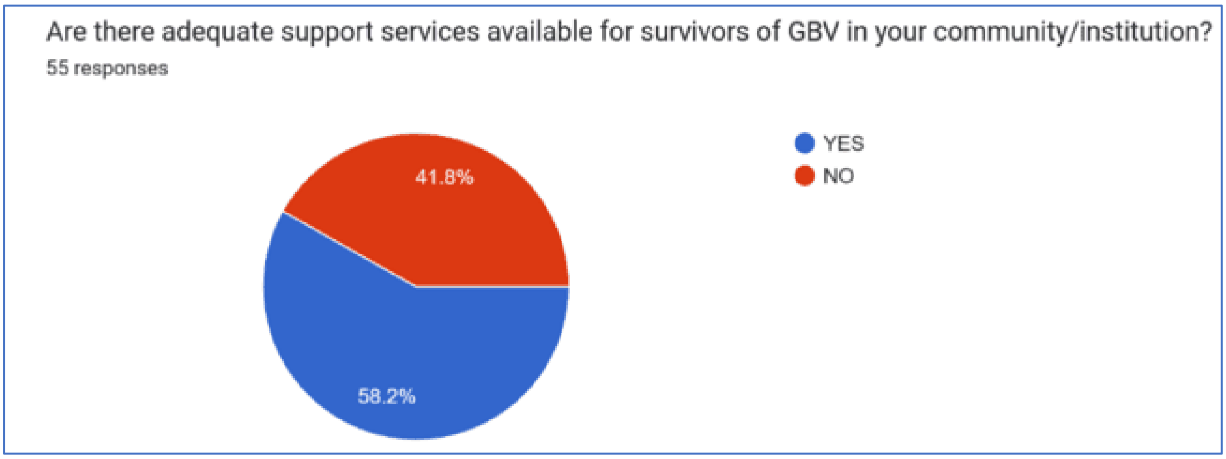


Figure 4.57: Respondents' Perception of the Availability of Adequate Support Services for GBV Survivors in the Community/Institution

Water Supply Sources

The distribution of water supply sources within the community or institution with a total of 57 respondents shows that boreholes are the primary source of water, accounting for 63.2% (36 respondents). This is followed by wells, which serve 35.1% (20 respondents), while only 7% (4 respondents) rely on rivers or streams (Figure 4.58). The dominance of borehole usage indicates reliance on groundwater as the main potable water source, which is typical in many semi-urban and institutional settings. The relatively low dependence on surface water sources suggests improved access to safer water options; however, continued monitoring of groundwater quality remains essential to ensure sustainability and public health protection.

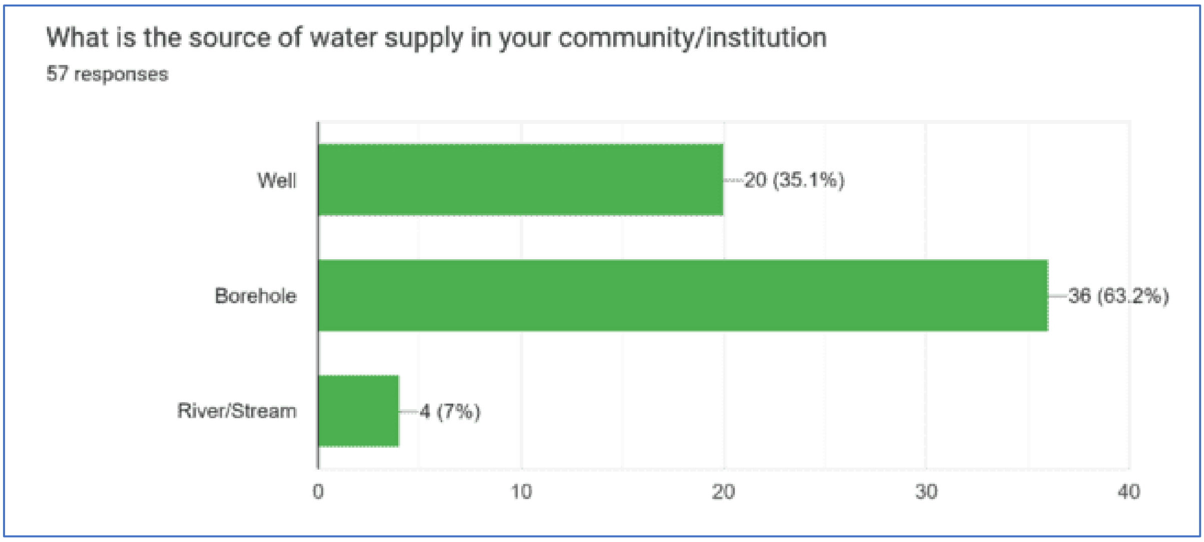


Figure 4.58: Sources of Water Supply in the Community/Institution

Condition of Potable Water

Regarding the condition of potable water with a total of 54 respondents, the majority of respondents rated it as good (68.5%)**,** while 18.5% described it as very good. A smaller proportion, 9.3%, considered it fair, and only a minimal percentage rated it as poor (Figure 4.59). These findings indicate general satisfaction with the quality and availability of water within the community. The predominance of positive ratings suggests that existing water infrastructure is functioning adequately. Nevertheless, the presence of respondents who rated water quality as fair or poor highlights the need for routine water quality assessment, maintenance of borehole systems, and continuous improvement to ensure safe and reliable potable water supply.

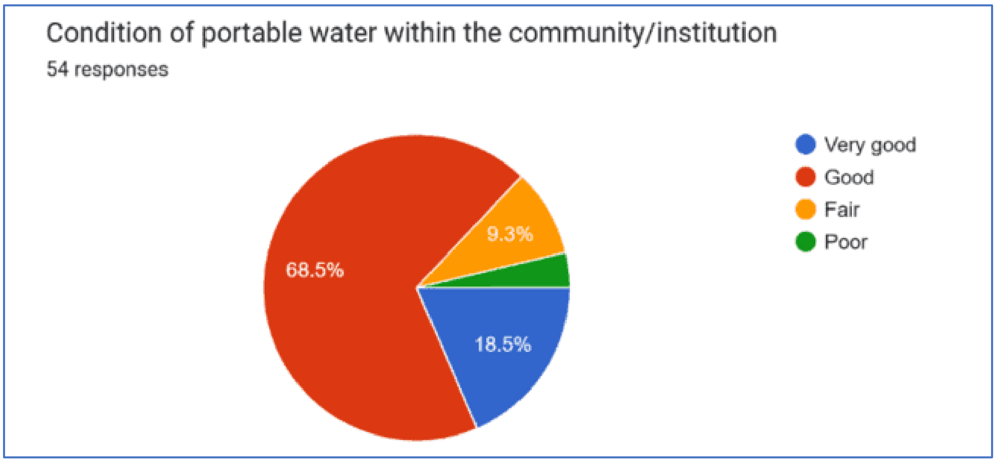


Figure 4.59: Condition of Potable Water within the Community/Institution

Distribution of Available Power Sources

The distribution of available power sources within the community or institution with a total of 57 respondents indicates that public electricity supplied by Distribution Companies (DisCos) is the dominant source, accounting for 52.6% (30 respondents)**.** This is followed by solar power at 29.8% (17 respondents), while 17.5% (10 respondents) rely on generators. A small proportion, 5.3% (3 respondents), use lanterns, and no respondents reported reliance on candles or other sources. The predominance of DisCo-supplied electricity suggests that the national grid remains the primary source of power in the area. However, the notable proportion of respondents using solar power reflects a growing adoption of renewable energy alternatives, while generator usage indicates supplementary reliance due to possible inconsistencies in grid supply.

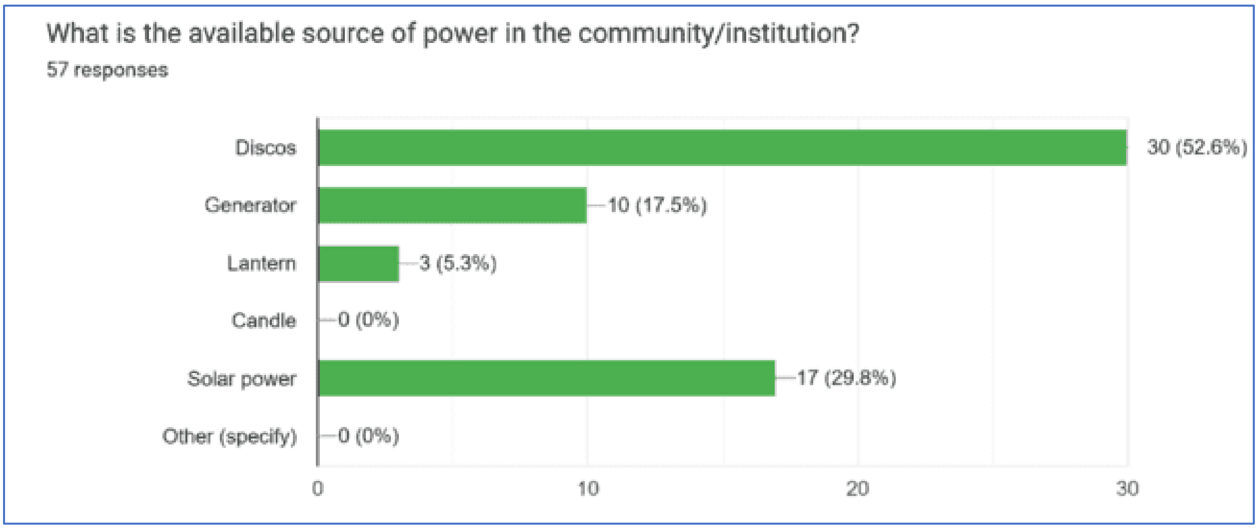


Figure 4.60: Available Sources of Power in the Community/Institution

Condition of Public Electricity

Regarding the condition of public electricity with total of 52 respondents, 44.2% of respondents rated it as good, while 30.8% described it as fair, and 15.4% considered it very good. A smaller proportion, 9.6%, rated it as poor. These findings suggest moderate satisfaction with public electricity supply, though the significant percentage rating it as fair or poor indicates issues related to reliability, stability, or duration of supply. The combined reliance on generators and solar systems further supports the perception that grid electricity may not be entirely dependable. Overall, the results highlight the need for improved electricity reliability and reinforce the relevance of the proposed solar power project in enhancing energy security and sustainability within the community.

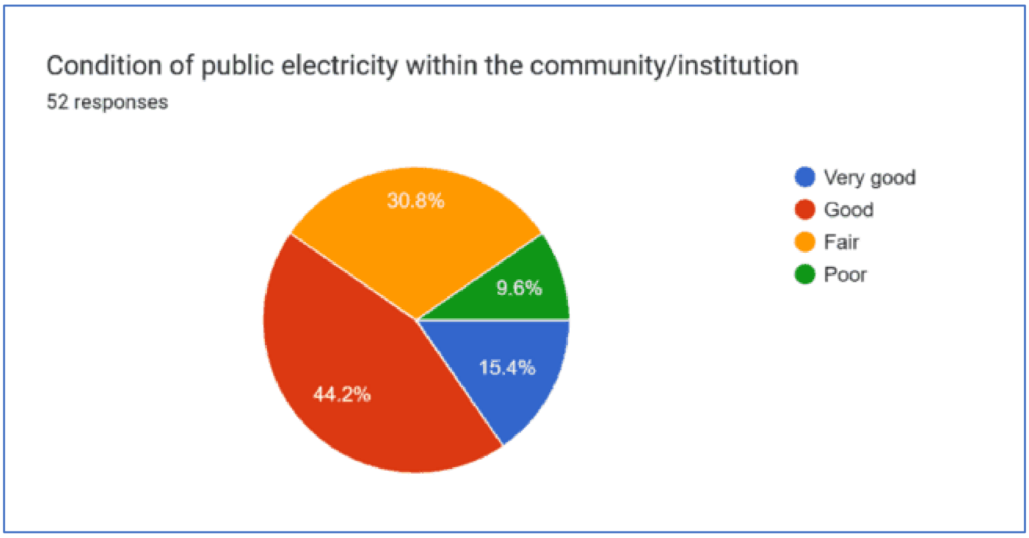


Figure 4.61: Condition of Public Electricity Supply within the Community/Institution

Sanitation Facilities

The distribution of sanitation facilities within the community or institution with total of 44 respondent indicates that 63.6% of respondents use water closet systems, making it the most common sanitation facility in the area. This is followed by 31.8% who rely on pit latrines, while a small proportion (approximately 4–5%) reported practicing open defecation. The predominance of water closet systems suggests relatively improved sanitation infrastructure within the community, likely influenced by its institutional and semi-urban characteristics. However, the continued use of pit latrines and the minimal occurrence of open defecation highlight existing gaps in universal access to improved sanitation. These findings underscore the need for sustained sanitation improvement programs, hygiene awareness, and infrastructure maintenance to enhance environmental health and reduce potential public health risks within the project area.

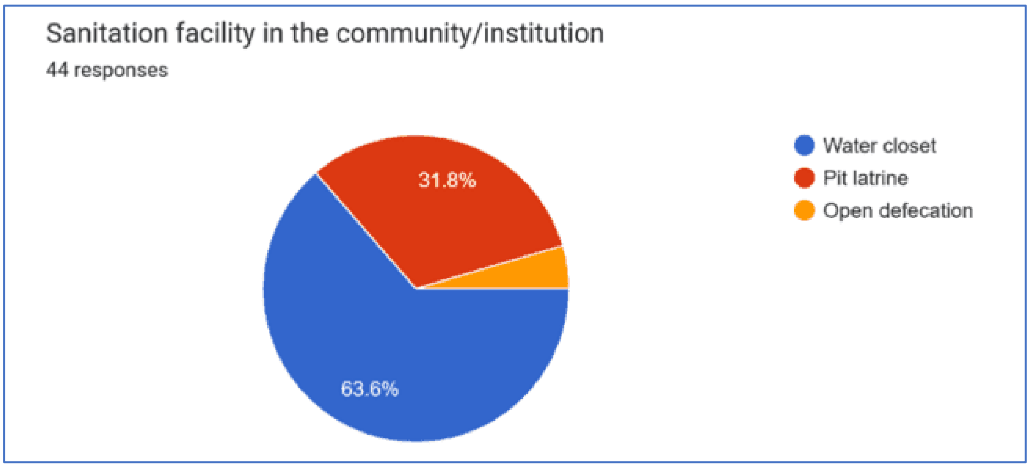


Figure 4.62: Distribution of sanitation facilities within the community or institution

Most Available and Affordable Cooking Sources

The distribution of the most available and affordable cooking sources within the community with a total of 58 respondents indicates that gas cookers are the most commonly used option, accounting for 37.9% (22 respondents). This is followed by charcoal at 32.8% (19 respondents) and firewood at 31% (18 respondents**)**, while only 5.2% (3 respondents) reported using **stoves**, and no respondents selected other options. The predominance of gas cookers suggests a gradual transition toward cleaner energy sources for cooking. However, the substantial reliance on charcoal and firewood indicates continued dependence on traditional biomass fuels, likely due to affordability and accessibility factors. The continued use of biomass fuels has environmental and health implications, including indoor air pollution and deforestation concerns. Overall, the results reflect a mixed energy-use pattern, highlighting the need for policies and awareness initiatives that promote cleaner and more sustainable cooking energy alternatives within the community.

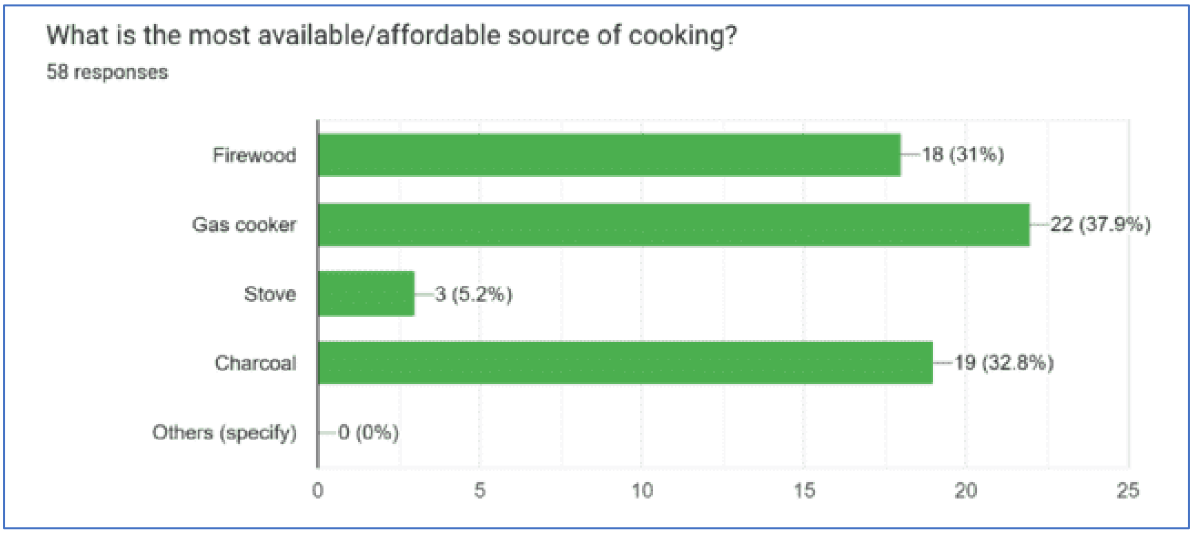


Figure 4.63: **Most Available and Affordable Sources of Cooking Energy in the Community/ Institution**

Educational Institutions

The distribution of educational institutions available within the community or institution with a total of 71 respondents indicates that tertiary institutions are the most prominent, accounting for 57.7% (41 respondents). This is followed by secondary schools at 26.8% (19 respondents) and primary schools at 23.9% (17 respondents)**,** while a small proportion, 2.8% (2 respondents), indicated other types of institutions.

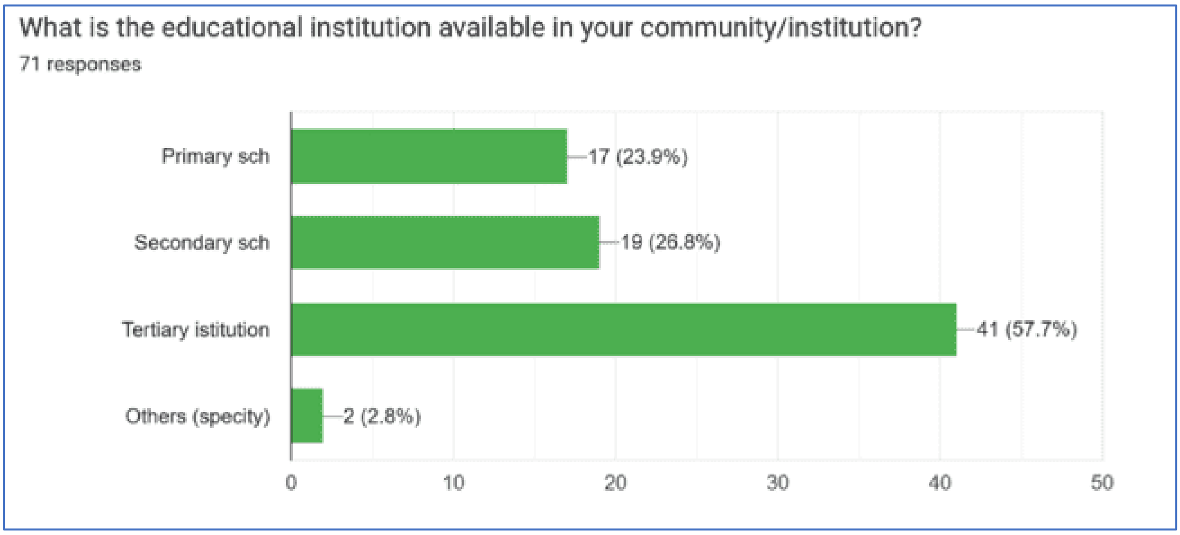


Figure 4.64: Educational Institutions Available in the Community/Institution

The predominance of tertiary institutions reflects the academic and institutional character of the study area, likely influenced by the presence of higher education establishments. The availability of primary and secondary schools further suggests a structured educational system that supports various levels of learning within the community. Overall, the results highlight the strong educational infrastructure in the area, which contributes to human capital development and enhances opportunities for socio-economic growth.

The distribution of waste disposal methods within the community (61) shows that bush burning is the most common method, accounting for 54.1% of responses**.** This is followed by public open dumping at 31.1%**,** while 13.1% of respondents reported using organized waste collection services. A very small proportion indicated the use of private open dumps, and negligible responses were recorded for burying waste. The predominance of bush burning and open dumping suggests reliance on informal and environmentally unsustainable waste management practices. These methods pose potential environmental and public health risks, including air pollution, soil contamination, and the spread of disease vectors.

The relatively low percentage of organized waste collection indicates limited access to structured waste management services within the community. Overall, the findings highlight the need for improved waste management infrastructure, enhanced environmental awareness, and strengthened institutional systems to promote sustainable and hygienic waste disposal practices in the project area.

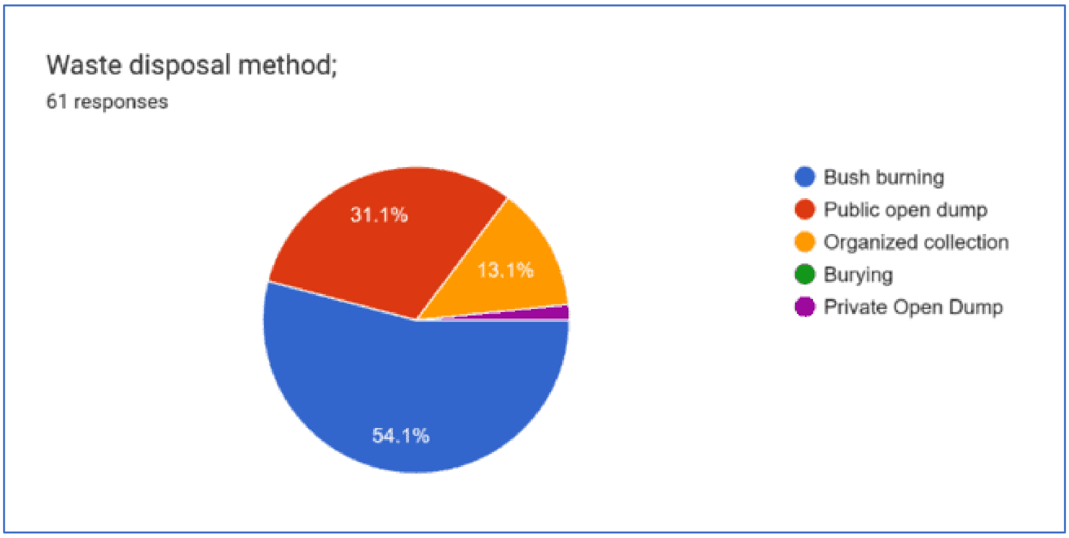


Figure 4.65: Waste Disposal Methods Practiced within the Community/Institution

Traditional Economic Activities

The distribution of traditional economic activities practiced by members of the community and institution with a total of 71 respondents indicates that farming is the most dominant activity, accounting for 80.3% (57 respondents). This is followed by traditional craft work at 15.5% (11 respondents), while mining, fishing, and business activities each account for 1.4% (1 respondent each). The overwhelming predominance of farming reflects the agrarian nature of the broader community, consistent with the socio-economic profile of many semi-urban areas in northern Nigeria. Although the study area is influenced by educational and institutional activities, agriculture remains a key livelihood source, particularly among surrounding host communities. The relatively low engagement in other traditional activities suggests limited diversification within the traditional economic base.

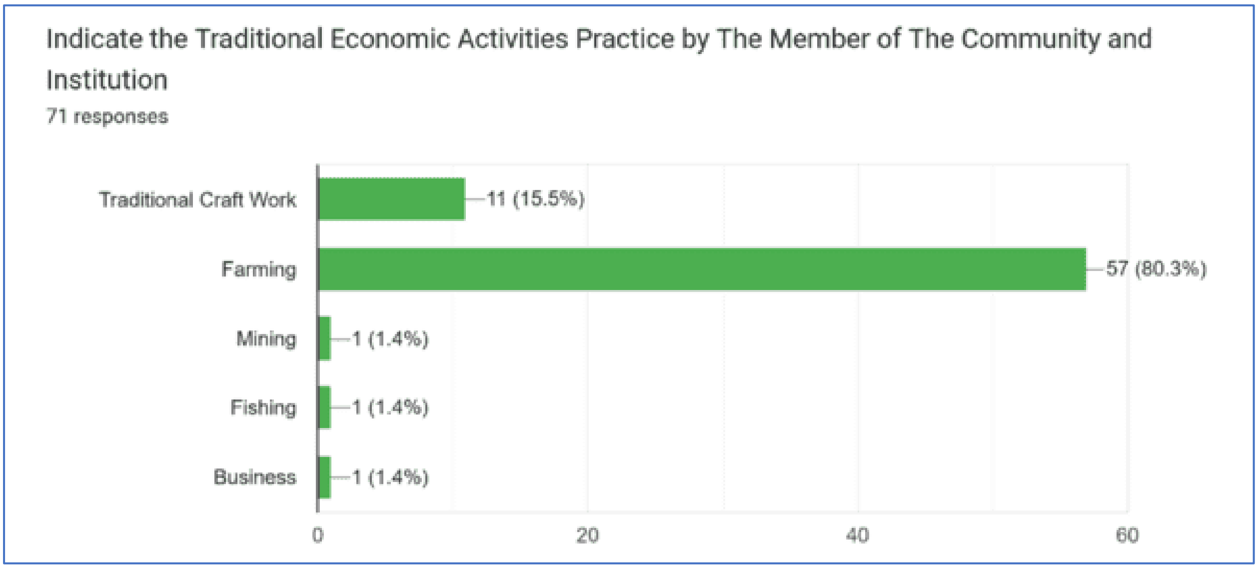


Figure 4.66: Traditional Economic Activities Practiced by Members of the Community/Institution

Traditional Laws and Spiritual Places

Regarding the observance of traditional laws and spiritual places, with a total of 71 respondents, 52.1% of respondents indicated that such traditions are still strictly observed, while 47.9% stated that they are not. This nearly balanced distribution suggests that traditional norms and spiritual practices continue to play a role in community life, although their influence may be gradually evolving. The slight majority affirming strict observance indicates the continued relevance of cultural heritage and customary practices within the community. However, the substantial proportion who disagreed reflects the impact of modernization, education, and institutional presence on traditional belief systems. Overall, these findings highlight a community that maintains cultural identity while simultaneously adapting to contemporary socio-economic dynamics.

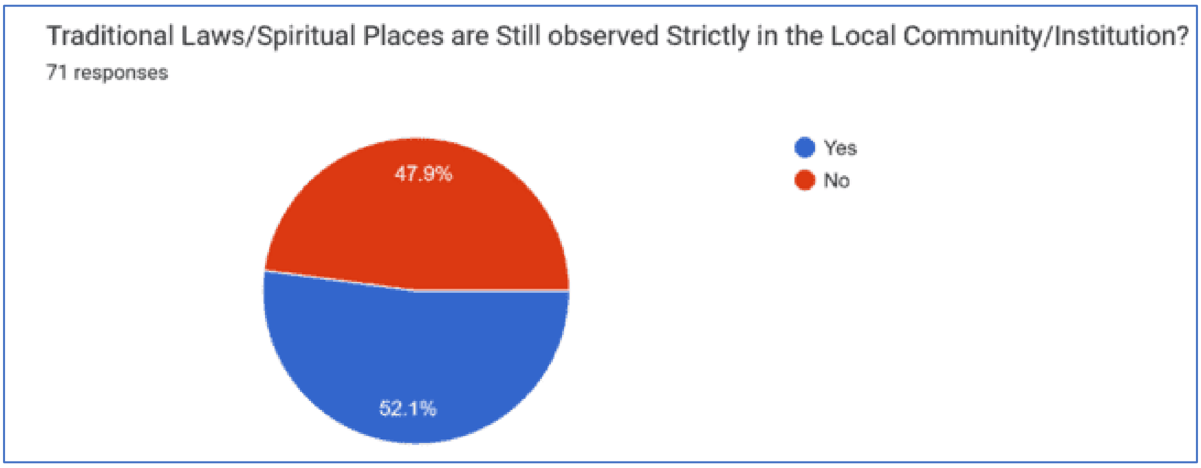


Figure 4.67: Observance of Traditional Laws and Spiritual Places within the Community/Institution

Affect Valued Resources, Cultural Assets, or Archaeological Sites

The responses regarding whether the proposed project will affect valued resources, cultural assets, or archaeological sites, with a total of 71 respondents indicate that 74.6% of respondents do not believe the project will have any effect, while 22.5% expressed concerns that it may have an impact**.** A very small proportion identified specific concerns such as farmland used for crop cultivation and school germination fields, or issues related to available electricity.

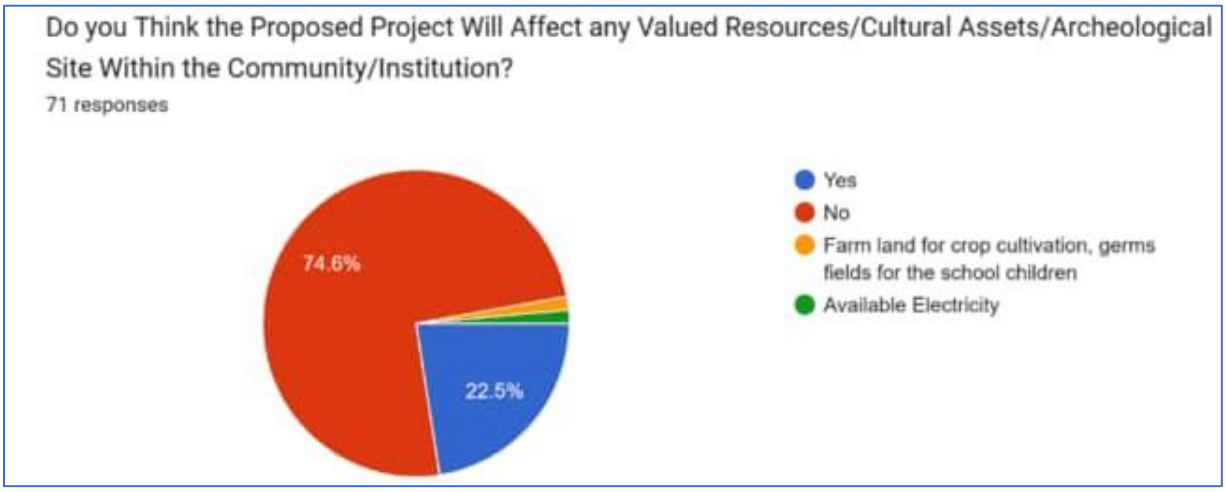


Figure 4.68: Respondents' Perception on Whether the Proposed Project Will Affect Valued Resources, Cultural Assets, or Archaeological Sites

The overwhelming majority who responded "No" suggests strong community confidence that the project will not interfere with culturally significant or heritage resources. This perception may be influenced by the location of the project within an institutional setting and the understanding that it is a renewable energy development with limited land disturbance.

Potential Effects Cultural Assets, or Archaeological Sites

Among respondents who expressed concern about potential effects, with a total of 65 respondents, 36.9% identified displacement as a possible impact**,** 35.4% cited vandalization**,** and 27.7% mentioned possible theft. These concerns reflect apprehensions related more to social and security risks than to direct destruction of cultural or archaeological assets. The relatively balanced distribution across these perceived risks suggests that community members are mindful of indirect impacts that could arise during construction or operation phases. Overall, while the majority perception is that the project poses minimal threat to valued resources, the expressed concerns highlight the importance of implementing adequate security measures, community engagement strategies, and careful site management to safeguard cultural and social assets.

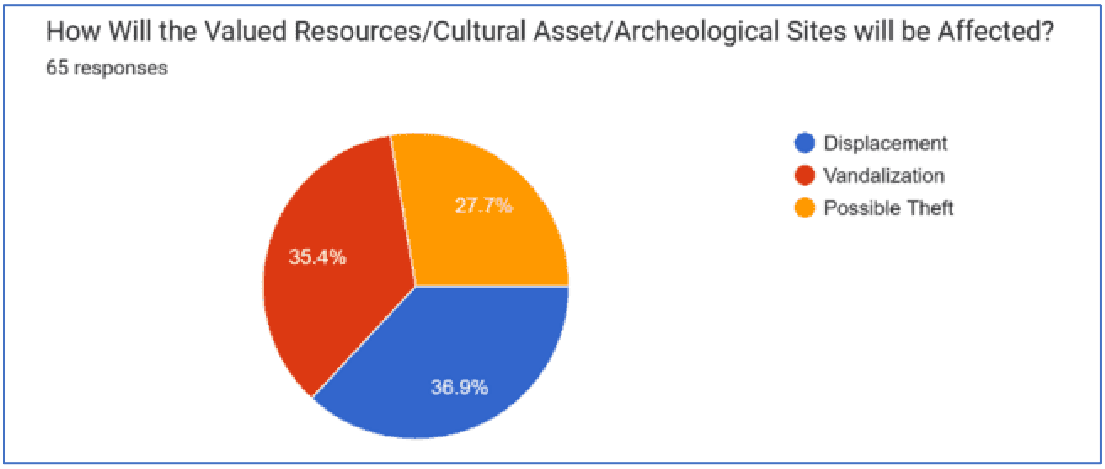


Figure 4.69: Perceived Ways in Which Valued Resources, Cultural Assets, or Archaeological Sites Could Be Affected

Community Awareness of the Proposed Project

The responses on community awareness of the proposed project, a total of 71 respondents indicate a nearly even distribution, with 50.7% of respondents affirming that members of the community are fully aware of the new project**,** while 49.3% believe they are not. This close margin suggests that awareness levels are moderate but not universal. While slightly more than half of the respondents perceive adequate awareness, the substantial proportion indicating limited awareness highlights the need for enhanced stakeholder engagement, information dissemination, and sensitization programs. Ensuring broader community understanding of the project's objectives, benefits, and potential impacts is essential for strengthening public trust and fostering inclusive participation.

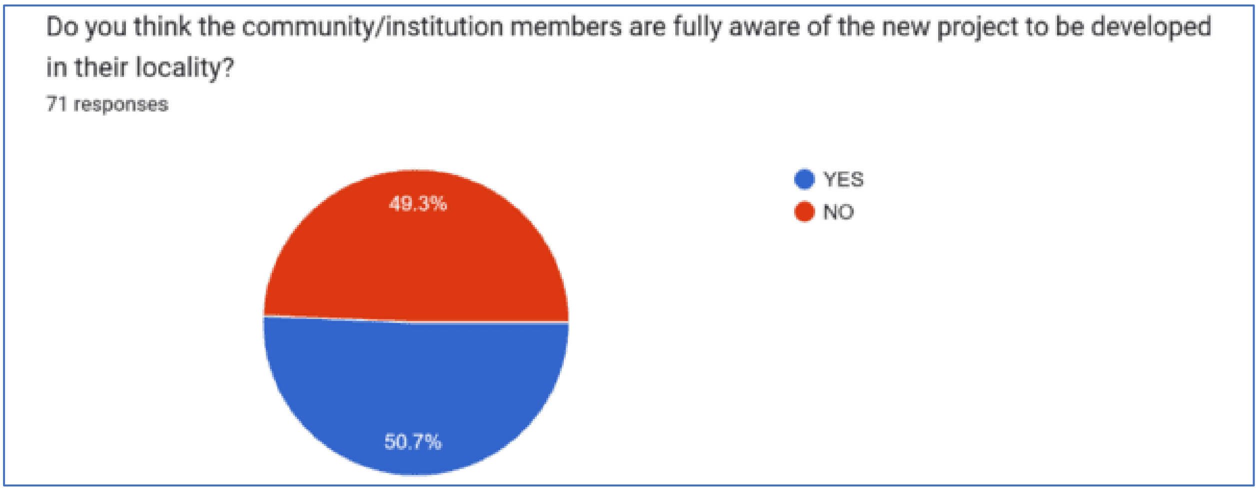


Figure 4.70: Respondents' Perception of Community Awareness of the Proposed Project

Regarding the perceived socio-economic benefits of the project, with a total of 69 respondents, 42% of respondents identified easy access to clean, reliable, and sustainable electricity as the primary benefit, followed by 37.7% who highlighted employment opportunities, and 24.6% who cited economic growth. A small proportion (1.4%) selected all of the above.

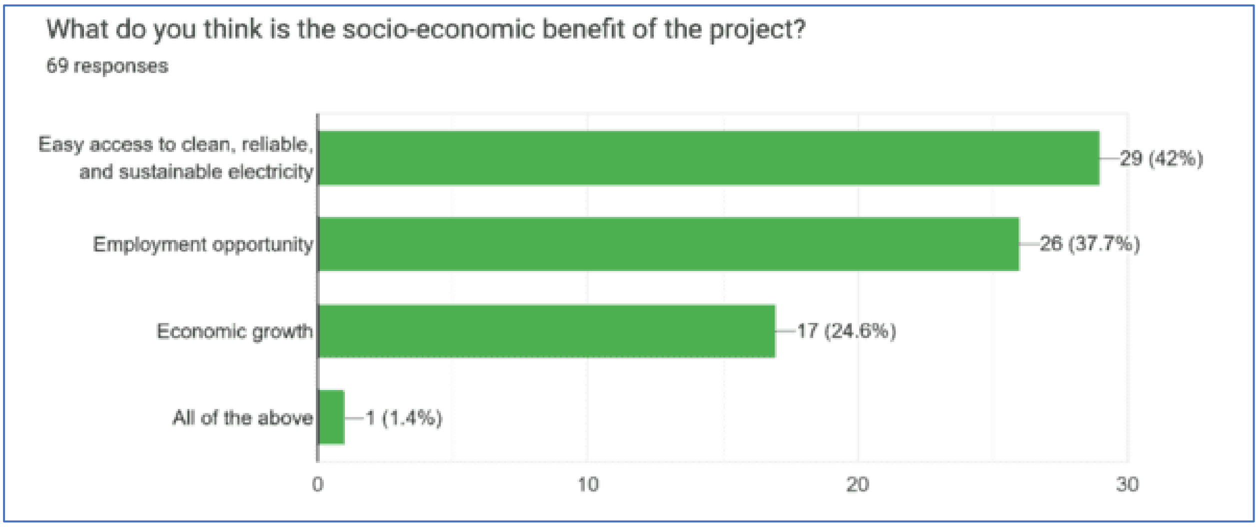


Figure 4.71: Perceived Socio-Economic Benefits of the Proposed Project

The findings indicate strong community expectations that the project will improve energy access, which is critical for institutional operations, business activities, and household welfare. The emphasis on employment opportunities further reflects the community's interest in job creation and economic empowerment. In all, the responses demonstrate positive perceptions of the project's developmental impact, particularly in enhancing energy security and stimulating local economic activities.

Social Associations Within the Community or Institution

The distribution of existing social associations within the community or institution with total of 70 respondents indicates that youth associations are the most prominent, accounting for 41.4% (29 respondents)**.** This is followed by farmers' associations at 34.3% (24 respondents) and women associations at 24.3% (17 respondents). The predominance of youth associations reflects the demographic structure of the community, likely influenced by the presence of educational institutions and a significant young population. The strong representation of farmers' associations further highlights the continued importance of agriculture as a key livelihood activity within the surrounding community. Meanwhile, the presence of women associations demonstrates organized platforms for female participation and empowerment. Overall, the results suggest an active civil and social structure within the community, which can serve as valuable entry points for stakeholder engagement, awareness campaigns, and project implementation activities.

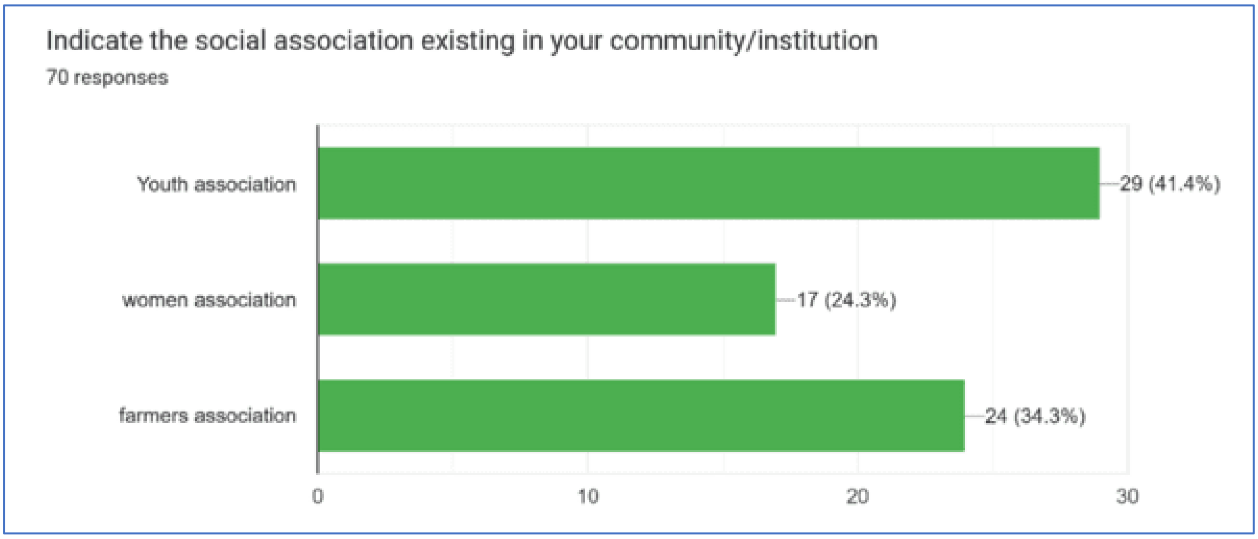


Figure 4.72: Social Associations Existing within the Community/Institution

Neighboring Communities/Institution to Benefit from the New Development Project

The distribution of responses on which neighboring communities or institutions are likely to benefit from the new development project shows that the Federal University of Education (FUE), Zaria received the highest proportion of responses (17.5%**,** indicating that it is perceived as the primary beneficiary of the project. Other notable communities identified include Gyallesu (8.8%)**,** FUE, Zaria (7.0%)**,** and Kongo (5.3%)**,** while several other surrounding communities such as Tudun Wada, Dembo and Dakace, Kwoyi, Sabon Gari, Amaru, and Jushi each accounted for smaller proportions (mostly between 1.8% and 3.5%). The wide range of communities mentioned suggests that respondents perceive the project's benefits as extending beyond the immediate project site to surrounding neighborhoods. This reflects expectations of broader socio-economic spillover effects, particularly in terms of improved electricity access, employment opportunities, and enhanced institutional development. Overall, the results indicate strong community perception that the project will have both direct and indirect benefits across multiple host and neighboring communities within the Zaria area.

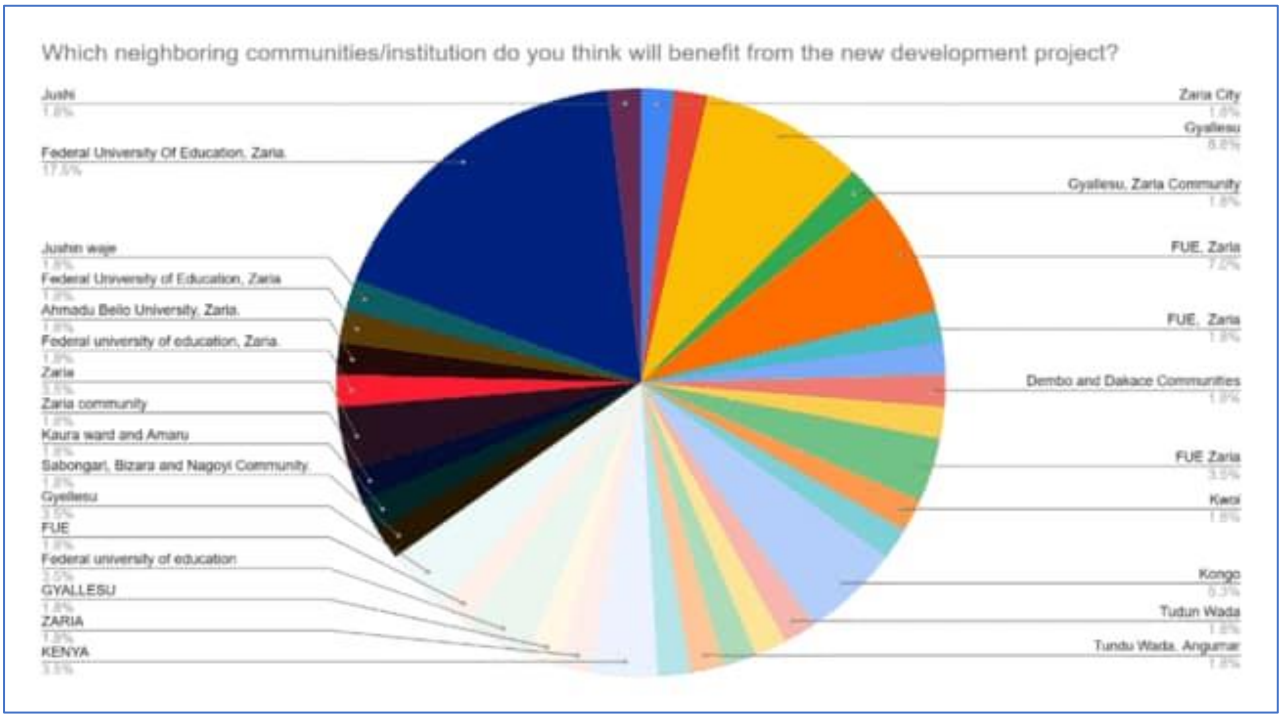


Figure 4.73: Neighboring Communities/Institutions Perceived to Benefit from the Proposed Development Project.

CHAPTER FIVE

ASSOCIATED AND POTENTIAL IMPACTS

5.0 Introduction

This chapter presents the potential environmental and social (E&S) impacts and risks associated with the proposed 2.0 MW solar-hybrid power plant and associated infrastructure in the Federal University of Education (FUE) Zaria, Kaduna State, under the Federal Government's Energizing Education Programme (EEP), a component of the Nigeria Electrification Project (NEP). It also includes the methodology employed to assess the significance of the E&S impacts and risks.

5.1 Impact Assessment Overview

The potential for an E&S impact exists where an environmental aspect has been identified i.e. where a project activity has been determined to have the potential to interact with the biophysical and socio-economic environment. The significance of each impact is then determined. Figure 5.1 illustrates the general overview of the impact assessment process employed for this ESIA.

The primary objectives of the impact assessment process are to:

- Establish the significance of identified potential impacts that may occur as a result of the proposed Project activities;
- Differentiate between those impacts that are insignificant and those that are significant; and
- Apply mitigation hierarchy measures for the identified significant impacts and assess residual impacts, including periodic monitoring of the effectiveness of the proffered mitigation measures through the entire life cycle of the Project.

The assessment of impact significance is both in qualitative and quantitative terms. Qualitatively, the impact significance is ranked on four (4) widely accepted levels: **Major**, **Moderate**, **Minor** and **Negligible.**

The impact assessment covers the entire life cycle of the Project. i.e.: pre- construction; construction; commissioning; operation; and decommissioning. However, environmental and social issues including mitigation and management plans related to decommissioning activities are discussed in Chapter 8.

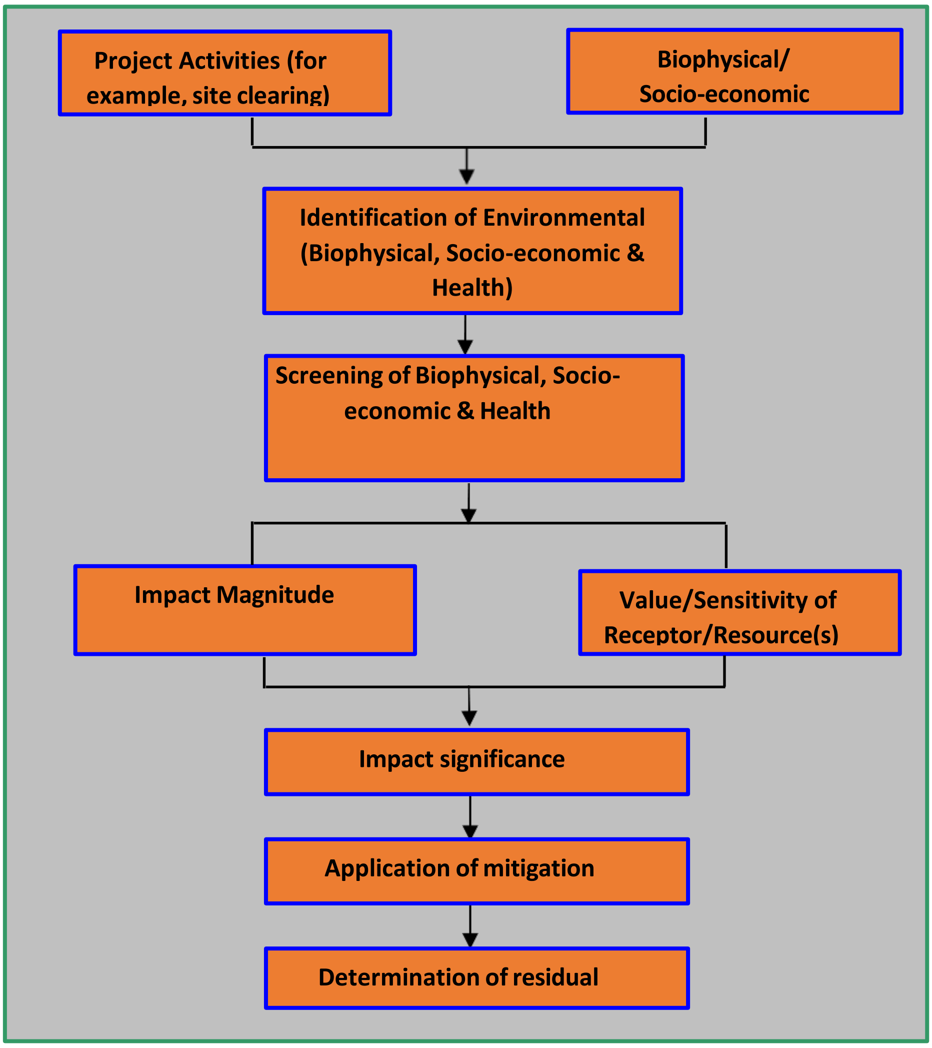


Figure 5.1: Overview of the Impact Assessment Process

5.2 Identification of Environmental and Socio-economic Aspects and Impacts

5.2.1 Defining Environmental and Socio-economic Aspects and Impacts

The International Organization for Standardization's Environmental Management Systems (EMS), ISO 14001, defines an environmental aspect as: *"An element of an organization's activities, products or services that can interact with the environment. while an* environmental impact is defined as: *"Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products or services."*

To identify environmental and social aspects of the Project, the proposed Project activities were considered in terms of their direct or indirect potential to:

- Interact with the existing natural environment including its physical and biological elements;

- Interact with the existing socio-economic environment; and
- Breach relevant policy, legal and administrative frameworks including national legislation, relevant international legislation/conventions, standards and guidelines, and corporate environmental policy and management systems.

Activities assessed covered planned and non-planned events.

Table 5.1 illustrates the links between project activity, environmental aspect and potential impact.

Table 5.1: Example of a Link between Activities, Environmental Aspects and Impacts

Project Activity	Environmental Aspect	Potential Impact
Site clearing and Grading	Removal of vegetation	Loss of biodiversity/sensitive receptors
Installation of PV panels	Soil excavation	Soil erosion and degradation
	Noise generation	Disturbance to surrounding environment and/or sensitive receptors

5.2.2 Potential Impact Characteristics

The following characteristics were also used to define potential impacts that may be associated with the proposed Project:

i. *Negative:* An impact that is considered to represent an adverse change from the baseline or to introduce a new undesirable factor.

ii. *Positive:* An impact that is considered to represent an improvement to the baseline or to introduce a new desirable factor.

iii. *Direct*: Impacts that result from the direct interaction between a planned project activity and the receiving bio-physical and socio-cultural environment.

iv. *Indirect:* Impacts that result from other activities that are encouraged to happen as a consequence of the project.

v. *Temporary:* Temporary impacts are predicted to be of short duration, reversible and intermittent/occasional in nature

vi. *Short-term:* Short term impacts are predicted to last only for a limited period but will cease on completion of the activity, or as a result of mitigation measures and natural recovery

vii. *Long-term:* Impacts that will continue for the life of the project, but cease when the project stops operating.

viii. *Permanent:* Potential impacts that may occur during the development of the project and cause a permanent change in the affected receptor or resource that endures substantially beyond the project lifetime

ix. *On-site:* Impact that is limited to the project site.

x. *Local:* Impacts that affect locally important environmental resources or are restricted to a single (local) administrative area or a single community.

xi. *Regional:* Impacts that affect regionally important environmental resources or are experienced at a regional scale as determined by administrative boundaries.

xii. *National:* Impacts that affect nationally important environmental resources; affect an area that is nationally protected; or have macro-economic consequences

xiii. *Reversible:* An impact that the environment can return to its natural state

xiv. *Irreversible:* An impact that the environment cannot return to its original state, e.g. the extinction of an animal or plant species

xv. *Cumulative/Synergistic*: Potential impacts that may result from incremental changes caused by other past, present or reasonably foreseeable actions together with the project. This also includes synergy with other projects/infrastructure in the project area

xvi. *Residual:* Both environmental and social impacts that will remain after the application of mitigation measures to project impacts during each of the project phases.

5.2.3 Screening and Scoping for Potential Impacts

A modified version of the Leopold Interaction-matrix technique was employed to screen and scope for the potential impacts of the proposed Project on the environment. The basis for the screening was derived from the following:

- Knowledge of the Project activities as summarized in Table 5.2.
- Detailed information on the environmental and socio-economic setting of the Project's area of influence as documented in Chapter 4. The potential environmental and social receptors/resources that could be affected by the proposed Project are summarized in Table 5.3.
- Consultation with relevant stakeholders including potentially affected community
- Review of other ESIA reports on similar projects/environments.
- Series of experts group discussions, meetings and experience on similar projects.

Table 5.2: Summary of the proposed Project Activities

S/N	Project Phase	Associated Activities
1.	Pre-Construction	Site selection
		Site clearing and preparation
		Mobilization of construction equipment and materials to site
2.	Construction/ Installation	Civil work activities including excavation, trenching, cable laying, foundation, construction of building (e.g. training centre)
		Installation of power plant facilities such as PV panels, mounting structures, inverters, power storage batteries; upgrade of existing distribution infrastructure; installation of streetlights
		Waste generation and disposal
3.	Commissioning	Testing of power plant and associated infrastructure
4.	Operation	Power generation (through PV panels) and distribution; provision of training on renewable energy
		Routine maintenance including occasional cleaning of PV panels; waste generation

Note: Activities related to decommissioning are discussed in Chapter 8

Table 5.3: Resource/Receptors and Impacts Indicators Considered

Environmental Receptor/Medium	Comment	Impact Indicators
Physical		
Air (REC-01)	Ambient air quality within the Project's area of influence.	Localized deterioration in ambient air quality within and immediately around active construction areas, primarily from dust-generating activities, vehicle movement and exhaust emissions. Impacts are expected to be greatest during site preparation, earthworks and construction and to reduce rapidly with distance from the source. Key parameters include TSP/PM_{10}, $PM_{2.5}$, CO, NO_2 and SO_2, assessed against applicable ambient air-quality limits.
Noise (REC-02)	Ambient noise level within the Project's area of influence.	Localized and temporary increase in ambient noise levels around active construction areas due to construction equipment, machinery and vehicle movement. Noise impacts are expected to decrease with increasing distance from the source and will be most pronounced during daytime construction activities. Key parameter is equivalent continuous sound level, LAeq (dB(A)), assessed against applicable daytime and nighttime noise limits.
Soil (REC-03)	Soil environment within the Project site and its surrounding environment.	Localized alteration of soil properties and soil structure within areas subject to vegetation clearance, excavation, grading and construction activities. Potential changes include soil compaction, loss of topsoil, increased erosion and localized contamination from accidental spills of fuels, oils or other materials. Key parameters include pH, moisture, electrical conductivity, organic matter/TOC, TPH and relevant heavy metals, assessed against applicable soil-quality criteria

Environmental Receptor/Medium	Comment	Impact Indicators
		where available.
Groundwater/Aquifers (REC-04)	Underground water resources within the Project's area of influence.	Potential localized alteration of groundwater quality arising principally from accidental release of fuels, oils, chemicals, wastes or other contaminants during construction and operation. Groundwater abstraction for Project activities may also result in a localized change in groundwater availability if sustained at significant volumes. Key parameters include pH, EC, TDS, turbidity, major ions, nutrients, microbiological indicators, heavy metals and hydrocarbons, assessed against applicable groundwater-quality standards.
Surface Water (REC-05)	The seasonal surface-water body identified during the baseline investigation is located outside the Project's 500 m AoI and is therefore not expected to be influenced by Project activities. The samples collected from this location provide supplementary baseline information on nearby surface-water conditions.	No direct or indirect Project-related impact is anticipated because the identified surface-water resource is outside the Project AoI and has no established pathway of influence from Project activities.
Landscape/Topography (REC-06)	The geomorphological landforms and terrain of the Project site and its surrounding environment.	Localized alteration of the existing landform, surface drainage and visual character within the Project footprint arising from site preparation, grading, excavation, foundations, equipment installation and associated infrastructure.
Biological		
Terrestrial Flora and Habitats (REC-07)	Plant species and terrestrial habitats within the Project's area of influence.	Localized loss or disturbance of vegetation and terrestrial habitat within areas requiring clearing for the Project infrastructure. Impacts will be concentrated within the approved Project footprint and will be minimized by restricting vegetation clearance to areas required for construction.
Terrestrial Fauna (REC-08)	Terrestrial fauna within the Project's area of influence.	Localized and temporary disturbance or displacement of terrestrial fauna resulting from vegetation clearance, construction noise, human presence, lighting and vehicle movement. Impacts are expected to be concentrated within and immediately around active construction areas.
Socio-economic Environment		
Land Use (REC-09)	Existing land use within the Project site and its surrounding environment. The entire Project area is owned and controlled by the University. No privately owned land will be acquired and no household or other physical displacement is required for Project implementation.	
Livelihoods and Access to Economic Resources (REC-10)		

Environmental Receptor/Medium	Comment	Impact Indicators
Visual Prominence (REC-11)	The aesthetic quality of the proposed Project on the surrounding visual catchment.	Localized alteration of the visual character of the Project site arising from the introduction of PV panels, mounting structures, inverters, batteries and associated infrastructure. Potential visual prominence and panel reflection will be greatest within the immediate visual catchment.
Demography (REC-12)	Demographic characteristics of communities and populations within the Project's area of influence.	No significant adverse demographic change is anticipated. Temporary increases in the number of workers and other project-related personnel may occur during construction but are expected to be localized and temporary.
Utilities (REC-13)	Existing utilities (e.g. power supply, water, sewer services, etc.) within the Project's area of influence.	Potential localized disruption or accidental damage to existing institutional utilities during excavation, construction and connection works. The operational phase is expected to improve electricity reliability within the University.
Infrastructure (REC-14)	Existing infrastructure such as roads, waste-handling facilities and other relevant infrastructure within the Project's area of influence.	Localized and temporary pressure on existing access roads and infrastructure during construction due to movement of workers, vehicles and construction materials. Potential risks include road deterioration, traffic obstruction and accidental damage to existing infrastructure.
Employment/Income (REC-15)	The employment situation within the Project's area of influence.	Temporary increase in employment and income opportunities during construction through engagement of local workers and service providers. Additional opportunities may arise during operation and maintenance, although at a lower scale.
Gender (REC-16)	Gender considerations and potential disproportionate gender impacts associated with Project activities.	Potential localized gender-related risks associated with recruitment, labour conditions and interaction between workers and the University community, including discrimination, unequal employment opportunities and GBV/SEA/SH risks.
Other (Health and Safety)		
Construction Workers (REC-17)	Health and safety of construction workers.	Potential for localized occupational health and safety impacts including injuries, falls, exposure to dust and noise, traffic-related incidents, electrical hazards, manual-handling injuries and fire during construction.
Workplace Health and Safety (REC-18)	Health and safety of employees involved in the operational phase of the Project.	Potential for localized occupational risks during operation and maintenance, particularly electrical hazards, working at height, battery-related hazards, heat exposure, fire and maintenance-related injuries.
General Public (REC-19)	Health and safety of the general public.	Potential localized risks to members of the University community and visitors arising from construction traffic, restricted access, open excavations, electrical infrastructure, fire and other project-related hazards.

Identified Project activities, biophysical and socio-economic receptors were integrated into a matrix. The Project activities are on the y-axis while the biophysical and socio-economic receptors are on the x-axis. The matrix was completed for each of the Project elements. The Leopold's Interaction matrix was subsequently assessed to identify every possible case of activity-receptor interaction. Where it was considered that an activity-receptor interaction was possible, the cell was marked denoting an identified environmental aspect (denoted as "X" in Table 5.4).

Table 5.4: Activity-Receptor Interaction for Impact Screening

Summary of Project Activities at various Phases	Receptors																
	Physical						Biological		Socio-economic						Others (Health and Safety)		
	Air Quality (REC-01)	Ambient Noise (REC-02)	Soil (REC-03)	Groundwater and Aquifers (REC-04)	Surface Water (REC-05)	Landscape/ Topography (REC-06)	Terrestrial Flora (REC-07)	Terrestrial Fauna (REC-08)	Land Use (REC-09)	Population (REC-12)	Utilities (REC-13)	Infrastructure (REC-14)	Employment/ Income (REC-15)	Gender (REC-16)	Construction workers (REC-17)	Workplace health and safety (REC-18)	General Public (REC-19)
Pre-construction Phase																	
Site selection									X								
Site clearing and preparation	X	X	X			X	X	X					X		X		
Mobilization of construction equipment and materials to site	X	X										X	X				X
Construction Phase																	
Civil work activities including excavation, trenching, cable laying, foundation, construction of building (e.g. training centre)	X	X	X	X	X					X			X	X	X		X
Installation of power plant facilities, upgrade of existing distribution infrastructure, installation of streetlights	X	X	X											X	X		
Waste generation and disposal			X	X								X	X		X		X
Commissioning Phase																	
Testing of power plant and associated infrastructure		X								X		X			X		X
Operational Phase																	
Power generation and distribution and provision of training on renewable energy		X											X	X		X	X
Routine maintenance; waste generation and disposal	X		X	X		X					X	X	X	X		X	X

Note: Decommissioning is separately covered in Chapter 8

Determination of Impact Significance

Once all environmental aspects (and interactions between a receptor/resource and Project activity) were identified, the levels of impacts that may result from the proposed Project activities were assessed. Three (3) stages were utilized to establish significance of impacts as follows:

- **Impact Magnitude** which is a function of the combination of the following impact characteristics: extent, duration, scale and frequency;

Value/Sensitivity/Fragility and importance of the relevant Receptor;

- **Identification of the impact significance,** which is the "product" of a combination of the above two (2) key variables.

Impact Magnitude

The magnitude designations employed for potential negative impacts are: **Negligible**; **Low**; **Medium**; and **High**. In the case of a positive impact, it is considered sufficient for the purpose of the impact assessment to indicate that the Project is expected to result in a positive impact, thus no magnitude designation is assigned.

The magnitude of an impact takes into account the various dimensions of a particular impact in order to make a determination as to where the impact falls on the spectrum from Negligible to High. These criteria are discussed further as follows:

Determining Magnitude for Biophysical Impacts

For biophysical impacts, the quantitative definitions for the spatial and temporal dimension of the magnitude of impacts used are summarized in the following paragraphs:

A **High Magnitude Impact** is considered to affect an entire area, system (physical), or species (biological) and at sufficient magnitude to cause a significant measureable numerical increase in measured concentrations when compared with national or international limits specific to the receptors) or a decline in species abundance beyond which natural process would not return that population or species, to its former level within several generations.

A **Medium Magnitude Impact** affects a portion of an area, system, aspect (physical), population or species (biological) and at sufficient magnitude to cause a measurable numerical increase in measured concentrations or levels (when compared with national or international limits and standards specific to the receptors) and may bring about a change in species abundance, but does not threaten the integrity of that population or any population dependent on it.

A **Low Magnitude Impact** affects a specific area, system, aspect (physical), group of localized individuals within a population (biological) and at sufficient magnitude to result in a small increase in measured concentrations or levels (when compared with national or international limits and standards specific to the receptors) over a short time period, but does not affect other trophic levels or the population itself), and localized area.

A Negligible Magnitude Impact: Some impacts will result in changes to the environment that may be immeasurable, undetectable or within the range of normal natural variation. Such changes can be regarded as essentially having no impact, and are characterized as having a very low or negligible magnitude.

Determining Magnitude for Socio-economic Impacts

For socio-economic impacts, the magnitude considers the perspective of those affected by taking into account the likely perceived importance of the impact, the ability of people to manage and adapt to change and the extent to which a human receptor gains or loses access to, or control over socio-economic resources resulting in a positive or negative effect on their well-being. The quantitative elements are included into the assessment through the designation and consideration of scale and extent of the impact. Table 5.5 below presents the impact magnitude criteria for socio-economic and health impacts.

Table 5.5: Impact Magnitude Criteria for Socio-economic Impacts

Category	Ranking	Definition
High	4	▪ Major impacts on human health (e.g. serious injury). ▪ Significant impact on the livelihoods of individuals (i.e. access to income source restricted over lengthy period of time). ▪ Serious impact on access to community facilities and utilities ▪ Breach of economy social policy and/or regulation.
Medium	3	▪ Modest impact on human health and well-being. ▪ Moderate impact on individual livelihoods (e.g. restricted access to income source). ▪ Medium impact on access to community facilities and utilities (e.g. access to utilities restricted for long periods (weeks) of time). ▪ Potential breach of company social policy and/or legislation.

Category	Ranking	Definition
Low	2	▪ Limited impact on human health and well-being (e.g. occasional dust, odour, traffic noise). ▪ Some impact on the livelihoods of individuals (e.g. isolated incidents related to ethnic tensions and some restrictions on access to income source). ▪ Some impact on access to community facilities and utilities (e.g. access to cultural centers restricted to a limited extent, i.e. (days).
Negligible	1	▪ Possible nuisance to human health and well-being (e.g. occasional unpleasant odours) ▪ Inconvenience experienced in accessing community facilities and utilities (e.g. electricity supply disruption for short (hours) period of time). ▪ No impact on livelihood, community facilities and human health.
Positive	+	▪ Beneficial improvement to human health. ▪ Benefits to individual livelihoods (e.g. additional employment opportunities). ▪ Improvements to community facilities/utilities. ▪ Increased economy (e.g. local procurement, sourcing of supplies).

Determining Receptor Sensitivity

In addition to characterizing the magnitude of impact, the other principal variable necessary to assign significance for a given impact is the value, and sensitivity/fragility of the receptor. This refers to economic, social, and/or environmental/ecological importance of the receptor, including reliance on the receptor by people for sustenance, livelihood, or economic activity, and to the importance of direct impacts to persons associated with the resource.

The receptors-sensitivity designations employed in this impact assessment process are **Low**, **Medium** and **High** which are universally acceptable.

The sensitivity/fragility/value/importance criteria for biophysical and socio- economic receptors are defined in Table 5.6.

Table 5.6: Bio-physical and Socio-economic Receptor-Sensitivity/ Fragility/ Value Criteria

Category	Ranking	Definition
Physical (for example, air quality)		
High	3	All ambient conditions/concentrations exceed guideline limits and are indicative of the resource being impacted or polluted. There is no (or very little) assimilation capacity for increased concentrations/ change in conditions.
Medium	2	Some ambient conditions/concentrations exceed guideline limits while others fall within the limits. There is some small assimilation capacity for increased concentrations/ change in conditions. Resource use does affect other users

Category	Ranking	Definition
		Physical (for example, air quality)
Low	1	All ambient conditions/concentrations are significantly lower than guideline limits and there is capacity for assimilation for additional concentrations/ change in conditions. Resource use does not significantly affect other users.
		Biological (for example, terrestrial ecology)
High	3	Specifically protected under Nigerian legislation and/or international conventions such as International Union for Conservation of Nature (IUCN); considered to be of critical importance to the local use; and totally dependent on for livelihood or means of survival.
		Physical (for example, air quality)
Medium	2	Not protected or listed but may be a species common globally but rare in Nigeria with little resilience to ecosystem changes, important to ecosystem functions, or one under threat or population decline; considered to be of moderate importance to the local use; and partially dependent on for livelihood or means of survival.
Low	1	Not protected or listed as common / abundant; or not critical to other ecosystem functions; considered to be of minor importance to the local use; and local communities do not depend on the resources for livelihood.
		Socio-economic and Health
High	3	Those affected will not be able to adapt to changes and continue to maintain pre-impact status.
Medium	2	Able to adapt with some difficulty and maintain pre-impact status but only with a degree of support.
Low	1	Those affected are able to adapt with relative ease and maintain pre-impact status.

Significance

The significance of the impact is determined by calculating the "product" of impact magnitude and severity/fragility/value/importance of the relevant receptor(s). Figure 5.2 illustrates the process for combining the impact magnitude with the receptor sensitivity.

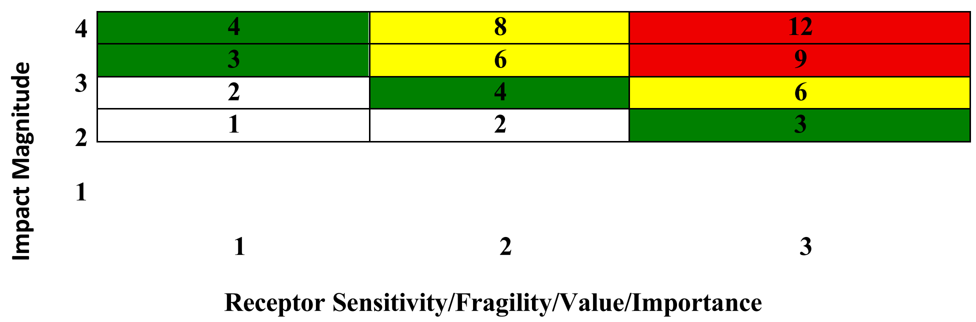


Figure 5.2: Impact Magnitude-Receptor Sensitivity Product Result

Based on its impact magnitude-receptor sensitivity/fragility/value score, each impact was again ranked into four (4) categories of significance as illustrated in Table 5.7.

Table 5.7: Environmental Impact Significance Rankings

Ranking (Impact Magnitude x Sensitivity of Receptor)	Significance
9 – 12	Major
6 – 8	Moderate
3 – 5	Minor
1 – 2	Negligible

Negligible Significant impacts are where a resource or receptor will not be affected in any way by a particular activity or the predicted effect is deemed to be 'negligible' or 'imperceptible' or is indistinguishable from natural background variations.

An impact of minor significance is one where an effect will be experienced, but the impact severity is sufficiently low (with or without mitigation) and well within accepted standards, and/or the receptor is of low sensitivity/value.

An impact of moderate significance is one within accepted limits and standards. Moderate impacts may cover a broad range, from a threshold below which the impact is minor, up to a level that might be just short of breaching a legal limit. The emphasis for moderate impacts is therefore on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable (ALARP).

An impact of major significant is one where an accepted limit or standards may be exceeded, or high magnitude impact occurs to highly valued/sensitive receptors/resources.

Determining the Significance of Potentials Impacts of the Project

To assist in calculating the overall significance of each of the identified potential impacts, expert discussions were constituted. They employed extensive use of screening matrices and predefined criteria for impact magnitude and sensitivity/fragility/value/importance of resources/receptors. The significance was then developed as seen in Table 5.8.

Table 5.8: Leopold's Activity-Receptor Interaction Matrix (Impact Significance Matrix)

Summary of Project Activities at various Phases	Receptors																
	Physical						Biological		Socio-economic						Others (Health and Safety)		
	Air Quality (REC-01)	Ambient Noise (REC-02)	Soil (REC-03)	Groundwater and Aquifers (REC-04)	Surface Water (REC-05)	Landscape/ Topography (REC-06)	Terrestrial Flora (REC-07)	Terrestrial Fauna (REC-08)	Land Use (REC-09)	Population (REC-12)	Utilities (REC-13)	Infrastructure (REC-14)	Employment/ Income (REC-15)	Gender issues (REC-16)	Construction workers (REC-17)	Workplace health and safety (REC-18)	General Public (REC-19)
Pre-construction Phase																	
Site selection									3(2)								
Site clearing and preparation	2(2)	2(2)	2(2)			2(1)	3(1)	3(1)					+		2(2)		
Mobilization of construction equipment and materials to site	2(2)	2(2)										2(2)	+				2(2)
Construction Phase																	
Civil work activities including excavation, trenching, cable laying, foundation, construction of building (e.g. training centre)	2(2)	2(2)	3(1)	2(2)	2(2)					3(2)			++	2(3)	2(3)		2(3)
Installation of power plant facilities, power storage batteries, upgrade of existing distribution infrastructure, installation of streetlights	2(2)	2(2)	3(1)											2(3)	2(3)		
Waste generation and disposal			2(2)	2(2)								2(1)	+		2(2)		2(2)
Commissioning Phase																	
Testing of power plant and associated infrastructure		2(1)								1(1)		1(1)			2(3)		2(2)
Operational Phase																	
Power generation and distribution and provision of training on renewable energy		2(1)											++	2(3)		2(3)	2(3)
Routine maintenance; waste generation and disposal	2(2)		2(2)	2(2)		2(2)					2(1)	1(2)	+	2(1)		2(2)	2(2)

Note: Decommissioning is separately covered in Chapter 8

The value assigned to each cell in the matrix is in the form "x (y)": where "x" denotes the impact magnitude and "y" the sensitivity/fragility/importance of receptor Impact magnitude ranking: 1 = Negligible; 2 = Low; 3 = Medium; 4 = High.

Impact sensitivity raking: 1 = Low; 2 = Medium; 3 = High.

Impacts Discussion

Potential Positive Impacts

The proposed Project seeks to provide independent and reliable power supply to Federal University of Education (FUE) Zaria, Kaduna through a renewable (solar) energy source and thus, enhance learning and institutional operations. It also forms part of the measures in ensuring that Nigeria achieves its carbon emission reduction targets (20% - 30% carbon emission reduction by the year 2030) as contained in Nigeria's Nationally Determined Contributions (NDC) on climate change. In line with the Federal Government's plans for Power Sector reform, the Project will assist to promote stronger relationship and collaboration between the Federal Government of Nigeria (FGN), Nigerian Universities, REA, and other relevant regulatory bodies.

Another component of the proposed Project is the construction of a world-class renewable energy workshop/training centre within the Project site. The facility will enhance learning in renewable energy in the University thus leading to certification. Also, the installation of streetlights as part of the proposed Project will boost safety and security within the University.

In addition, the Project will improve social economic activities within the University and help to enhance internally generated revenue. Furthermore, there are employment opportunities associated with the proposed Project for skilled, semi- skilled and unskilled workforce. The employment opportunities will lead to acquisition of new skills and introduction of all manners of income generating spill- over effects. For example, during the construction phase, about 4,000 workers would be engaged. The larger portion (60%) of the workforce (especially semi- skilled and unskilled craftsmen) would be drawn from the Project area.

Other potential benefits of the proposed Project include increase in local and regional economy through award of contracts and purchase of supplies for Project development as well as waste management.

Potential Negative Impacts

The potential negative impacts associated with the proposed Project are discussed under the following headings:

- Potential impact of the proposed 2.0 MW solar-hybrid power plant and associated infrastructure

- Potential cumulative impacts

It is important to note that the significance of potential environmental and social impacts discussed in this section is without mitigation measures except those already built into the Project design. Implementation of additional mitigation measures (presented in Chapter Six of this report) are expected to further reduce the impact rating as low as reasonably practicable.

Potential Impacts of the proposed Project

Pre-Construction Phase Activities

The pre-construction phase of the proposed Project includes the following activities:

- Site selection
- Site clearing and preparation
- Mobilization of equipment and materials to site

❖ Site Selection

The proposed Project will be sited on approximately 3.03 ha of land within the existing land property owned by FUE, Zaria. No additional land take, either from a private or public property, will be expropriated for the Project.

The impact significance of site selection for the proposed Project on the existing land use is rated **moderate**.

❖ Site Clearing and Preparation

The Project site will be cleared of vegetation prior to construction activities. The site clearing activities would likely involve the use of earth moving equipment such as tractor. The potential impacts associated with the site clearing activities are discussed as follows:

Potential Impact on Terrestrial Flora and Fauna

Site clearing activities associated with the proposed Project will lead to loss of terrestrial flora on the Project site. The potential impact on the terrestrial flora is considered to be negative, direct, site specific and largely irreversible. The impact magnitude is considered to be medium considering that not all the land area (3.0 ha) will be cleared for the Project. However, the sensitivity/importance of the receptor is regarded as low since the Project site is a modified habitat, and none of the plant species identified within the Project site during the baseline survey was found to be endangered or threatened based on the International Union for Conservation of Nature (IUCN)-2018 classification scheme. Also, the local community has no direct or indirect ecosystem services that they benefit from the site. Furthermore, there are no protected/conservation areas within the site. The significance of the potential impact of site clearing on the existing terrestrial flora species of the Project site is therefore regarded as **minor.**

While the plant species are unable to avoid the point of impact, most fauna species may be able to migrate away from unfavourable areas. Animals are generally mobile and, in most cases, can move away from a potential threat. The tolerance levels of some animal species are of such a nature that surrounding areas will suffice in habitat requirements of species forced to move from areas of impact.

With regard to the clearing of the Project site for construction purpose, the potential impact on terrestrial fauna species may include loss of individual or localized population of fauna species or disturbance to avifauna species. This is unlikely to lead to a change in conservation status of the species since none of the fauna species (including avi-fauna) encountered or reported in the Project site belongs to the IUCN classification of threatened animal species which include those classified as critically endangered, endangered or vulnerable. The major fauna species observed on the site were mostly the birds nesting on some of the trees within the site. However, the site is not a designated bird nesting area. The sensitivity of the fauna species recorded on the Project site is thus regarded as low. The impact magnitude is considered to be medium given that the site clearing activities would not cover all of the approximately 3.0 ha of land allocated for the Project. The impact significance is thus considered **minor.**

<u>Potential Impact on Soil</u> (REC-03)

The proposed site clearing and preparation activities could potentially impact the soil environment of the Project site. The potential effects on soil include degradation due to site preparation e.g. compaction of soil as a result of the movement of earth moving equipment. Soil degradation is the removal, alteration, or damage to soil and associated soil forming processes, usually related to human activities. The stripping of vegetation or disturbance to the natural ground level over disturbance areas will negatively affect soil formation, moisture levels, soil density, soil chemistry, and biological activity. Uncontrolled site clearance of vegetation could lead to direct surface soil exposure and hence erosion of soil which could be significant.

The impact magnitude is considered as medium as the extent of soil erosion could be high, especially if the site clearing activities are carried out in the wet season. However, based on the results of laboratory analysis conducted on soil samples from the Project area, the Project site is not considered to be significantly prone to land- based erosion.

Mobilization of Construction Equipment and Materials to Site

<u>Potential Impact on Air Quality and Ambient Noise</u> (REC-01, REC-02)

Construction equipment and materials will be moved to the Project site prior to commencement of main construction activities. The potential biophysical impacts associated with the mobilization activities include decrease in ambient air quality of the Project area as a result of emissions from vehicles that will convey materials and equipment to site.

It is anticipated that the potential impacts will be similar to those experienced during site clearing activities. The capacity for assimilation of vehicular emissions and dust associated with the mobilization activities in the Project's area of influence is considered to be high. The overall impact significance of mobilization activities on the ambient air quality and noise of the Project area is rated **minor**.

<u>Potential Impact on Infrastructure (Road)</u> (REC-14)

Regarding community health and safety, the mobilization activities during the pre-construction phase of the Project could increase the traffic volume in the Project area (and potential for road accident) as a result of movement of vehicles in and out of the Project site. The social aspects of these activities could lead to accident, traffic congestion and annoyance from other road users in the area. The magnitude of the impact is considered low since the mobilization activities would be less than 1 week. The sensitivity of the receptors is adjudged as medium given that the existing vehicular movement in the University environment is high. The prominent means of transportation are cars, tricycles, and motorcycles while buses/trucks are rare. The impact significance is considered to be **minor**.

Potential Impact on Workers Safety (REC-17)

Mobilization of construction materials will involve off-loading of heavy consumables such as cement, gravel, etc. Injuries and accidents may occur especially when those involved are unskilled. It is expected that the potential impacts will be similar to those experienced during site clearing and preparation activities. The impact significance is considered to be **minor**.

Summary of Potential Negative Impacts Associated with Pre-Construction Phase

Table 5.9 summarizes the potential negative impacts associated with the pre-construction phase of the proposed Project.

Table 5.9: Summary of Potential Negative Impacts Associated with the Pre-Construction Phase

Activity	Receptor	Associated Impact	Significance
Site Selection	Land Use (REC-09)	• The proposed Project site is located entirely on land owned and controlled by the University; therefore, no acquisition of privately owned land or physical displacement of households is required. • The selection and allocation of the 3.03 ha Project footprint will result in a permanent change from the existing land use to solar-energy infrastructure. • Existing staff farming activities within the Project footprint will be discontinued following the agreed transition to alternative farming areas provided by the University Management. Affected staff will be permitted to harvest their existing crops before Project implementation.	**Negligible**
	Livelihoods and Access to Economic Resources (REC-10)		**Negligible**
Site Clearing and Preparation	Terrestrial Flora and Fauna (REC-07, REC-08)	• Localized removal of vegetation within the approved Project footprint. • Direct disturbance to vegetation and soil-dwelling organisms during clearing and site preparation. • Temporary disturbance or displacement of terrestrial fauna within and immediately around active work areas due to vegetation removal, human presence, equipment movement and noise.	**Minor**

Activity	Receptor	Associated Impact	Significance
		• Impacts will be restricted primarily to the Project footprint and immediate surroundings.	
	Soil (REC-03)	• Localized removal and disturbance of topsoil during clearing, grading and site preparation. • Soil compaction from movement of construction equipment and vehicles. • Increased susceptibility to soil erosion, particularly on exposed surfaces during rainfall. • Potential reduction in soil structure, infiltration and percolation capacity within disturbed areas. • Potential for localized soil contamination from accidental spills or leakage of fuel, oils and other substances.	**Minor**
	Air Quality (REC-01)	• Temporary and localized deterioration of ambient air quality due primarily to fugitive dust generated during vegetation clearing, grading, earth movement and movement of construction equipment. • Additional localized emissions of TSP/PM_{10}, $PM_{2.5}$, CO, NO_2 and SO_2 from diesel-powered equipment and vehicles. • Impacts are expected to be greatest within and immediately around active work areas and to decrease with distance from the source.	**Minor**
	Noise (REC-02)	• Temporary and localized increase in ambient noise levels from earthmoving equipment, vehicles and other site-preparation activities. • Noise impacts are expected to be greatest during active daytime construction and to decrease with increasing distance from the work area.	**Minor**
	Workers' Health and Safety (REC-17)	• Potential for occupational injuries and accidents associated with vegetation clearing, operation of machinery, manual handling, uneven terrain and other site-preparation activities. • Potential exposure to dust, noise, moving equipment and other occupational hazards.	**Minor**
Mobilization of Construction Equipment and Materials to Site	Air Quality (REC-01)	• Temporary and localized deterioration of air quality due to exhaust emissions from construction vehicles transporting equipment and materials. • Fugitive dust may be generated from vehicle movement on unpaved surfaces. • Relevant parameters include TSP/PM_{10}, $PM_{2.5}$, CO, NO_2 and SO_2.	**Minor**
	Noise	• Temporary increase in ambient noise levels from movement and operation of construction vehicles and equipment.	**Minor**

Activity	Receptor	Associated Impact	Significance
		• Impacts will be localized along the access routes and around the Project site and will occur primarily during mobilization activities.	
	Roads and Traffic Infrastructure (REC-14)	• Temporary increase in vehicular movement associated with transportation of construction equipment and materials. • Potential for localized traffic congestion, road-surface deterioration and traffic-related accidents, particularly during delivery and offloading activities.	**Minor**
	Workers' Health and Safety (REC-17)	• Potential for injuries and accidents during transportation, loading, unloading and positioning of construction equipment and materials. • Potential exposure to vehicle movement, lifting operations and manual-handling hazards.	**Minor**

Construction Phase

The construction phase of the proposed Project will include activities such as civil and electrical works (excavation, trenching, concrete mixing, etc.), installation of PV panels and associated components; construction of training centre; installation of streetlights, upgrade of existing electricity distribution infrastructure; and waste waste generation and disposal. The potential environmental and social impacts associated with the construction phase of the proposed Project are assessed and discussed as follows:

<u>Potential Impact on Surface water</u> (REC-05)

No surface water body occurs within the proposed Project footprint. Although there is a seasonal surface water body associated with the River Kubani tributary serving the irrigational farming area behind the University, it is located at a considerable distance from the proposed development sites and is not hydraulically connected to the Project area. Consequently, construction and operational activities are not expected to directly affect the surface water body. Potential impacts are therefore considered unlikely under normal operating conditions. Nevertheless, standard good construction practices, including proper waste management, fuel and chemical handling, and erosion and sediment control measures, will be implemented to prevent any accidental off-site migration of pollutants. Based on the baseline water quality assessment, which showed no detectable hydrocarbon contamination or elevated heavy metal concentrations, the potential impact on surface water is assessed as negligible, indirect, highly localized, and reversible, with an overall impact significance of **negligible**.

<u>Potential Impact on Terrestrial Flora and Fauna</u> (REC-07, REC-08)

The construction activities may potentially cause disturbance to flora and fauna species as a result of increase in human activity, noise level, creation of areas of bare soil, etc. which may alter the composition and diversity of plant species around the Project site and drive many fauna species away from the area. In addition, the potential for plant species invasion is likely to increase as a result of increase in areas of bare soil around the Project site. Also the disturbance associated with noise and movement of construction equipment and personnel at the Project site may deter bird species from the area and disrupt the breeding of avifauna. It may also lead to increased risk to species such as snakes, rodents and mammals. The sensitivity of the receptor is adjudged to be low. The Project area is not known as a migratory route for avifauna species based on desktop reviews and field observation. The impact significance is regarded as **minor**.

<u>Potential Impact on Hydrogeology and Groundwater Quality</u> (REC-04)

The construction activities could lead to potential impacts on hydrogeology of the Project area. These include increased sediment load in the drainage channels as a result of erosion; increased storm water runoff from a decrease in infiltration; and increased runoff from hardstanding areas. Groundwater may be impacted as a result of infiltration of contaminants associated with spills or leaks of fuels, oils and lubricants from construction vehicles and/or storage containers. Currently, there are no boreholes within the Project site and the nearest borehole to the Project is over 300m away. The results of laboratory analysis conducted on groundwater samples from existing boreholes in the Project area did not reflect any heavy metal and hydrocarbon pollution. It is not anticipated that construction activities will have any direct impacts on the underground aquifer in the project area. Therefore, the potential for groundwater contamination as result of construction activities is rated **minor**

The potential impact on the existing underground aquifer (water reserve) of the Project area as a result of water abstraction for construction activities such as concrete mixing and washing of construction equipment is considered to be **negligible** since the use of water for construction activities would be minimal. There are several boreholes within the University campus as noted during the site visit. The recharge of the existing boreholes in the Project area is largely due to direct precipitation. During the rainy season, the water reserve of the aquifer in the study area increases; thus, hand dug wells and boreholes yields improve significantly.

Potential impact on Gender

Construction activities in Nigeria are typically dominated by males which presents a major challenge for equal opportunities for women. Generally, the Nigerian construction sector has a particularly low participation rate for women, both in industry and academia. Key Informant Interviews (KII) and Focus Group Discussions (FGD) conducted within the local community revealed that although women are allowed to work and trade freely; they are underrepresented in leadership positions.

During construction activities, women may experience discrimination as most employment and training opportunities may be provided to men, while women will be left with menial jobs. This may result in marginalization due to lack of adequate training, thereby reinforcing gender stereotypes and gender pay gaps. Furthermore, there is the possibility of gender-based violence cases (GBV) against women employed to work at the Project site. However, FGD with the women in the local community revealed that GBV incidents are not frequent within the community. The FUE, Zaria management expressed their commitment to providing a safe and conducive environment for all women within the institution. Nevertheless, the sensitivity of gender impacts is rated high due to cultural and religious doctrine that is deeply rooted in the belief and customs of an average Northerner therefore, the impact significance is regarded as **moderate**.

Potential Impact on Socio-economic and Health (REC-12, REC-19)

Impacts associated with the construction phase of a project are usually of a short to medium term in nature, but could have long term effects on the surrounding environment. During construction, the proposed Project has the potential to affect the nearby community.

With regard to the presence of construction workers on site, the manner in which the workers conduct themselves can affect the local community in terms of disruption of existing family structures due to influx of migrant workers. The potential behaviour of construction workers, most especially male construction workers, may lead to an increase in levels of crime and drug and alcohol abuse, and an increase in incidence of casual sexual relations, which may result in increase in sexually transmitted disease (such as HIV/AIDS infections) and unwanted pregnancies. Additional pressure may also be placed on existing social infrastructure. Considering that the proposed number of workers (approximately 4,000) for the construction phase of the Project is relatively high, the potential risk to local family structures is regarded as high. Given that the majority of the construction workers, especially unskilled labour force would be drawn from the local community, the impact significance is considered to be **moderate**.

Potential Impact on Infrastructure (Road) (REC-14)

Regarding road infrastructure, the movement of construction vehicles in and out of the Project site during construction has the potential to increase road traffic and accidents. The impact magnitude is considered as low due to the minimal (about 2-3 daily) number of Project vehicles and trucks to be used during the construction phase. The impact sensitivity is rated medium. Therefore, the impact significance is considered **minor**.

Potential Impact on Construction Workers Safety (REC-17)

Construction sites are potentially hazardous place. Occupational accidents may occur especially when those involved are unskilled. Such occupational accidents may result in loss of man-hours which may ultimately affect the schedule date of completion of the Project development especially if the man-hour losses are high. Potential impacts to construction workers include increase in noise level and air emissions from construction activities, injuries, electrical shocks, accident, and denial of rights. The impact significance is considered **moderate**.

Waste Generation and Disposal

Potential Impact on Soil (REC-03)

Construction activities are associated with waste generation. The potential wastes to be generated during the construction phase of the Project include scrap metals, electrical cables, spent oils, damaged batteries, wood/planks, paper waste, food remnants, leftover sand and gravel, etc. The waste streams if not properly handled, could contaminate the soil environment within the Project site and its surrounding environment. The impact sensitivity of the soil environment of the Project area is low judging by the results of laboratory analysis conducted on the soil samples. The impact significance is considered to be **minor**.

Potential Impact on Groundwater (REC-04)

Groundwater may be impacted as a result of infiltration of contaminants associated with liquid wastes especially from damaged batteries and spent oils. The impact magnitude is considered low; the nearest existing groundwater source to the Project site is over 300m away. The results of laboratory analysis conducted on groundwater samples from existing boreholes in the Project area did not reflect any heavy metal and hydrocarbon pollution. The potential for groundwater contamination as result of waste disposal is rated **minor**.

Potential Impact on Infrastructure (Waste Management Facility) (REC-14)

Construction waste can potentially have impact on the existing waste management facility of the Project area. Domestic wastes in FUE, Zaria are collected by Kaduna State Environmental Protection Authority (KEPA) accredited waste collectors. However, construction wastes such as scrap electrical components, batteries, damaged/defective panels and electrical cables (e-waste) cannot be disposed of in such manner. These wastes shall be returned to the manufacturers based on a take-back scheme or recycled as appropriate. The quantity of domestic wastes designated for the dumping site will thus be low. The impact of the waste on the waste management facility of the Project area is considered **negligible**.

Summary of Potential Negative Impacts Associated with Construction Phase

Table 5.10 summarizes the potential negative impacts associated with the construction phase of the proposed Project.

Table 5.10: Summary of Potential Negative Impacts Associated with the Construction Phase

Activity	Receptor	Associated Impact	Significance
Civil and Electrical Works/Installation Activities	Air Quality (REC-01)	• Temporary and localized deterioration of ambient air quality due to exhaust emissions from construction equipment, machinery and vehicles. [ESMP-02] • Increased fugitive dust generation from exposed/cleared surfaces, excavation, material handling and movement of vehicles, particularly during dry and windy conditions. • Relevant parameters include TSP/PM_{10}, $PM_{2.5}$, CO, NO_2 and SO_2, with impacts expected to be greatest within and immediately around active construction areas and to decrease with distance from the source.	**Minor**
	Ambient Noise (REC-02)	• Temporary and localized increase in ambient noise levels due to operation of construction machinery, generators, vehicles and electrical installation equipment. • Noise impacts will be most pronounced during active daytime construction and are	**Moderate**

Activity	Receptor	Associated Impact	Significance
		expected to decrease with increasing distance from the Project site. • The key parameter is LAeq (dB(A)), assessed against applicable daytime and nighttime noise limits.	
	Soil (REC-03)	• Localized disturbance and compaction of soil arising from excavation, foundation works, equipment movement and installation activities. • Increased potential for soil erosion on exposed surfaces, particularly during rainfall. • Reduction in soil structural stability, infiltration and percolative capacity within disturbed and compacted areas. • Potential localized soil contamination from accidental spills or leakage of fuels, oils, concrete materials and other construction substances.	**Minor**
	Terrestrial Flora and Fauna (REC-07, REC-08)	• Localized disturbance or removal of vegetation within areas required for civil and electrical works. • Temporary disturbance or displacement of terrestrial fauna due to increased human activity, construction equipment, vehicle movement and associated noise. • Potential introduction or spread of non-native plant species through imported materials, equipment or construction activities, although this is expected to be limited within the highly modified Project environment.	**Minor**
	Groundwater/ Hydrogeology (REC-04)	• Potential localized reduction in groundwater availability due to abstraction for construction activities such as concrete mixing, equipment washing and other construction requirements, depending on the volume and duration of abstraction. • Potential localized deterioration of groundwater quality from accidental release of fuels, oils, chemicals, cementitious materials or improperly managed wastes. • Relevant parameters include pH, EC, TDS, turbidity, major ions, nutrients, heavy metals and hydrocarbons.	**Minor**
	Surface Water (REC-05)	• The seasonal surface-water body identified during the baseline investigation is outside the Project's 500 m AoI and has no established pathway of influence from the construction activities.	**Negligible**

Activity	Receptor	Associated Impact	Significance
		• Consequently, no direct or indirect construction-related impact on the identified surface-water resource is anticipated.	
	Gender (REC-16)	• Potential for gender-based discrimination or unequal access to employment opportunities during recruitment and engagement of construction workers. [ESMP-03] [RM-03] • Potential for GBV/SEA/SH risks associated with interactions between construction workers and members of the University community.	**Moderate**
	Socio-economic and Community Health (REC-12, REC-19)	• Temporary increase in the number of workers and other persons associated with construction activities may increase interaction with the University community. • Potential increase in risks associated with communicable diseases, including sexually transmitted infections (STIs), if appropriate preventive measures are not implemented. • Potential for temporary disturbance to normal University activities from construction traffic, noise and other project-related activities.	**Moderate**
	Roads and Traffic Infrastructure (REC-14)	• Temporary increase in vehicular movement associated with transportation of construction materials, equipment and personnel. [RM-01] • Potential for localized road-surface deterioration, traffic obstruction and road-traffic accidents, particularly during peak delivery and construction periods.	**Minor**
	Construction Workers' Health and Safety (REC-17)	• Potential for occupational injuries and accidents arising from excavation, lifting operations, electrical installation, working at height, machinery operation, vehicle movement and manual handling. [ESMP-04] • Potential exposure to dust, noise, heat, electrical hazards, fire and other construction-related occupational risks.	**Moderate**
Waste Generation and Disposal	Soil (REC-03)	• Potential localized deterioration of soil quality resulting from indiscriminate disposal of construction waste, accidental spills, leakage of fuels and oils, and inappropriate handling of hazardous materials. • Potential alteration of soil chemical properties in areas receiving improperly managed wastes.	**Minor**
	Groundwater (REC-04)	• Potential localized groundwater contamination through infiltration of	**Minor**

Activity	Receptor	Associated Impact	Significance
		contaminants from improperly managed solid waste, hazardous materials, fuels, oils and other construction wastes.	
	Waste Management Infrastructure (REC-14)	• Temporary increase in demand for waste-management facilities arising from generation of construction wastes, including packaging materials, scrap materials, excavated materials and other construction debris. • Improper disposal could place additional pressure on existing waste-management facilities; however, impacts are expected to remain limited where approved waste-management arrangements are followed.	**Negligible**

Commissioning Phase

Once the construction phase of the proposed Project is completed, the power plant and associated infrastructure will be tested to ensure that they have been installed according to the pre-design and operational requirements. During the commissioning, there could be increase in noise level due to humming noise emission from the plant components (inverters and batteries), vehicular movement (transportation of commissioning officials), crowd noise, and other ceremonial activities. The ambient noise levels recorded in the area during baseline data gathering were generally below the FMEnv and World Bank recommended limits. Also, considering that the commissioning activities would be short-termed and localized, the impact significance is rated **minor**.

Also, there is potential for occupational hazards during the facility testing as a result of any wrong electrical connection. The impact significance is considered to be **moderate** on the workers' health and safety.

The commissioning phase will lead to an influx of guest and officials which will have an impact on the existing population and infrastructure (road) of the Project area. Due to the short duration of the commissioning activities, the impacts are considered to be **negligible**.

Table 5.11 summarizes the potential negative impacts associated with the commissioning phase of the proposed Project.

Table 5.11: Summary of Potential Impact Associated with the Commissioning Phase of the proposed Project

Activity	Receptor	Associated Impact	Significance
Plant Testing	Ambient Noise (REC-02)	• Temporary increase in ambient noise levels associated with testing and	Minor

Activity	Receptor	Associated Impact	Significance
		operation of electrical and power-generation equipment. • Noise impacts are expected to be localized within the Project site and its immediate surroundings and limited to the duration of testing activities. • The magnitude of the impact is expected to decrease with increasing distance from the equipment and active testing areas.	
Plant Testing	Workers' Health and Safety (REC-17) (REC-12)	• Potential occupational health and safety risks during equipment testing, energization and commissioning, including electrical shock/electrocution, arc flash, equipment malfunction, falls and other injuries. [ESMP-04] [RM-04] • The risks are primarily associated with incorrect electrical connections, inadequate isolation, equipment failure or unsafe testing procedures.	Moderate
Population Influx	Local Population/Demography	• Temporary increase in the number of personnel present at the Project site during commissioning activities. • The increase is expected to be small, temporary and largely restricted to the Project workforce and specialist commissioning personnel, with no significant change to the demographic structure of the surrounding population anticipated.	Negligible
Population Influx	Community Health and Safety (REC-19) (REC-14)	• Limited potential for interaction between commissioning personnel and members of the University community. • Given the temporary and limited nature of commissioning activities, significant adverse effects on community health or safety are not anticipated.	Negligible
Commissioning-Related Movement	Roads and Traffic Infrastructure (REC-14)	• Temporary increase in vehicular movement associated with the movement of commissioning personnel, equipment and materials. [RM-01] • Potential for localized traffic disturbance and road-traffic accidents, although the volume and duration of commissioning-related traffic are expected to be limited.	Negligible

❖ ***Routine Maintenance, Waste Generation and Disposal***

<u>Potential Impact on Soil</u> (REC-03)

Routine maintenance of the Project facilities has the potentially for waste generation. Such wastes if not handled properly could lead to soil contamination. The major waste stream will be e-waste generated from spent/damaged components of the Project such as batteries, inverters and PV panels. These wastes will be stored within the Project site according to the manufacturer's instructions. All components to be used for the Project will have buy back agreements with the manufacturers as specified in the Extended Producer Responsibility Program (EPRP). The impact significance is considered to be **minor**.

Potential Impact on Groundwater (REC-04)

Potential impacts may include decrease in amount of groundwater reservoir as a result of water abstraction for cleaning of the PV panels. Cleaning of the PV panels is envisaged to be carried out about three (3) times during the raining reason and this would be more than three times during the dry season.

Based on previous experience, each panel would require approximately 5 litres of water per cleaning cycle. With an estimated number of 6,600 panels for 2.2 MW generation, it is envisaged that the proposed Project would consume approximately 16,500 litres of water per cleaning cycle. The water required for the cleaning purpose would be obtained from the existing boreholes within the University campus. Based on observations noted during the field survey and the estimated quantity of water required for occasional cleaning of the PV panels, water abstraction for the Project is not envisaged to have serious effect on the existing groundwater aquifer of the Project area as well as the local water use. Thus, the impact significance is considered **minor**.

Potential Impact on Occupational Health, and Safety of Workers (REC-18)

During routine maintenance, workers may be exposed to occupational health and safety issues (e.g. electrical and field exposure, shock hazards and mechanical injuries). The impact significance is considered to be **minor** primarily due to the low number of staff (approximately) required for maintenance activities and low frequency of maintenance.

Summary of Potential Negative Impacts Associated with Operation Phase

Table 5.12 below summarizes the potential negative impacts associated with the operational phase of the proposed Project.

Table 5.12: Summary of Potential Negative Impacts Associated with Operational Phase of the proposed Project

Activity	Receptor	Associated Impact	Significance
Power Generation and Distribution	Gender (REC-16)	• Potential for discrimination against women in employment, recruitment or advancement opportunities. [ESMP-03]	**Moderate**

Activity	Receptor	Associated Impact	Significance
		• Potential for GBV, including sexual harassment, exploitation and abuse, and other inappropriate workplace conduct. • Potential for unequal working conditions or treatment of female workers.	
Power Generation and Distribution	Socio-economic Environment (Visual Prominence) (REC-11)	• Permanent alteration of the visual character of the Project site resulting from the presence of PV panels, mounting structures, electrical equipment and associated infrastructure. • Visual effects will be localized primarily to the Project site and its immediate visual catchment and are expected to be compatible with the existing institutional character of the University environment.	**Minor**
Power Generation and Distribution	Community Health and Safety (REC-19)	• Potential exposure of workers and members of the University community to electromagnetic fields (EMF) associated with electrical equipment and power-distribution infrastructure. • EMF exposure is expected to be localized to areas surrounding the relevant electrical equipment and infrastructure and will be managed through appropriate equipment design, installation, restricted access and adherence to applicable exposure limits.	**Negligible**
Power Generation and Distribution	Health, Safety and Welfare of Staff During Plant Operation (REC-18)	• Potential for electric shock, electrocution, burns, falls and other injuries associated with operation of electrical equipment and power-generation infrastructure. [ESMP-04] [RM-04] • Potential work-related issues including discrimination, denial of workers' rights, unfair treatment and poor working conditions.	**Moderate**
Routine Maintenance, Waste Generation and Disposal	Soil (REC-03)	• Potential localized soil contamination from improper handling, storage or disposal of spent batteries, inverters, oils and other maintenance-related wastes. • The potential impact is primarily associated with accidental leakage or inappropriate disposal and will be confined largely to areas where such materials are handled or stored.	**Minor**
Routine Maintenance, Waste Generation and Disposal	Groundwater (REC-04)	• Groundwater abstraction for periodic cleaning of PV panels may result in a localized reduction in groundwater availability depending on the volume and frequency of water abstraction. • The significance will depend on the panel-cleaning frequency, number of panels, water requirement per cleaning cycle and sustainable yield of the borehole/aquifer.	**Minor**
Routine Maintenance, Waste Generation and Disposal	Soil and Groundwater (REC-03, REC-04)	• Potential localized contamination of soil and groundwater from accidental release, leakage or improper disposal of spent batteries, inverters, oils and other hazardous maintenance wastes. • Contamination pathways may include direct soil contact and subsequent infiltration to groundwater.	**Negligible**
Routine Maintenance and Maintenance Activities	Health, Safety and Welfare of Staff During	• Potential for electric shock, electrocution, burns, falls, manual-handling injuries and other occupational accidents during inspection, repair,	**Minor**

Activity	Receptor	Associated Impact	Significance
	Maintenance (REC-18)	replacement and maintenance of electrical and mechanical equipment. [ESMP-04] [RM-04] • Risks are expected to be localized to maintenance personnel and active maintenance areas.	

Potential Cumulative Impacts

Cumulative impacts are those impacts resulting from the combined effects of past, present or reasonably foreseeable actions owing to the project aspects and activities outside the project (GSI, 2003). The concept of cumulative effects is an important one. It holds that, while impacts may be small individually, the overall impact of all environmental changes affecting the receptors taken together can be significant. When a resource is nearing its tolerance threshold, a small change can push it over. The major existing activities around the Project area are farmlands and the university switchyard. Given the nature of the activities associated with the proposed Project and the existing activities around the project area, the potential cumulative impacts of the Project on road traffic, ambient noise levels and groundwater availability is considered **low**.

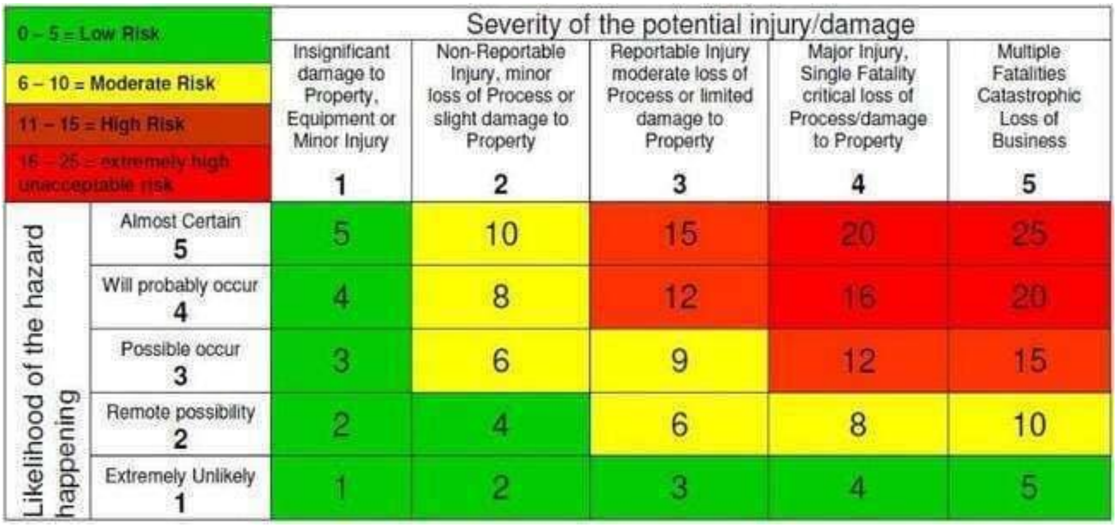
Risk and Hazard Assessment

Overview

Risk assessment is the determination of quantitative or qualitative estimate of *risk* related to a concrete situation and a recognized threat (also called hazard). The assessment of the risks and hazards associated with the proposed Project involves the following steps:

- Identification of hazards/risks
- Likelihood of occurrence
- Consequence/severity of the hazards

The risk assessment matrix is then developed as presented in Figure 5.3.



0 – 5 = Low Risk 6 – 10 = Moderate Risk 11 – 15 = High Risk 16 – 25 = extremely high unacceptable risk		Severity of the potential injury/damage				
		Insignificant damage to Property, Equipment or Minor Injury 1	Non-Reportable Injury, minor loss of Process or slight damage to Property 2	Reportable Injury moderate loss of Process or limited damage to Property 3	Major Injury, Single Fatality critical loss of Process/damage to Property 4	Multiple Fatalities Catastrophic Loss of Business 5
Likelihood of the hazard happening	Almost Certain 5	5	10	15	20	25
	Will probably occur 4	4	8	12	16	20
	Possible occur 3	3	6	9	12	15
	Remote possibility 2	2	4	6	8	10
	Extremely Unlikely 1	1	2	3	4	5

Figure 5.3: Risk Assessment Matrix

Project Specific Risks and Hazards

The potential risks and hazards associated with the proposed Project are described below:

<u>Fire and Explosion</u> (REC-18, REC-19)
The major risk associated with the operational phase of the Project is fire and explosion. PV systems are subject to electrical faults like any other electrical installation such as short circuits, ground faults and reverse currents. These faults and other failures of the system, including cable insulation breakdowns, rupture of a module, and faulty connections, can result in hot spots that can ignite combustible material in their vicinity. Wrongly installed or defect DC/AC inverters have been the reason of several photovoltaic fires as well.

Fire could possibly occur during operation of the power plant. Overcharging, high temperatures and physical stress to Lithium ion battery cells can cause thermal runaway, which commonly leads to the destruction of the battery, fire and even explosions. In addition deep discharging can also cause battery fires. Any outbreak of uncontrolled fire in the area can escalate to dangerous dimensions which could be critical. The hazard is classified as **high risk**.

Electrocution (REC-18, REC-19)
Electrocution from direct contact with high-voltage electricity or from contact with tools, vehicles, ladders, or other devices that are in contact with high-voltage electricity could occur during the Plant operation. The likelihood of the hazard happening is remotely possible and its severity if occurs may result into marginal consequence. The hazard is classified as **moderate risk**.

Occupational Hazards (REC-17, REC-18)

Workers may be exposed to occupational hazards when working at elevation during construction. Also, there could be electrical hazards to workers. Common electrical accidents result in shocks and/or burns, muscle contractions, and traumatic injuries associated with falls after the shock. The likelihood of the hazards occurring is considered to be possible while its severity is considered to be marginal. The hazard is classified as **moderate risk**.

Summary

In summary, the key potential impacts and risks associated with the proposed Project have been evaluated in this chapter. From such, the significance of the identified negative impacts/risks will be minimized to as low as reasonably practicable with the implementation of appropriate mitigation measures presented in the next chapter of this report. Enhancement measures for the identified positive impacts are also contained in the chapter.

CHAPTER SIX
MITIGATION MEASURES

6.0 Introduction

Following the detailed description of the associated and potential impacts of the proposed Project in Chapter 5, the recommended mitigation measures for the identified negative impacts are presented in this chapter as well as the enhancement measures for the potential positive impacts. The implementation of the mitigation measures shall be overseen by the Rural Electrification Agency's Project Management Unit (REA-PMU).

6.1 Mitigation Measures Approach

Mitigation refers to measures or interventions necessary to avoid, minimize, reduce or offset adverse impacts. Approach for selecting appropriate mitigation measures followed the framework stated by AfDB:

- Anticipate and avoid risks and impacts
- Where avoidance is not possible, minimize or reduce risks and impacts to acceptable levels
- Once risks and impacts have been minimized or reduced, mitigate
- Where significant residual impacts remain, compensate or offset them, where technically and financially feasible

In proffering mitigation measures for the various negative impacts identified in the previous chapter, preference was given to avoidance or prevention of adverse impacts and where not feasible, measures which are practicable and cost-effective using best available technology were suggested to reduce and/or minimize the impacts while rehabilitation, restoration or compensation was considered as the last resort.

6.2 Mitigation Measures for the Identified Significant Negative Impacts

The recommended mitigation measures for the identified negative impacts associated with the proposed Project are highlighted in Table 6.1. The unmitigated potential negative impacts ranked as negligible are not included in the table. The recommended mitigation measures are considered adequate to address the adverse impacts identified in Chapter 5 of this report. There are no potential long-term impacts associated with the Project that cannot be mitigated to acceptable levels of residual impact. The residual impacts of the proposed Project, following the implementation of the proffered mitigation measures highlighted in Table 6.1, are of negligible to minor significance.

6.3 Mitigation Measures for the Identified Project Risks and Hazards

The mitigation measures for the identified Project risks and hazards are highlighted below:

Fire and Explosion (REC-18, REC-19)

- Only PV modules which comply with international and local standards for electrical performance and safety shall be used.
- Only solar cables suitable for outdoor applications and severe weather conditions shall be used
- Inverters shall not be mounted on combustible walls such as wood panels or combustible sandwich panels
- Inverters shall be easily accessible and protected from severe weather conditions.
- The local fire department shall be informed of and familiarized with the photovoltaic installation.
- PV systems shall only be installed by qualified contractors.
- PV systems shall be inspected regularly by qualified professionals.
- PV systems shall be regularly checked for damage from rodents and other pests, which could compromise wiring or insulation.
- Batteries installed for the power plant shall be monitored regularly to prevent overcharging and deep discharging during operations
- Protection devices (e.g. Current interrupt devices (CIDs), positive temperature coefficient (PTC) thermistors, current-limiting fuses, diodes, battery management systems (BMSs), etc.) shall be installed to protect the batteries
- The batteries shall be housed in well ventilated, dust free containers under optimal conditions.
- Emergency response plan shall be developed and implemented.
- Fire extinguishers, fire notices, warning signs) shall be installed at different locations within the Plant site.

Electrocution (REC-18, REC-19)

- Use of signs, barriers and public outreach to prevent public contact with distribution cables shall be employed.
- Grounding conducting objects (e.g. fences or other metallic structures) shall be installed where required to prevent shock.

Occupational Hazards (REC-17, REC-18)

- Provision of an adequate work-positioning device system for workers shall be ensured.
- Hoisting and lifting equipment shall be rated and maintained and operators trained in their use.
- Appropriate Personal Protective Equipment shall be worn.
- Electrical installation shall be carried out by trained personnel in line with the approved procedures.

6.4 Enhancement Measures for Identified Positive Impacts

6.4.1 Reduction in Carbon Emissions

The Project will enhance Nigeria's intention of reducing its carbon emissions by 20% in the year 2030 as contained in its NDC on climate change. To enhance this impact, the following measures shall be implemented:

- In cases where the power generated (2 MW) is insufficient to meet the power demands of the University in the next 10 to 20 years, power shall be distributed to high priority areas so as to reduce/eliminate the use of diesel- powered generators. In addition, the Project will be designed and constructed to allow for further expansion in power generation and distribution capacity to meet the University's demands.
- The University shall implement energy conservation measures such as encouraging switching off appliances, use of energy-saving bulbs, purchase of low-energy appliances such as printers, computers, refrigerators, etc.

6.4.2 Enhancement of Learning

The Project will help to overcome the barrier on research and learning posed by epileptic power supply to the University. To enhance this impact, the following measures shall be implemented:

- Power distribution priority shall be given to all classrooms, lecture theatres, research centers, libraries, laboratories, and other academic buildings especially during learning hours.
- Research centres, laboratories, and libraries shall have 24-hour power supply.

6.4.3 Direct Employment and Training (REC-15)

The Project will give rise to direct employment opportunities across different skill levels, from unskilled to highly skilled labour. It is estimated that during construction phase, at least 100 job opportunities would be created. Training for local people from skilled technicians shall also be carried out. The following measures shall be implemented to ensure that direct employment and training opportunities are maximized:

- A Labour and Employment Management Plan (LEMP) shall be developed prior to construction, detailing percentages and numbers of the workforce to be sourced from the local area and various demographics as well as influx management. The plan shall follow local and international employment guidelines.
- The EPC contractor shall provide notification to different groups in the community on specific jobs and skills required for the project, prior to the commencement of construction. Subsequently, the group leaders shall notify the local population prior to the commencement of construction of job opportunities and relevant skills/qualifications required to be employable on the Project.
- A Gender Management Plan (GMP) shall be developed and implemented to ensure that the Project does not increase women's burden and that women not only contribute, but also benefit from it.
- The EPC contractor shall initiate training and skills development programmes prior to the commencement of construction, as a means of ensuring that members of the local workforce are up-skilled and can be employed on the Project.

During the operational phase of the Project, job opportunities will also be created. About 15 people will be employed. This will be a mixture of skilled labour (such as electrical and mechanical technicians) and unskilled labour (such as PV module cleaners and security personnel). Periodic capacity building will be offered to the workforce.

6.4.4 Procurement and Indirect Employment (REC-15)

The construction and operation of the proposed Project will create opportunities for the supply of goods and services to the Project and in turn, indirect employment will be created in the supply chain. Other opportunities for local companies to provide catering, waste / recycling and landscaping facilities, etc. will also be created. Local and regional procurement targets shall be included in the Project's LEMP to enhance this potential opportunity.

Table 6.1: Mitigation Measures for the Potential Negative Impacts of the proposed Project

Project Activities	Receptors	Summary of Potential Impacts	Potential Impact Significance (without mitigation)	Mitigation Measures	Residual Impact (after implementation of mitigation measures)
Pre-construction Phase					
Site clearing and preparation	Terrestrial flora and fauna (REC-07, REC-08)	• Vegetation loss [ESMP-01] • Direct impacts on vegetation and soil-dwelling organisms; indirect impacts on fauna species in the immediate surroundings of the Project site	Minor	▪ Vegetation clearing shall be limited to the areas within the site needed for the Project. ▪ The extent of vegetation to be cleared shall be clearly identified and appropriately demarcated. Clearing exceeding the approved working corridor shall be prohibited. ▪ Bush burning shall be avoided. ▪ Use of herbicides for site clearing shall be avoided. ▪ Any cleared areas which are not used will be re-vegetated using plants or seeds of locally occurring species.	Negligible
	Soil (REC-03)	• Effects on top soil and soil compaction associated with site clearing • Increased erosion potential • Reductionin structural stability and percolative ability of soil	Moderate	▪ Removal of vegetation shall be restricted to the areas required for the Project. ▪ Disturbed areas will be rehabilitated as soon as possible to prevent erosion. ▪ The extent of vegetation to be cleared shall be clearly identified and appropriately demarcated. Clearing exceeding the approved working corridor shall be prohibited. ▪ Use of silt traps or similar systems to reduce discharge of silt shall be ensured.	Minor
	Air quality and noise (REC-01, REC-02)	• Air quality impacts due to emission from site clearin g equipment [ESMP-02] • Increase in ambient noise levels	Minor	▪ Site clearing equipment / machinery shall be operated and maintained under optimum fuel-efficient conditions. ▪ Noise suppression equipment shall be fitted on machinery. ▪ Site clearing equipment shall be turned off when not in use. ▪ Equipment/machinery with lower sound power levels shall be selected and used for site clearing.	Negligible

Project Activities	Receptors	Summary of Potential Impacts	Potential Impact Significance (without mitigation)	Mitigation Measures	Residual Impact (after implementation of mitigation measures)
	Workers Safety (REC-17)	• Injuries and accidents to workers during site clearing and preparation.	Minor	▪ Site clearing shall be limited to the day time as much as possible. ▪ Unregistered labourers and touts shall not be engaged for off-loading materials ▪ Provision of adequate personal protective equipment (PPE) such as nose masks shall be ensured. All employees will be required to wear the appropriate PPE whilst performing their duties.	Negligible
Mobilization of personnel, materials and equipment to site	Air quality and noise (REC-01, REC-02)	• Air quality impacts from vehicular emissions [ESMP-02] • Increase in ambient noise levels	Minor	▪ Construction vehicles with efficient engine performance and with minimal noise and air emissions shall be selected and used. This can be achieved through regular servicing and maintenance. ▪ All materials with potential to result in dust emissions shall be covered during transport. ▪ Onsite vehicle speed on unhardened roads and surfaces shall be limited to about 15 – 20km/h so as to reduce dust generation.	Negligible
	Infrastructure (road) (REC-14)	• Increase in vehicular movement and traffic around the project site; [RM-01] • Potential for road accident.	Minor	▪ A traffic management plan (TMP) shall be developed by the EPC Contractor and implemented. ▪ Appropriate signage and safety measures (barrier, formalized crossing points) to reduce the risk of accidents in the Project area shall be provided. ▪ The local community shall be sensitized about the Project activities and the need to comply with the traffic management plan put in place.	Negligible

Project Activities	Receptors	Summary of Potential Impacts	Potential Impact Significance (without mitigation)	Mitigation Measures	Residual Impact (after implementation of mitigation measures)
				▪ Project related vehicles shall be regularly serviced and maintained. ▪ Drivers' competency shall be assessed and where required, appropriate training shall be provided. This will include training on safe driving measures such as adherence to speed limits (of less than 10 km/h) in the Project area. ▪ A procedure for recording traffic incidents/accidents associated with the Project shall be developed and implemented. This will include date/time, location, reason for accident, corrective measures, etc.	
Construction Phase					
Civil and Electrical Works/ Installation Activities	Soil (REC-03)	• Increased erosion potential as a result of construction activities such as excavation • Reduction in structural stability and percolative ability of soil resulting from compaction during civil works and installation activities	Minor	▪ Excavation works shall not be executed under aggressive weather conditions. ▪ Stockpiles shall be appropriately covered to reduce soil loss as a result of wind or water erosion. ▪ Disturbed areas shall be rehabilitated with erosion control plants (using native plant species) as soon as possible to prevent erosion. ▪ Work areas shall be clearly defined and where necessary demarcated to avoid unnecessary disturbance of areas outside the development footprint.	Negligible

Project Activities	Receptors	Summary of Potential Impacts	Potential Impact Significance (without mitigation)	Mitigation Measures	Residual Impact (after implementation of mitigation measures)
	Air Quality (REC-01)	• Air quality impacts due to emission from construction equipment [ESMP-02] • Increase in dust from cleared land and windblown Stockpiles	Minor	▪ Regular maintenance and servicing of construction equipment /machinery shall be ensured. ▪ Only modern and well maintained equipment and machinery shall be used for construction activities. ▪ Routine water sprinkling shall be carried out to minimize dust generation during construction.	Negligible
	Ambient Noise (REC-02)	• Increase in noise level due to Construction	Moderate	▪ Construction activities shall be limited to day-time (08.00hr to 17.00hr during weekdays; and weekends 09.00hr- 13.00hr). In the event that noisy activities are undertaken	Minor
		activities; • Disturbance to neighbouring community and local ecology		outside of the specified working hours, all noise receptors in the Project area shall be informed of such activities in advance. ▪ Construction machinery shall be turned off when not in use. ▪ Machinery/equipment to be used for construction work shall meet industry best standard in relation to noise attenuation. ▪ Construction equipment shall be properly maintained and serviced. ▪ Major construction activities shall be limited to a particular area within the site. ▪ Construction-related vehicles shall be limited to access areas. ▪ Noise complaints related to the construction activities shall be assessed and appropriately addressed. ▪ Noise monitoring at locations with persistent noise complaints shall be maintained.	

Project Activities	Receptors	Summary of Potential Impacts	Potential Impact Significance (without mitigation)	Mitigation Measures	Residual Impact (after implementation of mitigation measures)
	Infrastructure (road) (REC-14)	• Road damage, traffic and safety impacts.	Minor	▪ A TMP shall be developed by the EPC Contractor and implemented. ▪ Speed limits for all construction-related vehicles shall be established and enforced. ▪ Construction related vehicles shall be regularly serviced and maintained. ▪ Appropriate barriers and signage shall be provided to demarcate areas in which construction traffic is active. ▪ Drivers' competency shall be assessed and where required training shall be provided. ▪ A procedure for recording all construction related traffic incidents/accidents shall be developed and implemented. This will include date/time, location, reason for accident, corrective measures, etc. ▪ The NEP Grievance Redress Mechanism (GRM) shall be implemented for receiving complaints arising from damage to infrastructure and private property during construction activities shall be developed. The EPC contractor shall receive the complaints and repair damages as quickly as possible.	Negligible
	Groundwater and surface water (REC-04, REC-05)	• Groundwater and surface water contamination	Minor	▪ Training shall be provided for workers on safe storage and handling practices and rapid spill response and clean-up techniques during induction. ▪ Spill control and response plans to respond to spills and leaks shall be implemented. ▪ Waste receptacles shall be provided within a secured area within the project site for collection of solid waste. ▪ General wastes that cannot be reused shall be periodically evacuated by the government accredited waste contractor	Negligible

Project Activities	Receptors	Summary of Potential Impacts	Potential Impact Significance (without mitigation)	Mitigation Measures	Residual Impact (after implementation of mitigation measures)
	Terrestrial Flora and Fauna (REC-07, REC-08) (REC-07)	• Loss of fauna as a result of increased human activity and associated noise.	Minor	▪ Construction workers shall be provided with appropriate training on ecological awareness, as appropriate to their work activities. ▪ All construction equipment shall be cleaned (mud and soil removed) at source before being brought to site to minimize introduction of alien species. ▪ If sand or other natural materials for building are required and brought onto site, the stored heaps will be monitored for the growth and germination of alien species and will be regularly cleared during construction. ▪ Regular monitoring will be undertaken to ensure that alien plants are not increasing as a result of the disturbance that has taken place. ▪ In order to reduce collision of vehicles with fauna, a 10 km/hr speed limit by construction-related vehicles shall be enforced in the Project area.	Negligible
	Gender (REC-16)	• Discrimination during employment and training opportunities [ESMP-03] • GBV (sexual harassment, intimate partner violence, poor working)	Moderate	▪ Equal treatment of workers shall be ensured. ▪ The GBV Action Plan for EEP shall be implemented for the Project ▪ All workers on the project shall be required sign a code of conduct to prohibit any form of Gender Based Violence/Sexual Exploitation and Abuse (GBV/ SEA) ▪ GBV sensitive channels for reporting in GRM shall be implemented for the Project ▪ The EPC Contractor shall be required to hire a Gender/GBV officer. ▪ Collaboration with appropriate government institutions or GBV service providers on potential GBV case management shall be ensured. ▪ All workers shall be required to undergo regular training and refreshers on GBV	Minor

Project Activities	Receptors	Summary of Potential Impacts	Potential Impact Significance (without mitigation)	Mitigation Measures	Residual Impact (after implementation of mitigation measures)
				▪ The EPC Contractor shall provide separate facilities for men and women and add GBV-free signage at the project site. ▪ All gender-based violence incidents shall be reported and dealt with as per the law.	
	Construction workers safety (REC-17)	• Injury to construction workers during construction activities.	Moderate	▪ Health and Safety Plan shall be developed and implemented. The plan shall provide for recording, reporting, and investigating accidents and near misses, and developing measures to prevent recurrence. ▪ Construction workers shall be sensitized and monitored on the need to be safety conscious. ▪ Daily toolbox talks prior to commencement of work activities shall be carried out. ▪ Construction activities shall be limited to daytime as much as possible. ▪ Onsite safety officer shall be engaged to monitor the compliance of workers to safety rules. ▪ Proper safety signs and signage shall be placed at strategic locations within the site. ▪ PPE such as safety boot, coverall, eye google, safety helmets, reflective vests, etc. shall be provided to construction workers and the level of PPE compliance shall be monitored. ▪ Safety training focused on safe working practices, information on specific hazards, first aid and fire-fighting shall be included in the induction programme for workers. ▪ A mechanism procedure for receiving and addressing the concerns of workers shall be put in place and implemented. ▪ The site shall be secured with perimeter fencing and/or security. ▪ Sanitary amenities and potable water shall be provided	Minor

Project Activities	Receptors	Summary of Potential Impacts	Potential Impact Significance (without mitigation)	Mitigation Measures	Residual Impact (after implementation of mitigation measures)
	Socio-economic and health (REC-12, REC-19)	• Influx of people, increase in sexual transmitted diseases.	Moderate	▪ Construction workers (e.g. semi-skilled and unskilled craftsmen) shall be drawn from the local community as much as possible. ▪ No person under the age of 18 shall be engaged to work on the project. The EPC Contractor shall ensure that children and minors are not employed directly or indirectly on the project ▪ Any child dropout should be reported to the relevant government agency ▪ The local community shall be informed of the Project activities prior to commencement of work. ▪ An induction and sensitization programme, including a Code of Conduct, for all construction workers shall be carried out prior to construction activities. This will increase sensitivity to local norms and customs, provide awareness to construction workers of appropriate and acceptable behaviours, and will govern worker interactions with the local community. ▪ Awareness education about GBV/SEA/HIV/AIDS and other sexually transmitted diseases shall be created among the workforce and extended to the local community. ▪ The CoC shall include provisions to prohibit any form of Gender Based Violence/Sexual Exploitation and Abuse by workers within the local community. ▪ Public access shall be restricted to construction area via security fencing and appropriate signage. ▪ Substance abuse prevention and management programs shall be implemented for workers. ▪ Sanctions (e.g., suspension and dismissal) shall be introduced for workers involved in criminal activities ▪ Procedure for receiving and addressing community concerns shall be developed and implemented.	Minor

Project Activities	Receptors	Summary of Potential Impacts	Potential Impact Significance (without mitigation)	Mitigation Measures	Residual Impact (after implementation of mitigation measures)
Waste Disposal and Generation	Infrastructure (waste management facility) (REC-14)	• E-waste generation • Disposal of construction wastes to existing waste management facility in the Project area.	Minor	▪ A Waste Management Plan shall be developed and implemented ▪ Training shall be provided for workers on safe storage, use and handling of e-waste on site. ▪ E-wastes generated shall be stored in appropriate locations prior to recycling and/or disposal ▪ Waste receptacles shall be provided within a secured area for collection of solid waste. ▪ Construction vehicles and equipment shall be serviced regularly.	Negligible
	Soil (REC-03)	• Soil contamination from solid and liquid construction waste streams.	Minor	▪ Hazardous substances and materials (e.g. fuel, lubricating oil, etc.) shall be stored in appropriate locations with impervious hard standing and adequate secondary containment. ▪ Portable spill containment and clean-up kits shall be available onsite. ▪ Construction workers shall be provided with adequate training on use, storage and handling of hazardous substances.	Negligible
	Groundwater (REC-04)	• Groundwater contamination of liquid construction waste streams.	Minor	▪ Training shall be provided for workers on safe storage, use and handling of hazardous materials (e.g. fuel, lubricating oil) on site. ▪ Hazardous substances and materials (e.g. fuel, lubricating oil, etc.) shall be stored in appropriate locations with impervious hard standing and adequate secondary containment. ▪ Portable spill containment and clean-up kits shall be available onsite. ▪ Waste management plan (WMP) shall be developed by the EPC Contractor and implemented. ▪ Waste bins shall be provided at designated locations on site for temporary storage of different waste streams. ▪ Construction waste, as much as practicable, shall be reused or recycled.	Negligible

Project Activities	**Receptors**	**Summary of Potential Impacts**	**Potential Impact Significance (without mitigation)**	**Mitigation Measures**	**Residual Impact (after implementation of mitigation measures)**
				▪ Waste that cannot be reused or recycled shall be disposed of at an approved dumpsite.	
			Commissioning Phase		
Plant Testing	Ambient noise (REC-02)	• Increase in ambient noise level	Minor	▪ The Power Plant components shall be installed in line with the pre-established standards and as per manufacturer recommendations. ▪ Strict compliance to the Standard Operating Procedures shall be ensured. ▪ The inverters and batteries to be used for the Project shall meet industry best standard in relation to noise attenuation.	Negligible
	Workers (REC-17)	• Occupational health and safety hazards (e.g. injuries, electrocution, etc.) as a result of any wrong electrical connection. [ESMP-04] [RM-04]	Moderate	▪ Plant testing shall be carried out by experienced personnel. ▪ Adequate PPE shall be worn. ▪ The Project components shall be installed in line with the pre-established standards and as per manufacturer recommendations. ▪ The EPC contractor shall develop the Standard Operating Procedures (SOPs) for the operational phase of the project ▪ Strict compliance to the (SOPs) shall be ensured. ▪ Prior to the Plant commissioning, appropriate emergency equipment (such as first aid box, fire extinguishers) shall be provided onsite. ▪ Plant testing shall be restricted to the daytime. ▪ The site shall be secured with perimeter fencing and/or security ▪ Sanitary amenities and potable water shall be provided	Negligible
			Operational Phase		
Power Generation and Evacuation	Socio-economic (visual prominence) (REC-12, REC-19, REC-11) (REC-11)	• Landscape alterations resulting in unpleasant changes in the visual character of the area	Minor	▪ All lighting will be kept to a minimum within the requirements of safety and efficiency. Where such lighting is deemed necessary, low-level lighting, which is shielded and directed downward, to reduce light spillage will be used. ▪ Site fencing if required shall be implemented.	Negligible

Project Activities	Receptors	Summary of Potential Impacts	Potential Impact Significance (without mitigation)	Mitigation Measures	Residual Impact (after implementation of mitigation measures)
	Health, safety and welfare of staff during Plant operation (REC-18)	• Electric shock, injuries to personnel associated with the Power Plant operations, [ESMP-04] [RM-04] • Work related issues such as discrimination, denial of rights, unfair treatment, poor working conditions	Moderate	▪ Appropriate PPE shall be provided for workers. ▪ Training shall be provided to employees on emergency preparedness and responses. ▪ Provision of medical insurance scheme for employees shall be ensured. ▪ Appropriate safety signage shall be placed at strategic locations within the site. ▪ Strict compliance to the SOPs/ code of conduct shall be ensured. ▪ A grievance mechanism procedure for receiving and addressing the concerns of employee shall be put in place and implemented.	Negligible
	Gender (REC-16)	• Discrimination during employment and training opportunities [ESMP-03] • GBV (sexual harassment, intimate partner violence, poor working)	Minor	▪ Equal treatment of workers shall be ensured. ▪ Continuous implementation of the GBV Action Plan for EEP shall be sustained for the Project ▪ All workers on the project shall be required sign a code of conduct to prohibit any form of Gender Based Violence/Sexual Exploitation and Abuse (GBV/ SEA) ▪ GBV sensitive channels for reporting in GRM shall be implemented for the Project ▪ The O&M Contractor shall be required to hire a Gender/GBV officer. ▪ Collaboration with appropriate government institutions or GBV service providers on potential GBV case management shall be sustained. ▪ All workers shall be required to undergo regular training and refreshers on GBV ▪ The O&M Contractor shall provide separate facilities for men and women and add GBV-free signage at the project site. ▪ All gender-based violence incidents shall be reported and dealt with as per the law.	Negligible

Project Activities	Receptors	Summary of Potential Impacts	Potential Impact Significance (without mitigation)	Mitigation Measures	Residual Impact (after implementation of mitigation measures)
Routine Maintenance, Waste Generation and Disposal	Soil (REC-03)	• Soil contamination from spent batteries and inverters	Minor	▪ General housekeeping to ensure the site is not overgrown with grasses shall be maintained ▪ Waste bins shall be provided at designated locations on site for temporary storage of different waste streams. ▪ General waste that cannot be reused or recycled shall be disposed of at an approved dumpsite. ▪ WMP shall be implemented. ▪ Burning of waste shall be prohibited. ▪ Damaged/expired Lithium-ion batteries, solar panels, inverters and electric components shall be returned to the manufacturer based on the Extended Producer Warranty (EPR) model. Prior to returning them to the manufacturers, they will be stored on impermeable surfaces within the site.	Negligible
	Health, safety and welfare of staff during Maintenance (REC-18)	• Electric shock, injuries to personnel during maintenance [ESMP-04] [RM-04]	Minor	▪ Appropriate PPE shall be provided for workers. ▪ Maintenance workers shall imbibe the workplace safety rules via proper sensitization procedures. ▪ Strict compliance to the SOPs shall be ensured.	Negligible
	Groundwater (REC-04)	• Groundwater abstraction from cleaning of PV panels	Minor	▪ Water management plan shall be implemented ▪ Manual cleaning of the PV panels with water shall be regulated as much as practicable. The frequency of cleaning of PV panels with water is dependent on the rainfall pattern in the project area. During rainy season, cleaning is estimated to occur not more than thrice; however, during dry season the interval shall depend on the rate of dust accumulation. ▪ Periodic monitoring of groundwater resources in the Project's area of influence shall be implemented.	Negligible

CHAPTER SEVEN

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

7.0 Introduction

The potential and associated impacts of the proposed 2.0 MW solar-hybrid power plant and associated infrastructure in the Federal University of Education (FUE) Zaria, Kaduna, Kaduna State, as part of the Federal Government's Energizing Education Programme, have been analyzed and documented in Chapter 5 of this report. The results show that if the recommended mitigation measures (presented in Chapter 6) are implemented, the identified impacts of the Project are not severe and can be reduced to as low as reasonably practicable. It is thus important that those recommended mitigation measures be translated into practical management actions, which can be adequately resourced and integrated into the Project phases.

Hence, this chapter presents the management measures and actions required to address the potential environmental and social impacts of the proposed Project. It also includes monitoring programme as well as performance indicators, responsible parties, timeframe and cost estimates for the implementation of recommended measures to address the associated impacts of the project throughout its life cycle. In addition, the framework for the contents of additional management plans to be developed and implemented as part of this ESMP is provided.

7.1 Objectives of the ESMP

The ESMP is essential for successfully implementing the Project's environmental and social performance throughout the life of the Project. Having this framework in place ensures a systematic approach to bringing environmental and social considerations into decision-making and day-to-day operations. It establishes a framework for tracking, evaluating and communicating environmental and social performance and helps ensure that environmental risks and liabilities are identified, minimized and managed including roles, responsibilities, and budget.

The ESMP will be a living document and will continue to develop during the design and construction phases to enable continuous improvement of the Project's environmental performance.

The specific objectives of the ESMP are to:

- Promote environmental and social management and communicate the aims and goals of the ESMP;
- Ensure that all workers, subcontractors and others involved in the Project meet legal and

regulatory requirements with regard to environmental management;

- Incorporate environmental and social management into Project design and operating procedures;
- Serve as an action plan for environmental and social management for the Project;
- Provide a framework for implementing Project environmental and social commitments (i.e. mitigation measures identified in the ESIA);
- Prepare and maintain records of Project environmental and social performance (i.e. monitoring, audits and non-compliance tracking).

7.2 Environmental and Social Management Measures

Tables 7.1 to 7.5 present the recommended environmental and social management measures required to mitigate the identified impacts of the Project development and operation. Environmental and social measures for the decommissioning are documented in Chapter 8.

Table 7.1a: Environmental Management Measures for Pre-construction Phase of the proposed Project

Project Activity / Associated Impact	Mitigation Measures	Monitoring			Responsible Party		Cost (US Dollars)
		Requirements / Parameters	Frequency	Performance Indicator	Implementation	Monitoring	
Site Clearing and Preparation							
Vegetation loss; direct impacts on vegetation and soil-dwelling organisms; indirect impacts on fauna species (REC-07, REC-08, REC-03) [ESMP-01]	Vegetation clearing shall be limited to the areas within the site needed for the Project. Use of herbicides for clearing shall be avoided. Site clearing and preparation shall be done mechanically.	Inspection [EM-04] [EM-05]	Daily	Adherence to measures	EPC Contractor	REA (PMU) FUE Zaria (Site Engineer)	1500
	Bush burning shall be avoided.	Inspection [EM-04] [EM-05]	Daily	Adherence to measures			
	Any cleared areas which are not used will be re-vegetated using plants or seeds of locally occurring species.	Inspection [EM-04] [EM-05]	Monthly after the site clearing phase	Re-vegetated land			
	The extent of vegetation to be cleared shall be clearly identified and appropriately demarcated. Clearing exceeding the approved working corridor shall be prohibited.	Inspection [EM-04] [EM-05]	Monthly before the site clearing activities	Adherence to measures			
	Hunting or deliberate killing of animals by workers shall be prohibited and monitored. Workers shall be sensitized on ecological protection	Inspection	Daily before the site clearing activities	Adherence to measures			
	Removal of vegetation and soil cover shall be restricted to the areas required for the Project. Soil conservation measures shall be implemented such as stockpiling topsoil or for the remediation of disturbed areas.	Inspection	Daily	Re-vegetated land			
	Use of silt traps or similar systems to reduce discharge of silt shall be ensured.	Inspection	Monthly before the site clearing activities	Re-vegetated land			
Air quality impacts due to emission from site clearing	Site clearing equipment / machinery shall be operated and maintained under optimum	Maintenance records; Fuel	Daily	Adherence To measures			

Project Activity / Associated Impact	**Mitigation Measures**	**Monitoring**			**Responsible Party**		**Cost (US Dollars)**
		Requirements / Parameters	**Frequency**	**Performance Indicator**	**Implementation**	**Monitoring**	
equipment; increase in ambient noise levels (REC-01, REC-02) [ESMP-02]	fuel efficient conditions.	consumption records [EM-01] [EM-02]					
	Site clearing activities shall be carried out only during the daytime (08.00hr to 17.00hr during weekdays; and weekends 09.00hr-13.00hr)	Inspection [EM-01] [EM-02]	Daily	Adherence To measures			
Mobilization of Materials and Equipment to Site							
Air quality impacts from vehicular emissions; Increase in ambient noise levels (REC-01, REC-02) [ESMP-02]	Project vehicles with efficient engine performance and with minimal noise and air emissions shall be selected and used. This can be achieved through regular servicing and maintenance	Inspection; Maintenance records [EM-01] [EM-02]	Once before vehicle commences journey	Adherence To measures	EPC Contractor	REA (PMU) FUE, Zaria (Site Engineer)	2000
	All materials with potential to result in dust emissions shall be covered during transport.	Inspection	Once before vehicle commences journey	Adherence To measures	EPC Contractor		
	Onsite vehicle speed on unhardened roads and surfaces shall be limited to about 15 – 20km/h so as to reduce dust generation.	Inspection	Daily	Adherence to measures	EPC Contractor		
	Unnecessary engine idling shall be avoided.	Inspection	Daily	Adherence to measures	EPC Contractor		
	Site roads and access roads shall be sprinkled as needed to prevent dust entrainment.	Inspection	Daily	Adherence to measures	EPC Contractor		

Table 7.1b: Social Management Measures for Pre-construction Phase of the proposed Project

Project Activity / Associated Impact	Mitigation Measures	Monitoring			Responsible Party		Cost (US Dollars)
		Requirements / Parameters	Frequency	Performance Indicator	Implementation	Monitoring	
Site Clearing and Preparation							
	Only the portion of the site required for Project development shall be cleared for construction.	Inspection	Prior to construction activities	Adherence measure	EPC Contractor	REA (PMU)	
Mobilization of Personnel, Materials and Equipment to Site							
	Provision of adequate PPE especially gloves, safety shoes, and hard hats to workers shall be ensured. All employees will be required to wear the appropriate PPE whilst performing their duties.	Availability of PPE	Daily	PPE compliance	EPC Contractor	REA (PMU) FUE, Zaria (Site Engineer)	500
	Unregistered labourers and touts shall not be engaged for off-loading materials.	Employment records of all staff on site	Once before commencement of mobilization	Labour Act	EPC Contractor		
	A TMP shall be developed by the EPC contractor and implemented	TMP implementation records	Daily	Benchmarks stated in the TMP	EPC Contractor	REA (PMU) FUE, Zaria (Site Engineer)	1000
	Appropriate signage and safety measures (barrier, formalized crossing points) to reduce the risk of accidents in the Project area shall be provided.	Safety signs and barriers	Before and during mobilization	Adherence to measures	EPC Contractor		
	Speed limit around community areas shall be limited to a maximum of 20 km/hr	Evidence of consultation with local community	Before and during mobilization	Adherence to measures	EPC Contractor		
	Drivers' competency shall be assessed and where required, appropriate training shall be provided.	Drivers' competency assessments; training records	Once before commencement of mobilization	Passing of competency assessment or training completion certificates	EPC Contractor		

Project Activity / Associated Impact	**Mitigation Measures**	**Monitoring**			**Responsible Party**		**Cost (US Dollars)**
		Requirements / Parameters	**Frequency**	**Performance Indicator**	**Implementation**	**Monitoring**	
	A procedure for recording traffic incidents/accidents associated with the Project shall be developed and implemented.	Incident forms	Daily	Completed incident forms	EPC Contractor		
	Employee violations of speed limit and other traffic rules will result in disciplinary action ranging from warning to dismissal.	Incident forms, GRM	Daily	Completed incident forms	EPC Contractor		

Table 7.2a: Environmental Management Measures for Construction Phase of the proposed Project

Project Activity / Associated Impact	**Mitigation Measures**	**Monitoring**			**Responsible Party**		**Cost (US Dollars)**
		Requirements / Parameters	**Frequency**	**Performance Indicator**	**Implementation**	**Monitoring**	
Civil and Electrical Works/ Installation Activities							
Air quality impacts due to emission from construction equipment; (REC-01) [ESMP-02]	Regular maintenance and servicing of construction equipment / machinery shall be ensured. [EM-01]	Maintenance records	Monthly during construction phase	Adherence to measures	EPC Contractor	REA-PMU FUE, Zaria (Site Engineer)	2000
Increase in dust from cleared land and windblown stockpiles (REC-01)	Routine water sprinkling shall be carried out to minimize dust generation during construction. [EM-01]	Inspection	Daily during civil work activities	Adherence to measures	EPC Contractor	Kaduna State Ministry of Environment	2000
Increase in noise level (REC-02)	Construction activities shall be limited to day-time (08.00hr to [EM-02] 17.00hr during weekdays; and weekends 09.00hr-13.00hr).	Inspection	Daily during construction phase	Adherence to measures	EPC Contractor	REA-PMU FUE, Zaria (Site Engineer) Kaduna State Ministry of Environment	1500
	Construction machinery shall be turned off when not in use. [EM-02]	Inspection	Daily during construction phase	Adherence to measures	EPC Contractor		
	Construction equipment shall be properly maintained and serviced. [EM-02]	Maintenance records	Monthly during construction phase	Adherence to measures	EPC Contractor		
	Noise complaints related to the	Complaint records	Weekly during	World Bank Good	EPC Contractor		

Project Activity / Associated Impact	**Mitigation Measures**	**Monitoring**			**Responsible Party**		**Cost (US Dollars)**
		Requirements / Parameters	**Frequency**	**Performance Indicator**	**Implementation**	**Monitoring**	
	construction activities shall be assessed and appropriately addressed. [EM-02]		construction phase	Practice Note on addressing grievances			
	Noise monitoring at locations with persistent noise complaints shall be maintained. [EM-02]	Noise monitoring records	Monthly during construction phase	FMEnv Noise limit World Bank Noise Limit	EPC Contractor		
Increased soil erosion potential; reduction in structural stability and percolative ability of soil (REC-03)	Excavation works shall not be [EM-04] executed under aggressive weather conditions.	Inspection	Daily during excavation activities	Adherence to measures	EPC Contractor	REA-PMU FUE, Zaria (Site Engineer) Kaduna State Ministry of Environment	1000
	Stockpiles shall be appropriately covered to reduce soil loss as a result of wind or water erosion. [EM-04]	Inspection	Daily during civil work activities	Adherence to measures	EPC Contractor		
Loss of plant species as a result of introduction of alien plants; loss of fauna as a result of (REC-07, REC-08)	Construction workers shall be provided with appropriate training on ecological awareness, as [EM-05] appropriate to their work activities.	Training records	Once before start of construction phase	Certificates of Training	EPC Contractor	REA-PMU FUE, Zaria (Site Engineer)	1000
Increased human activity and associated noise. (REC-07, REC-08)	Regular monitoring will be undertaken to ensure that alien plants are not increasing as a result of the disturbance that has taken place. [EM-02]	Monitoring records	Monthly during construction phase	Adherence to measures	EPC Contractor	Kaduna State Ministry of Environment	750
Waste Disposal and Generation							
E-waste generation (REC-14)	E-wastes generated shall be stored in appropriate locations prior to collection by e-waste contractors for proper recycling and/or disposal	Waste consignment notes, waste receptacles on site	Weekly during construction phase	Adherence to measures	EPC Contractor	REA-PMU FUE, Zaria (Site Engineer) FMEnv Kaduna State Ministry of Environment	1500

Project Activity / Associated Impact	**Mitigation Measures**	**Monitoring**			**Responsible Party**		**Cost (US Dollars)**
		Requirements / Parameters	**Frequency**	**Performance Indicator**	**Implementation**	**Monitoring**	
Soil contamination from solid and liquid construction waste streams. (REC-03)	Hazardous substances and materials shall be stored in appropriate locations with impervious hard standing and adequate secondary containment. Portable spill containment and clean-up kits shall be available onsite. [EM-04]	Inspection	Daily during construction phase	Adherence to measures World Bank General EHS Guidelines	EPC Contractor	REA-PMU FUE, Zaria (Site Engineer) FMEnv Kaduna State Ministry of Environment	2000
	Construction workers shall be provided with adequate training on use, storage and handling of hazardous substances. [EM-04]	Training records	Once before commencement of construction	Certificates of Completion of trainings	EPC Contractor		
Groundwater contamination of liquid construction waste streams. (REC-04)	Training shall be provided for workers on safe storage, use and handling of hazardous materials (e.g. fuel, lubricating oil) on site. [EM-03]	Training records	Once before commencement of construction	Certificates of Completion of trainings	EPC Contractor	REA-PMU FUE, Zaria (Site Engineer) FMEnv Kaduna State Ministry of Environment	1500
	Hazardous substances and materials shall be stored in appropriate locations with impervious hard standing and adequate secondary containment. Portable spill containment and clean-up kits shall be available onsite. [EM-03]	Inspection	Daily during construction phase	Adherence to measures World Bank General EHS Guidelines	EPC Contractor		
	Waste management plan (WMP) shall be developed and implemented. [EM-03]	WMP implementation records	Daily during construction phase	Benchmarks stated in WMP World Bank General EHS Guidelines	EPC Contractor		

Bolben Energy and Environmental Services Limited
Suite B214, Zitel Plaza, Jabi Abuja
ceo@bolben.org
Draft Report, September 2026.

Table 7.2b: Social Management Measures for Construction Phase of the proposed Project

<table>
<tr><th rowspan="2">Project Activity / Associated Impact</th><th rowspan="2">Mitigation Measures</th><th colspan="3">Monitoring</th><th colspan="2">Responsible Party</th><th rowspan="2">Cost (US Dollars)</th></tr>
<tr><th>Requirements / Parameters</th><th>Frequency</th><th>Performance Indicator</th><th>Implementation</th><th>Monitoring</th></tr>
<tr><td colspan="8">Civil and Electrical Works/ Installation Activities</td></tr>
<tr><td>Discrimination during employment and training opportunities (REC-16, REC-15)</td><td>Employment of workers for construction activities shall be open and fair. However, no person under the age of 18 shall be engaged on the project sites.</td><td>Employment records</td><td>Once before start of construction</td><td>Adherence to measures</td><td>EPC Contractor</td><td>REA-PMU

FUE, Zaria (Site Engineer)

FMEnv

Kaduna State Ministry of Environment</td><td></td></tr>
<tr><td rowspan="6">GBV (sexual harassment, intimate partner violence, poor working) (REC-16) [ESMP-03]</td><td>The EEP GBV Action Plan shall be implemented for the Project</td><td>Implementation by the EPC Contractor</td><td>Once before start of construction</td><td>Evidence to show implementation of EEP GBV action Plan</td><td>EPC Contractor</td><td rowspan="6">REA-PMU

FUE, Zaria (Site Engineer)

FMEnv

Kaduna State Ministry of Environment

Kaduna State Ministry of Women Affairs and Social Development

GBV/SEA service providers</td><td rowspan="6"></td></tr>
<tr><td>All workers shall be required to undergo regular training and refreshers on GBV</td><td>Organize regular onsite training and refreshers</td><td>Monthly during construction phase</td><td>Records of regular training and attendance</td><td>EPC Contractor</td></tr>
<tr><td>All workers on the project shall be required sign a code of conduct to prohibit any form of Gender Based Violence/Sexual Exploitation and Abuse (GBV/ SEA)</td><td>Develop CoC forms for workers</td><td>Once before start of construction</td><td>Signed CoC forms</td><td>EPC Contractor</td></tr>
<tr><td>GBV sensitive channels for reporting in GRM shall be implemented for the Project</td><td>Establish accessible GRM reporting channels</td><td>Monthly during construction</td><td>GRM records</td><td>EPC Contractor</td></tr>
<tr><td>The EPC Contractor shall be required to hire a Gender/GBV officer</td><td>Employ GRM Officer</td><td>Once before start of construction</td><td>Employment records and job description</td><td>EPC Contractor</td></tr>
<tr><td>Collaboration with appropriate government institutions or GBV service providers on potential GBV case management shall be ensured</td><td>Engagement of GBV service provider</td><td>Once before start of construction</td><td>Records of ongoing engagement and consultation with GBV service</td><td>EPC Contractor</td></tr>
</table>

Project Activity / Associated Impact	Mitigation Measures	Monitoring			Responsible Party		Cost (US Dollars)
		Requirements / Parameters	Frequency	Performance Indicator	Implementation	Monitoring	
				Providers			
	The EPC Contractor shall provide separate facilities for men and women and add GBV-free signage at the project site	Erection of separate convenience facilities and display of GBV signage	Once before start of construction	Inspection of facilities to ensure adequacy	EPC Contractor		
Influx of people, increase in sexual transmitted diseases. (REC-12, REC-19)	Construction workers (e.g. semi- skilled and unskilled craftsmen) shall be drawn from the local community as much as possible.	Employment records and prepare a labour management plan	Once before start of construction	Adherence to measures	EPC Contractor	REA-PMU FUE, Zaria (Site Engineer) FMEnv	
	An induction and sensitization programme, including a Code of Conduct, for all construction workers shall be carried out prior to construction activities. This will increase sensitivity to local norms and customs, provide awareness to construction workers of appropriate and acceptable behaviours, and will govern worker interactions / fraternization with the local community.	Induction records and training on the code of conduct	Once before start of construction	Adherence to Measures	EPC Contractor		
	Awareness education about GBV/SEA/HIV/AIDS and other sexually transmitted diseases shall be created among the workforce and extended to the local community	Training records	Once before start of construction	Adherence to measures	EPC Contractor	Kaduna State Ministry of Environment Kaduna State Ministry of women affairs and Social Development GBV/SEA service providers	
	Public access shall be restricted to construction area via security fencing and appropriate signage	Inspection	Daily during construction phase	Adherence to measures	EPC Contractor		
	All workers on the project shall be required to sign a code of conduct to prohibit any form of Gender Based Violence/Sexual Exploitation and Abuse	Signed code of conduct records	Once before start of construction	Adherence to measures	EPC Contractor		

Project Activity / Associated Impact	Mitigation Measures	Monitoring			Responsible Party		Cost (US Dollars)
		Requirements / Parameters	Frequency	Performance Indicator	Implementation	Monitoring	
	The NEP GRM Procedure for receiving and addressing community concerns shall be developed and implemented.	Consultations and grievance records	Weekly during construction phase	World Bank Good Practice Note on Addressing Grievances	EPC Contractor		
Injury to construction workers during construction activities (REC-17)	Health and Safety Plan shall be developed and implemented.	Health and Safety plan implementation records	Daily during construction phase	Benchmarks stated in Health and Safety Plan	EPC Contractor	REA-PMU FUE, Zaria (Site Engineer) FMEnv Kaduna State Ministry of Environment,	
	Community members and construction workers shall be sensitized and monitored on the need to be safety conscious. Daily toolbox talks prior to commencement of work activities shall be carried out for all workers.	Daily toolbox records	Daily during construction phase for workers and Monthly for communities as part of engagement	Benchmarks stated in Health and Safety Plan	EPC Contractor		
	Onsite safety officer shall be engaged to monitor the compliance of workers to safety rules.	Qualified and dedicated safety officer	Once before commencement of construction	Adherence to measures	EPC Contractor		
	PPE such as safety boot, coverall, eye google, safety helmets, reflective vests, etc. shall be provided to construction workers and the level of PPE compliance shall be monitored.	Availability of PPE	Daily during construction phase	PPE compliance	EPC Contractor		
	Safety training focused on safe working practices, information on specific hazards, first aid and fire- fighting shall be included in the induction programme for workers.	Training records	Before commencement of construction and weekly	Certificates of Completion of trainings	EPC Contractor		
	A mechanism procedure for receiving and addressing the concerns of workers shall be put in place and implemented.	Completed grievance forms	Weekly during construction phase	Adherence to measures	EPC Contractor		
	Hazardous substances and materials shall	Inspection	Daily during	Adherence to	EPC Contractor		

Bolben Energy and Environmental Services Limited
Suite B214, Zitel Plaza, Jabi Abuja
ceo@bolben.org
Draft Report, September 2026.

Project Activity / Associated Impact	Mitigation Measures	Monitoring			Responsible Party		Cost (US Dollars)
		Requirements / Parameters	Frequency	Performance Indicator	Implementation	Monitoring	
	be stored in appropriate location with impervious hard standing and adequate secondary containment. Portable spill containment and clean-up kits shall be available onsite.		construction phase	measures World Bank General EHS Guidelines			
Road damage, traffic and safety impacts (REC-14)	TMP shall be developed by the EPC Contractor and implemented.	TMP implementation records	Daily during construction phase	Benchmarks stated in the TMP	EPC Contractor	REA-PMU FUE, Zaria (Site Engineer) FMEnv Kaduna State Ministry of Environment	
	Speed limits for all construction-related vehicles shall be established and enforced.	Inspection	Daily during construction phase	Adherence to measures	EPC Contractor		
	Appropriate barriers and signage shall be provided to demarcate areas in which construction traffic is active.	Safety signs and barriers	Once before commencement of construction	Adherence to Measures	EPC Contractor		
	Drivers' competency shall be assessed and where required training shall be provided.	Drivers' competency assessments; training records	Once before commencement of construction	Passing of competency assessment or training completion Certificates	EPC Contractor		
	A procedure for recording all construction related traffic incidents/accidents shall be developed and implemented.	Incident forms	Daily during construction phase	Completed incident forms	EPC Contractor		
	The EPC contractor shall promptly repair damage to public infrastructure and repair or compensate for damage to private property.	Incident forms, GRM	Daily during construction phase	Completed incident forms	EPC Contractor		

Table 7.3a: Environmental Management Measures for Commissioning Phase

Project Activity / Associated Impact	Mitigation Measures	Monitoring			Responsible Party		Cost (US Dollars)
		Requirements / Parameters	Frequency	Performance Indicator	Implementation	Monitoring	
Plant testing							
Increase in ambient noise level due to Plant testing (REC-02)	Strict compliance to the Standard Operating Procedures (SOPs) shall be ensured.	SOPs [EM-02]	Once before commissioning	Adherence To measures	EPC Contractor	REA-PMU FUE, Zaria (Site Engineer) FMEnv Kaduna State Ministry of Environment	1000
	The EPC contractor shall develop Standard Operating Procedures (SOPs) for the operational phase of the Project	SOPs [EM-02]	Once before commissioning	Adherence To measures	EPC Contractor		
	The Power Plant components shall be installed in line with the pre-established standards and as per manufacturer recommendations	SOPs [EM-02]	Once before commissioning	Adherence To measures	EPC Contractor		

Table 7.3b: Social Management Measures for Commissioning Phase

Project Activity / Associated Impact	Mitigation Measures	Monitoring			Responsible Party		Cost (US Dollars)
		Requirements / Parameters	Frequency	Performance Indicator	Implementation	Monitoring	
Plant testing							
Occupational health and safety hazards (e.g. injuries, electrocution, etc.) as a result of any wrong electrical connection. (REC-17, REC-18) [ESMP-04] [RM-04]	Plant testing shall be carried out by experienced personnel.	Qualified and dedicated Engineer	Once before commissioning	Adherence To measures	EPC Contractor	REA-PMU FUE, Zaria (Site Engineer) FMEnv Kaduna State Ministry of Environment	2000
	Adequate PPE shall be worn	Availability of PPE	Once before commissioning	Adherence To measures			
	Prior to the Plant commissioning, appropriate emergency equipment.	Availability of emergency response equipment	Once before commissioning	Adherence To measures			
Wrong electrical connection leading to explosion/fire (REC-18, REC-19) [RM-02]	Plant testing shall be carried out by experienced personnel.	Qualified and dedicated Engineer	Once before commissioning	Adherence To measures	EPC Contractor	REA-PMU FUE, Zaria (Site Engineer)	1000

Project Activity / Associated Impact	**Mitigation Measures**	**Monitoring**			**Responsible Party**		**Cost (US Dollars)**
		Requirements / Parameters	**Frequency**	**Performance Indicator**	**Implementation**	**Monitoring**	
						FMEnv Kaduna State Ministry of Environment	

Table 7.4a: Environmental Management Measures for Operational Phase

Project Activity / Associated Impact	**Mitigation Measures**	**Monitoring**			**Responsible Party**		**Cost (US Dollars)**
		Requirements / Parameters	**Frequency**	**Performance Indicator**	**Implementation**	**Monitoring**	
Power Generation and Evacuation							
Landscape alterations resulting in unpleasant changes in the visual character of the area (REC-11)	All lighting will be kept to a minimum within the requirements of safety and efficiency. Where such lighting is deemed necessary, low-level lighting, which is shielded and directed downward, to reduce light spillage will be used.	Inspection	Monthly during operations	Adherence to measures	O&M Contractor	REA-PMU FUE, Zaria (Site Engineer) FMEnv Kaduna State Ministry of Environment	-
Routine Maintenance, Waste Generation and Disposal							
E-waste generation and disposal (REC-14)	Training shall be provided for workers on safe storage, use and handling of e-waste on site.	Training Records	At induction of new staff , and in annual refresher training	Certificates of completion of trainings	O&M Contractor	REA-PMU FUE, Zaria (Site Engineer) FMEnv Kaduna State Ministry of	2000
	E-wastes generated shall be stored in appropriate locations prior to recycling; consignment notes will be maintained	Waste consignment notes, waste receptacles on Site	Continuous during operations	Adherence to measures	O&M Contractor		

Project Activity / Associated Impact	Mitigation Measures	Monitoring			Responsible Party		Cost (US Dollars)
		Requirements / Parameters	Frequency	Performance Indicator	Implementation	Monitoring	
	Waste receptacles shall be provided within a secured area for collection of solid waste.	Waste consignment notes, waste receptacles on Site	Continuous during operations	Adherence to measures	O&M Contractor	Environment	
Soil contamination from spent batteries and inverters (REC-03)	Waste that cannot be reused or recycled shall be disposed of at an approved dumpsite. Spent batteries and inverters shall be sent to manufacturers in line with the Extended Producer Responsibility (EPR) policy. Spent batteries shall also be managed in accordance with the National Environmental (Battery Control) Regulations, 2024 (S.I. No. 11 of 2024).	Consignment notes for spent batteries to [EM-04] manufacturers for recycling [EM-04]	Yearly	World Bank General EHS Guidelines	O&M Contractor	REA-PMU FUE, Zaria (Site Engineer) Kaduna State Ministry of Environment	1000
	WMP shall be implemented.	WMP [EM-04] implementation records [EM-04]	Quarterly during operation phase	Benchmarks stated in WMP World Bank General EHS Guidelines	O&M Contractor		
Groundwater abstraction from cleaning of PV panels (REC-04)	Water management / conservation plan shall be implemented	Implementation records of water [EM-03] management plan	Quarterly during operations	Benchmarks in water conservation plan World Bank General EHS Guidelines	EPC Contractor	REA-PMU FUE, Zaria (Site Engineer) Kaduna State Ministry of Environment	500

Table 7.4b: Social Management Measures for Operational Phase

Project Activity / Associated Impact	Mitigation Measures	Monitoring			Responsible Party		Cost (US Dollars)
		Requirements / Parameters	Frequency	Performance Indicator	Implementation	Monitoring	
Power Generation and Evacuation							
GBV (sexual harassment, intimate partner violence, poor working) (REC-16) [ESMP-03]	The EEP GBV Action Plan shall be implemented during operations	Implementation by the O&M Contractor	Continuously during operations	Evidence to show implementation of EEP GBV action plan	O&M Contractor	REA-PMU FUE, Zaria (Site Engineer) FMEnv Kaduna State Ministry of Environment	2000
	All workers shall be required to undergo regular training and refreshers on GBV	Organize regular onsite training and refreshers	Monthly during operation phase	Records of attendance			
	All workers on the project shall be required sign a code of conduct to prohibit any form of Gender Based Violence/Sexual Exploitation and Abuse (GBV/ SEA)	Develop CoC forms for workers	Once before start of operations	Signed CoC forms			
	GBV sensitive channels for reporting in GRM shall be implemented for the Project	Establish GRM reporting channels	Once before start of operations	GRM records			
	The EPC Contractor shall be required to hire a Gender/GBV officer	Hire GRM Officer	Once before start of operations	Employment records and job description			
	Collaboration with appropriate government institutions or GBV service providers on potential GBV case management shall be ensured	Engagement of GBV service provider	Once before start of operations	Records of ongoing engagement and consultation with GBV service providers			
	The EPC Contractor shall provide separate facilities for men and women and add GBV-free signage at the project site	Erection of separate convenience facilities and display of GBV signage	Once before start of Operations	Inspection of facilities to Ensure Adequacy			
Health, safety and welfare of staff during Plant operation (REC-	Provision of medical insurance scheme for employees shall be ensured.	Employment forms of employees	Quarterly during operations	Adherence to measures	O&M Contractor	REA-PMU FUE, Zaria (Site	3000

Project Activity / Associated Impact	Mitigation Measures	Monitoring			Responsible Party		Cost (US Dollars)
		Requirements / Parameters	Frequency	Performance Indicator	Implementation	Monitoring	
18) [ESMP-04]	Appropriate safety signage shall be placed at strategic locations within the site.	Safety signs	Quarterly during operations	Adherence to measures		Engineer) FMEnv Kaduna State Ministry of Environment	
	Strict compliance to the SOPs shall be ensured.	SOPs	Quarterly during operations	Adherence to measures			
	The NEP grievance mechanism procedure for receiving and addressing the concerns of employee shall be put in place and implemented.	Completed grievance forms	Monthly during operations	Adherence to measures			
Routine Maintenance, Waste Generation and Disposal							
Electric shock, injuries to personnel during maintenance (REC-18) [ESMP-04] [RM-04]	Appropriate PPE shall be provided for workers.	Availability of PPE	Quarterly during operations	Adherence to measures	O&M Contractor	REA-PMU FUE, Zaria (Site Engineer) Kaduna State Ministry of Environment	500
	Strict compliance to the SOPs shall be ensured.	SOPs	Quarterly during operations	Adherence to measures			

7.3 Roles, Responsibilities and Accountabilities

The main responsibility for overseeing the implementation of the ESMP lies with the REA PMU throughout the project life span. However, conformance with the specific environmental measures detailed in Chapter Six of this report will be ensured by the EPC contractor during the construction phase and Operations and Maintenance (O&M) Contractor at the operational phase of the Project.

7.3.1 Pre-construction Phase

The key personnel and institutions with major roles in the implementation of the ESMP during pre-construction phase are:

FUE, Zaria Director of Physical Planning

- Select the land for the proposed Project
- Appoint a Site Engineer
- Arrange and ensure adequate training is carried out for the Site Engineer
- Review the ESMP from the consultant
- Ensure the University's commitment to the ESMP implementation

REA-PMU

- Provide technical support to the University in identifying sufficient and suitable land for power station construction and the training center
- Appoint an EPC contractor
- Supervise the activities of the EPC contractor
- Review the ESMP from the consultant
- Ensure REA's commitment to the ESMP implementation

FUE, Zaria Site Engineer

- Attend adequate training on ESMP implementation
- Supervise the activities of the EPC contractor and ensure compliance ESMP with mitigation measures
- Report to FUE, Zaria Director of Physical Planning on ESMP compliance and non-compliance issues

EPC Contractor

- Familiarize with ESMP requirements
- Ensure that all personnel are made aware of the management measures/plans that are to be implemented
- Report to the REA-PMU and FUE, Zaria Site Engineer on ESMP compliance and non-compliance issues
- Implement ESMP requirements relevant to work being undertaken

7.3.2 Construction Phase

The key personnel and institutions with major roles in the implementation of the ESMP during construction phase are:

FUE, Zaria Director of Physical Planning

- Supervise the activities of the Site Engineer by reviewing reports on ESMP issues
- Suggest ESMP improvements to REA-PMU to address non-compliance and upcoming issues

REA-PMU

- Supervise the activities of the EPC contractor by reviewing reports on ESMP issues
- Discuss ESMP improvements with FUE, Zaria Director of Physical Planning to address non-compliance and upcoming issues
- Monitors the implementation of the ESMP

FUE, Zaria Site Engineer

- Supervise the activities of the EPC contractor and ensure compliance ESMP with mitigation measures
- Report to FUE, Zaria Director of Physical Planning on ESMP compliance and non-compliance issues

EPC Contractor

- Implement ESMP requirements relevant to work being undertaken
- Hire a Gender/GBV officer
- Report to the REA-PMU and FUE, Zaria Site Engineer on ESMP compliance and non-compliance issues

FMEnv Representatives

- Monitor the implementation of ESMP requirements (impact mitigation monitoring) relevant to work being undertaken
- Discuss ESMP improvements with FUE, Zaria Director of Physical Planning and REA-PMU to address non-compliance and upcoming issues

Kaduna State Ministry of Women Affairs and Social Development and GBV service provider

- Monitor the implementation of Gender mitigation measures relevant to work being undertaken
- Discuss ESMP improvements with the Gender/GBV officer, FUE, Zaria Director of Physical Planning, and REA-PMU to address non-compliance and upcoming issues

Kaduna State Ministry of Environment Representatives

- Monitor the implementation of ESMP requirements (impact-mitigation monitoring) relevant to work being undertaken
- Discuss ESMP improvements with FUE, Zaria Director of Physical Planning and REA-PMU to address non-compliance and upcoming issues

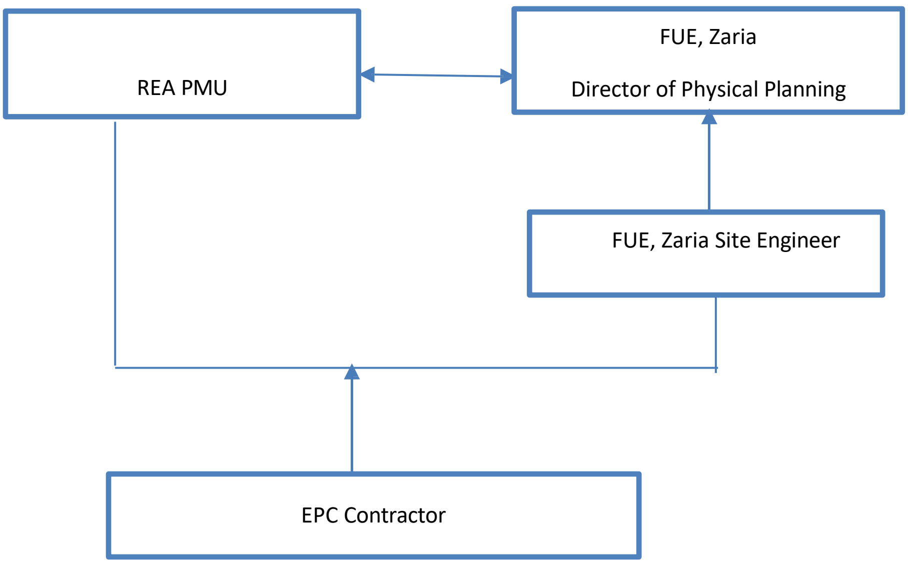


Figure 7.1: Roles and Responsibilities for the Pre Construction and Construction Phase

7.3.3 Operational Phase

FUE, Zaria Director of Physical Planning

- Supervise the activities of the Site Engineer by reviewing reports on ESMP issues
- Suggest ESMP improvements to O&M Contractor and PMU to address non-compliance and upcoming issues

REA-PMU

- Appoint a O&M Contractor
- Supervise the activities of the O&M Contractor by reviewing reports on ESMP issues
- Discuss ESMP improvements with FUE, Zaria Director of Physical Planning to address non-compliance and upcoming issues

FUE, Zaria Site Engineer

- Supervise the activities of the O&M Contractor and ensure compliance ESMP with mitigation measures
- Report to FUE, Zaria Director of Physical Planning on ESMP compliance and non-compliance issues

O&M Contractor Implement ESMP requirements relevant to work being undertaken

- Hire a Gender/GBV officer
- Report to the REA-PMU and FUE, Zaria Site Engineer on ESMP compliance and non-compliance issues

FMEnv Representatives

- Monitor the implementation of ESMP requirements (environmental compliance monitoring) relevant to work being undertaken
- Discuss ESMP improvements with FUE, Zaria Director of Physical Planning and REA-PMU to address non-compliance and upcoming issues

NESREA Representatives

- Monitor the implementation of ESMP requirements (environmental compliance monitoring) relevant to work being undertaken
- Discuss ESMP improvements with FUE, Zaria Director of Physical Planning and REA-PMU to address non-compliance and upcoming issues

Kaduna State Ministry of Women Affairs and Social Development and GBV service provider

- Monitor the implementation of Gender mitigation measures relevant to work being undertaken
- Discuss ESMP improvements with the Gender/GBv officer, FUE Zaria Director of Physical Planning, and REA-PMU to address non-compliance and upcoming issues

Kaduna State Ministry of Environment Representatives

- Monitor the implementation of ESMP requirements (environmental compliance monitoring) relevant to work being undertaken
- Discuss ESMP improvements with FUE, Zaria Director of Physical Planning and REA-PMU to address non-compliance and upcoming issues

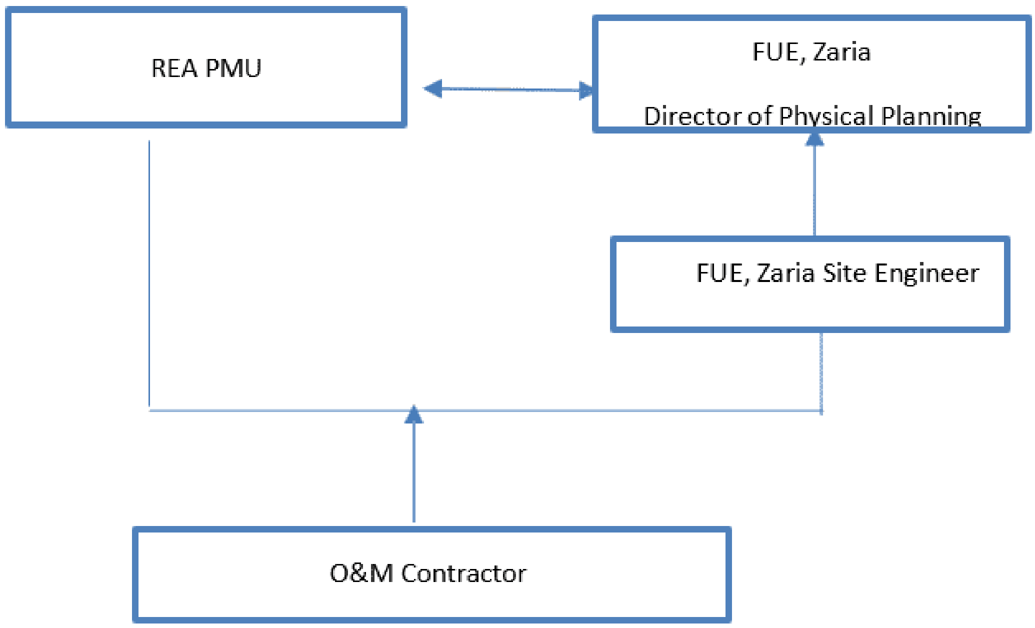


Figure 7.2: Roles and Responsibilities for the Operational Phase

7.4 Additional Management Plans

This section provides a framework for the contents of additional management plans to be developed and implemented, in support of this ESMP, for the proposed Project. As the Project progresses, the management plans will be expanded to include specific procedures to guide implementation by the relevant Project personnel including contractor and subcontractors.

The documents will be prepared strictly in line with the requirements set out in the relevant international standards and guidelines such as the World Bank General EHS Guidelines as well as other applicable national and local regulations and guidelines.

7.4.1 Stakeholder Engagement Plan

A Stakeholder Engagement Plan (SEP) shall be developed and implemented throughout the lifecycle of the proposed Project. The objectives of developing SEP for the proposed Project include the following:

- Ensuring stakeholder inclusion and involvement across the various phases of the project;
- Ensuring clarity and understanding through an open, inclusive and transparent process of culturally appropriate engagement and communication undertaken to ensure that stakeholders are well informed about the proposed Project;
- Building and maintaining productive relationship between REA and its various stakeholders through supporting open dialogue;
- Engaging vulnerable groups through an open and inclusive approach to consultation, thereby increasing the opportunity for stakeholders to provide comment and voice their concerns on the proposed Project;
- Managing expectations to ensure that the proposed Project does not create or allow unrealistic expectations to develop amongst stakeholders about proposed Project benefits. The engagement process will serve as a mechanism for understanding and managing stakeholder and community expectations, where the latter will be achieved by disseminating accurate information in an accessible way.
- Ensuring compliance with both local regulatory requirements and international best practice.
- Ensuring stakeholders are free of external manipulation or coercion.

REA is committed to implementing stakeholder management as part of its operations. As such REA will ensure that the responsibility for implementing the SEP is duly assigned and all components of the plan are well-defined within its organizational processes. REA shall also commit to providing the necessary support to implement the SEP.

In line with the Environmental and Social Management framework (ESMF) for NEP, an effective SEP should:

- ❖ Describe regulatory, lender, company, and/or other requirements for consultation and disclosure.
- ❖ Identify and prioritize key stakeholder groups, focusing on Affected Communities.
- ❖ Provide a strategy and timetable for sharing information and consulting with each of these groups.
- ❖ Describe resources and responsibilities for implementing stakeholder engagement activities.
- ❖ Describe how stakeholder engagement activities will be incorporated into a company‘s management system.

A sample SEP is outlined in the Environmental and Social Management framework (ESMF) for NEP (NEP ESMF, 2019).

Grievance Redress Mechanism

A Grievance Redress Mechanism (GRM) has been developed for NEP. The proposed solar-hybrid power plant and associated infrastructure in FUE Zaria is part of the NEP. The GRM provides a framework for addressing Project-related complaints, including logging, tracking, and grievances resolution. The GRM will be communicated to all stakeholders in the course of Project development and implementation and will make publicly available a record documenting the responses to all grievances received. The GRM shall be maintained throughout the project life cycle.

Emergency Preparedness and Response Plan (EPRP)

An Emergency Preparedness and Response Plan (EPRP) shall be developed and implemented for the proposed Power Plant. As part of the EPRP, the fire protection system for the Project will be designed to meet the requirements of the local fire codes under the National Fire Protection Association. In addition, the grounding and lightning protection systems for the Project shall be installed in a manner that will limit the effect of ground potential gradients to such voltage and current levels that will not endanger the safety of people or equipment under normal and fault conditions.

The EPRP shall include procedures for addressing all reasonably foreseeable and possible emergencies such as: fire, spill or release of hazardous wastes, medical and weather-related emergencies. It shall address the following aspects, amongst others:

- o Identification of the emergency scenarios and the development of appropriate and specific emergency response procedures for each scenario;
- o Training of emergency response teams on the appropriate procedures and the use of emergency response equipment;
- o Identification of emergency contacts and support services and the development of effective

communication systems / protocols;

- Emergency equipment and facilities must be provided (e.g., first aid stations, fire-fighting equipment, personal protective equipment);
- Development of decontamination / clean-up procedures and identify critical remedial measures to contain, limit and reduce pollution;
- Identification of potential risk relating the uncontrolled release of hazardous materials and the preparation of a spill prevention, control, and response plans including:
  - Training of operators on spill prevention.
  - Implementation of inspection programmes to confirm the integrity of secondary containment structures and equipment.
  - Development of standard operating procedures for filling containers or equipment and the transfer of hazardous materials.
  - Identification and availability of the appropriate personal protective equipment and equipment.

Waste Management Plan (WMP)

The primary purpose of the WMP is to ensure that wastes (hazardous/non- hazardous) are avoided or minimized, and any wastes that are generated are properly managed and disposed in an environmentally sound manner. The waste management hierarchy is expressed as follows:

- Prevention: avoid waste generation;
- Reduction at source - minimization of waste generation through installation of pollution abatement equipment;
- Reuse - Using an item for its original purpose, or similar purpose, in its original form;
- Recycling – conversion of waste materials into reusable objects;
- Disposal - disposal of wastes in an environmentally sound manner.

Occupational Health and Safety (OHS) Plan

The OHS plan must include the following elements, amongst others:

- Identification of potential hazards and development of responses to eliminate sources of risk or minimize workers' exposure to hazards;
- Provision of Personal Protective Equipment (PPE) to workers at no cost;
- Provision of training to all workers on all relevant aspects of occupational health and safety issues associated with their daily work, including emergency arrangements;
- Third parties (visitors and external service providers) must be briefed on the relevant aspects of

health and safety and emergency response when accessing the site premises.

Local and Employment Management Plan (LEMP)

The LESMP should aim to promote Employment opportunities and training for local people in the Project's area of influence and include, amongst others:

- Targets for employing local labour;
- Targets for work experience opportunities;
- Notification of all Employment and training opportunities prior to them being advertised elsewhere;
- Measures to provide verifiable monitoring information regarding training and Employment. The training status for all workers must be recorded;

Erosion Control Management Plan

This Plan should aim to control soil erosion in the Project area. The timing of works and the installation of control measures has a major influence on the management of storm water. The Plan should include the following measures, amongst others:

- Clearing of only those areas necessary for construction works shall be ensured.
- Slopes of all cut and fill areas shall be rigorously controlled and will at no time be allowed to be greater than the slope established in the final design;
- Piles of soil or other materials shall be allowed for short periods of time and will be located only in flat areas and away from any storm water courses;
- Temporary protection of exposed soil surfaces with measures such as plastic film, bio-membranes or other means, will be implemented whenever necessary;

Water Conservation Plan

The Plan will address the appropriateness of water conservation, and efficient use of groundwater for construction activities and cleaning of PV panels during the operational phase of the Project.

EEP Gender-Based Violence (GBV) Action Plan

The GBV action plan shall be implemented throughout the project lifecycle. The components of the plan include:

- A GBV risk assessment; which has been conducted as part of the ESIA.
- Integration of GBV risk management in the ESMP.
- REA-PMU shall define GBV requirements in the contractor bid documents including the hiring of a Gender/GBV officer.

- REA-PMU shall evaluate GBV response protocol of the contractors before finalizing engagement contract.
- Contractors shall ensure that there are GBV-sensitive channels for reporting in GRM.
- Contractors shall inform Project affected communities about GBV risks.
- Contractors shall ensure code of conducts (CoC) forms are signed and understood by all workers. Workers shall be trained on CoC including regular training and refreshers
- Contractors shall ensure separate facilities for men and women and install GBV-free signage at the Project site.

Timely implementation of the EEP GBV action plan shall reduce GBV/SEA risks that may arise during Project development and operation.

Summary of Additional Management Plans

Table 7.5 summarizes the additional management plans required for the Project, including the cost estimate for developing each of the plans.

Table 7.5: Additional Management Plans and Timing for Development

S/N	Plan	Timing for Development	Cost Estimates (US Dollars)
1.	Emergency Preparedness and Response Plan	Pre-construction	2000
2.	Traffic Management Plan	Pre-construction	2000
3.	Waste Management Plan	Pre-construction	3000
4.	Occupational Health and Safety	Pre-construction	2000
5.	Local and Employment Management Plan	Pre-construction	1500
6.	Erosion and Sediment Control Plan	Pre-construction	2000
7.	Water Conservation Plan	Pre-construction	1000
8.	EEP Gender Action Plan	Pre-construction	2000
9.	Stakeholder Engagement Plan	Pre-construction	2000
Total			17,500

7.5 Environmental Monitoring Programme

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. Table 7.6 summarizes the environmental monitoring programme for the Project.

Table 7.6: Environmental Monitoring Programme for the proposed Project

Environmental Components/ Matrix	Sampling Locations	Sampling Method	Environmental/ Social Parameters to be monitored	Compliance Requirement	Frequency of Monitoring	Responsible Party	Project Development Phase	Estimated Cost (US Dollars)
Atmosphere (Air Quality & [EM-01] [EM-02] Noise) (REC-01, REC-02)	• Project Site • Power evacuation route	• Air Quality Monitoring Equipment • Sound level meter	TSP, CO, NOX, SOX, Noise Level (dBA)	FMEnv/ WHO/ World Bank	Monthly monitoring; Monthly reporting	EPC Contractor	• Construction Phase	1000
Groundwater Quality (REC-04) [EM-03]	Borehole within the University	Thermometer, Water sampler, Turbidity meter, pH meter, AAS etc.	Temperature, pH, salinity, TDS, conductivity, DO, BOD, TOC, COD, NO3, PO4, Chloride, sulphate, Microbiology, Heavy metals, TSS and Turbidity	FMEnv/ WHO	Quarterly monitoring and reporting	EPC Contractor O&M Contractor	• Construction Phase • Operations Phase	4000
Soil (REC-03) [EM-04]	Unpaved sections of the Plant	Composite soil samples collection for laboratory analysis.	pH, Moisture, TOC, THC, TPH, NO3, PO4, Chloride, sulphate, Microbiology, Heavy metals.	NESREA/ World Bank	Quarterly monitoring and reporting	EPC Contractor O&M Contractor	• Construction Phase • Operations Phase	4000
Solid Waste	Operational areas	Monitor the handling and disposal of solid wastes generated onsite; waste tracking documentation.	Operational solid wastes including used packaging waste.	FMEnv/NESREA/ World Bank	Monthly monitoring; Quarterly reporting	EPC Contractor O&M Contractor	• Construction Phase • Operations Phase	2000
Health and Safety (REC-17, REC-18)	Workers and Operational areas	Observe compliance to PPE and unsafe working conditions	Health and Safety Plan	FMEnv/NESREA/ World Bank	Daily monitoring; Quarterly reporting	EPC Contractor O&M Contractor	• Construction Phase • Operations Phase	2000
Training	Workers	Observe compliance with existing training plan	Training plan and records	FMEnv/NESREA/ World Bank	Quarterly monitoring and reporting	EPC Contractor O&M Contractor	• Construction Phase • Operations Phase	2000

Environmental Components/ Matrix	Sampling Locations	Sampling Method	Environmental/ Social Parameters to be monitored	Compliance Requirement	Frequency of Monitoring	Responsible Party	Project Development Phase	Estimated Cost (US Dollars)
General Housekeeping (REC-11)	Construction sheds and operational areas	Observe cleanliness and aesthetics of Plant	Cleanliness and aesthetics of Plant	FMEnv/NESREA/ World Bank	Daily monitoring; Quarterly reporting	EPC Contractor O&M Contractor	• Construction Phase • Operations Phase	2000
Stakeholder Engagement	• Local community • Regulatory agencies	Observe evidence of stakeholder consultations	Stakeholder Engagement Plan	FMEnv/NESREA/ World Bank	Quarterly monitoring and reporting	EPC Contractor O&M Contractor	• Construction Phase • Operations Phase	2000

Training, Awareness and Capacity Building

REA shall identify, plan, monitor, and record training needs for personnel whose work may have a significant adverse impact upon the environmental or social conditions. The Project recognizes that it is important that employees at each relevant phase of the Project are aware of the potential impacts of their activities; and roles and responsibilities in achieving conformance with the management measures documented in this ESMP. This will be achieved through a formal training process.

In addition, training for local community on general environmental awareness and ESMP mitigation measures pertaining to community health, safety and security shall as be provided as indicated in Table 7.7.

Table 7.7: Institutional Capacity Strengthening Plan

Target Audience	Training Overview	Cost Estimates (US Dollars)
Site Engineer, REA, EPC contractor and their sub-contractors, O&M contractor	In-depth understanding of the mitigation measures proffered by the ESMP. Training on implementation of all emergency response procedures; training on Health, Environment, Safety, and Security Management Plan	2000
Local community	General environmental awareness and mitigation measures proffered by the ESMP pertaining to community health, safety and security.	1000
Total		**3000**

Implementation Schedule and Reporting

The implementation of the ESMP will take place from the planning stages to ensure quality equipment and support services is sourced, through construction, commissioning, operation to decommissioning phases. Once monitoring of the ESMP begins the officers responsible will report all issues identified to respective authorities in REA and corrective/ remedial actions taken without delay to ensure optimal performance of the Project while promoting environmental sustainability.

Also, REA shall keep the regulatory authorities (FMEnv, NESREA, Kaduna State Ministry of Environment) informed of the Project performance with respect to E&S related matters through reports that will be made available to the regulators when required. REA will provide appropriate documentation of HSE related activities, including internal inspection records, training records, and reports to the relevant authorities.

ESMP Costing

Table 7.8 provides the summary of cost estimate required to effective and efficiently implement the recommended mitigation measures and management plans required to address the potential and associated impacts of the proposed Project.

Table 7.8: ESMP Costing

S/N	Fundamental ESMP Activities	Cost Estimates (US Dollars)
1.	Pre-construction phase E&S management activities	4,000
	Construction phase E&S management activities	13,500
	Commissioning phase E&S management activities	700
	Operational phase E&S management activities	9,000
2.	Preparation of additional management plans	17,500
3.	Institutional Capacity Strengthening Plan	3,000
4.	Monitoring and Evaluation Programme	19,000
Total		**66,700**

7.6 Stakeholder Engagement and Grievance Redress Mechanism

This section describes the Stakeholder engagement activities as well as the grievance mechanism to be implemented for the proposed 2.0 MW solar power plant and associated infrastructure in Federal University of Education (FUE) Zaria, Kaduna State, as part of the Federal Government of Nigeria (FGN) Energizing Education Programme (EEP) Phase II.

7.6.1 Stakeholder Engagement

Stakeholder engagement is an ongoing process of sharing Project information, understanding stakeholder concerns, and building relationships based on collaboration. Stakeholder consultation is a key element of engagement and essential for effective Project delivery. Disclosure of information is equally as vital and must focus on informed consultation and participation with the local community and relevant stakeholders. If there are risks or adverse impacts from a Project, consultation must be inclusive and culturally appropriate and provide stakeholders with opportunities to express their views. In line with current guidance from the World Bank, consultation should ensure "*that appropriate project information on environmental and social risks and impacts is disclosed to stakeholders in a timely, understandable, accessible and appropriate manner and format*" In other words, effective consultation requires the prior disclosure of relevant and adequate Project information to enable stakeholders to understand the risks, impacts, and opportunities. The Project's consultation program was intended to ensure that stakeholder concerns are considered, addressed and incorporated in the development process, especially during the ESIA.

7.6.2 Objectives of Stakeholder Engagement

The stakeholder engagement process was designed to conform to the Nigerian EIA Act and international standards. For this Project, the key objectives for stakeholder engagement are:

- inform and educate stakeholders about the proposed Project;
- gather local knowledge to improve the understanding of the environmental and social context;
- better understand the locally-important issues;
- provide a means for stakeholders to have input into the Project planning process; take into account the views of stakeholders in the development of effective mitigation measures and management plans; and
- lay the foundation for future stakeholder engagement.

7.6.3 Stakeholder Identification and Analysis

Stakeholders are persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and/or the ability to influence its outcome, either positively or negatively (IFC, 2007). Stakeholders may include locally affected communities or individuals and their formal and informal representatives, national or local government authorities, politicians, religious leaders, civil society organizations and groups with special interests, the academic community, or other businesses.

Proper stakeholder identification forms the basis on which the stakeholder engagement was conducted for the Project as well as the development of the stakeholder engagement plan. It is necessary to determine who the stakeholders of a project are and understand their priorities and objectives. In addition it is also essential that stakeholders are classified based on their position, influence, capacity and interests in order to develop a functional Stakeholder Engagement Plan (SEP) that is tailored to meet the individual and group needs of the identified stakeholders.

A list of identified stakeholders for the Project is shown in Table 7.9. This consists of individuals, groups, and organizations that may be affected by or may influence project development positively or negatively. The list was developed using international guidance and considered the following groups: national and local governments; Local community leaders; community members including potentially vulnerable sub-groups such as women, youth and elderly; international, national and local environmental and social Non-Government Organizations (NGOs); Potential contractors and service suppliers; and local businesses/cooperatives and associations.

Table 7.9: Identified stakeholders associated with the Project

Stakeholder Group and Interest in the proposed Project	Stakeholder Name	Stakeholder Level				Connection to the Proposed Project
		International	National	State	Local	
Development Financial Institution	AfDB	□				Provide financial and technical support to project development and operation
Regulatory Authorities	Federal Ministry of Environment (FMEnv)		□			Has the responsibility for overseeing EIA process for the proposed Solar Projects and ensuring compliance to relevant environmental laws and regulations
	National Environmental Standards and Regulations Enforcement Agency (NESREA)		□			Has the responsibility of enforcing the environmental laws, guidelines, standards and regulations in Nigeria, specifically during the operational phase of developmental projects.
	Federal Ministry of Power (Department of Renewable Energy)		□	□		The Department of the Renewable Energy and Rural Power Access of the Federal Ministry of Power, Works and Housing is charged with the responsibility to coordinate all issues relating to renewable energy and energy efficiency
	Nigerian Electricity Regulatory Commission (NERC)		□	□		Responsible for granting operating licences for the Solar Projects
	Kaduna State Ministry of Environment		□	□		The Ministry oversees the protection of environment in Kaduna State
	Kaduna State Environmental Protection Authority		□	□		Responsible for waste management in Kaduna State
	Kaduna State Ministry of Women Affairs and Social Development		□	□		Promotes the development of women with equal rights and corresponding responsibilities including gender inclusion
	Kaduna State Ministry of Sports and youth development		□			Responsible for the inclusion of youths in Nigeria's development as well as the coordination of sports and recreational activities in the State
	Zaria Local Government Authority			□		

Stakeholder Group and Interest in the proposed Project	Stakeholder Name	Stakeholder Level				Connection to the Proposed Project
		International	National	State	Local	
Communities	Gyellesu Community				□	Households, communities and groups that may be directly or indirectly affected by the proposed Project and its activities.
University Representatives	Management of FUE, Zaria				□	Direct Project beneficiaries.
	Physical Planning Office				□	
	FUE, Zaria Student Union Body				□	

Stakeholder Register

The project shall maintain a stakeholder engagement register for recording stakeholder information such as contact details, dates of engagement with comments and follow up requirements.

Stakeholder Engagement Process

REA adopts a proactive approach towards building and maintaining mutually beneficial relationships with all relevant stakeholders, throughout its operations. The engagement program shall be implemented to comply with national and international standards. The stakeholder engagement will be free of manipulation, interference, coercion, and intimidation. It is conducted on the basis of timely, relevant, understandable and accessible information.

Effective stakeholder engagement depends on mutual trust, respect and transparent communication between the Project and its stakeholders. It thereby improves REA's decision-making and performance by:

- **Managing costs:** Effective engagement can help project REA avoid costs, in terms of money and reputation;
- **Managing risk:** Engagement helps project REA and communities to identify, prevent, and mitigate environmental and social impacts that can threaten project viability;
- **Enhancing reputation:** By publicly recognising human rights and committing to environmental protection, REA and financial institutions (World Bank) involved in financing the project can boost their credibility and minimise risks;
- **Avoiding conflict:** Understanding current and potential issues such as land rights and proposed project activities;
- **Improving corporate policy:** Obtaining perceptions about a project, which can act as a catalyst for changes and improvements in REA corporate practices and policies;
- **Identifying, monitoring and reporting on impacts:** Understanding a project's impact on

stakeholders, evaluating and reporting back on mechanisms to address these impacts; and

- **Managing stakeholder expectations:** Consultation also provides the opportunity for REA to become aware of and manage stakeholder attitudes and expectations. Table 7.10 presents elements of the stakeholder engagement program to be implemented by REA.

Table 7.10: Stakeholder Engagement Process

Stakeholder Engagement Activity	Approach
Stakeholder Identification and Analysis	An initial stakeholder identification and analysis has been conducted as part of this ESIA. REA shall maintain a register of identified stakeholders and undertake periodic review on a need basis.
Information Disclosure	REA shall ensure that information is provided to relevant stakeholders on an on-going basis over the course of the Project lifecycle. REA shall maintain regular communication with its stakeholders throughout the project lifecycle.
Stakeholder Consultation	REA shall consult with its various stakeholders on mutual concerns to fulfil its compliance obligations in line with industry best practice. REA shall maintain records of its consultation with its various stakeholders.
Negotiation and Partnerships	REA shall adopt a stakeholder management process that fosters the mutual interest of all parties and adds value to its operation.
Grievance Management	REA shall provide appropriate channels for stakeholders to raise their concerns and grievances about its operations
Stakeholder Involvement	This entails procedures that allow the direct involvement of stakeholders in project related functions in order to foster transparency and credibility.
Reporting to Stakeholders	REA shall establish reporting procedure that allows information disclosure to stakeholders about the environmental social and economic performance of its operations.
Management Functions	REA shall build and maintain management capacity within the company to manage the process of stakeholder engagement, track commitments and report on progress.

Stakeholder Engagement Tool and Communication

REA recognizes the need to tailor its stakeholder engagement approach and information disclosure to suit the needs of each of its stakeholder. REA shall adopt a variety of communication and engagement methods to ensure continuous engagement, dialogue and feedback is established during its engagement activities. Table 7.11 presents various tools and methods to be adopted by REA during its stakeholder engagement process.

Table 7.11: Stakeholder Engagement Tools and Communication

Medium	Most Appropriate Application
Stakeholder meetings	
One-on-one consultations	REA shall on a need basis hold consultation meetings with its individual stakeholders. These meetings will be held to: • Solicit views and opinions; • Discuss freely and confidently about stakeholder concerns and provide feedback etc.; • Build personal relations with stakeholders.

Medium	Most Appropriate Application
Focus group discussions	REA shall on a need basis hold focus group discussions (FGDs) to pull together a small group of people with the same interest into a single meeting to engage them on common issues. FGDs would have specific objective and be aligned with the expectations and interest of the stakeholders present.
Workshops	REA shall on a need basis hold workshops with its various stakeholders. Workshops are ad-hoc outcomes based meetings that seek to find solutions for specific issues facing the environment and social aspects. When conducting a workshop, REA shall use participatory exercises to facilitate group discussions, brainstorm issues, analyse information, and develop recommendations strategies.
Forum	REA shall on a need basis use forums to engage with various stakeholders. Participatory tools and methodologies such as workshops, town hall meetings, and FGDs will continue to be utilized, as they are more likely to increase stakeholder involvement in the process and elicit alternative responses, especially if there is controversy or complexity, or a need to build a consensus around possible solutions.
❖ Written / visual/electronic communication	
	REA shall use a variety of communication methods to disseminate information to its stakeholders. The approach adopted shall be based on the nature of the issue and the concerned stakeholder. External communications will include: o Project newsletters o Emails o Meetings o Executive Summary of the Environmental Impact Assessment o Mass Media, newspapers print etc. o Surveys

Table 7.12 presents a stakeholder analysis with respect to appropriate levels of consultation for each of the major stakeholder groups. REA shall determine the frequency of these interactions.

Table 7.12: Stakeholder Group Consultation Methods

STAKEHOLDER GROUP	CONSULTATION METHOD
Government and Regulators	• Email exchanges and letters • One-on-one consultations • Formal meetings • Print media • Compliance reporting • Performance report (Audits)
Project beneficiaries (FUE, Zaria Management, Physical Planning, Students)	• Formal meetings • One-on-one consultations • Print media • Strategic collaboration • Information Centre
Employees	• Phone / email / text messaging/ WhatsApp • Print media • Workshops • Focus group meetings • Surveys • Management/departmental meetings • Performance appraisal • Trainings

STAKEHOLDER GROUP	CONSULTATION METHOD
NGO's	• Phone / email • One-on-one interviews • Town hall meetings • Focus group meetings • Information Centre

Principles for Effective Stakeholder Engagement

Stakeholder engagement is usually informed by a set of principles defining core values underpinning interactions with stakeholders. Common principles based on International Best Practice include the following:

- **Commitment** is demonstrated when the need to understand, engage and identify the key stakeholders is recognized and acted upon;
- **Integrity** occurs when engagement is conducted in a manner that fosters mutual respect and trust;
- **Respect** is created when the rights, values and interests of stakeholders and neighbours are recognized;
- **Transparency** is demonstrated when stakeholder concerns are responded to in a timely, open and effective manner;
- **Inclusiveness** is achieved when broad participation is encouraged and supported by appropriate participation opportunities; and
- **Trust** is achieved through open and meaningful dialogue that respects stakeholder's values and opinions.

7.7 Summary of Previous Stakeholder Engagement Activities

Stakeholder consultation and socio-economic engagement activities were undertaken as an integral component of the Environmental and Social Impact Assessment (ESIA) for the proposed 2 MW Solar-Hybrid Power Plant and associated infrastructure at the Federal University of Education (FUE), Zaria, Kaduna State. The engagement activities were conducted during the ESIA baseline field investigations and were designed to facilitate stakeholder participation, obtain relevant socio-economic information, assess awareness and perceptions of the proposed Project, identify potential environmental and social concerns, and understand stakeholder expectations regarding the anticipated benefits and impacts of the Project.

The stakeholder engagement process was integrated with the wider socio-economic baseline survey and involved consultation meetings with the top management of FUE Zaria and relevant associated departments and units, as well as direct field-based interactions, questionnaire administration, individual interviews and group discussions with relevant stakeholders within the Project Area of Influence. The engagements were carried out from February 1 to 4, 2026 and covered different categories of stakeholders, including:

- Top management of the Federal University of Education (FUE), Zaria;
- The Physical Planning, and Works department and administrative units;
- Students and members of the FUE Zaria community;
- Male and female respondents within the Project Area of Influence;
- Members of the Gyellesu host community and other persons within the Project Area of Influence; and
- Other interested persons encountered during the socio-economic baseline survey.

The consultations and socio-economic survey provided opportunities to obtain information on existing socio-economic conditions, prevailing land-use practices, electricity supply conditions, community awareness of the proposed Project, perceptions of potential environmental and social impacts, anticipated Project benefits, employment expectations, community health and safety considerations, and other issues relevant to the assessment. The meetings with FUE Zaria's top management and associated departments and units also provided institutional and technical information relevant to the proposed Project, including the University's existing electricity supply challenges, proposed Project locations, existing and planned land uses, campus infrastructure, access arrangements, institutional development priorities, and the anticipated benefits of the proposed solar-hybrid power system.

The engagement activities were undertaken through a combination of formal and direct consultations, structured questionnaires, direct interviews, field observations and group-level interactions. Particular attention was given to ensuring the participation of institutional stakeholders, students, both male and female respondents, and persons whose existing activities could potentially be affected by Project development. Photographic evidence of the stakeholder consultation and socio-economic questionnaire administration activities is presented in the appendices of this ESIA report.

The stakeholder engagement activities indicated a generally positive perception of the proposed Project. FUE Zaria's management and relevant associated departments and units recognized the importance of the proposed Project in addressing the University's electricity supply challenges and supporting teaching, learning, research, administration and other institutional activities. Respondents also recognized the potential of the proposed solar-hybrid power plant to improve the reliability of electricity supply, enhance teaching, learning and research activities, support institutional productivity, create employment and economic opportunities, improve campus security through enhanced street lighting, and contribute to the deployment of renewable energy infrastructure.

At the same time, the engagement and wider socio-economic assessment provided a basis for considering potential environmental and social issues associated with Project implementation, including temporary disruption of existing land uses, construction-related disturbance, occupational and community health and safety, employment expectations, labour influx, Gender-Based Violence (GBV), Sexual Exploitation and Abuse/Sexual Harassment (SEA/SH), waste management, and the need for continuous information disclosure and stakeholder participation throughout the Project lifecycle.

The principal findings of the stakeholder engagement activities are summarized in Table 7.13, and the pictorial samples of the consultation meetings are provided in Appendix One.

Table 7.13: Summary of Stakeholder Consultation Findings

Stakeholder Group	Priority Issues/Areas of Interest	Consultation Findings and Stakeholder Perceptions	Project Response/ESIA Measures
FUE Zaria Top Management	Project development; electricity supply; institutional energy requirements; land availability; campus development; Project benefits	The University's top management expressed support for the proposed Project and recognized its importance in addressing existing electricity supply challenges and improving teaching, learning, research, administration and other institutional activities. The engagement also provided relevant information regarding the University's existing and projected energy requirements, institutional priorities and the proposed locations for Project infrastructure.	The Project design and ESIA take into consideration the University's electricity requirements, institutional development priorities, existing campus infrastructure and environmental and social conditions. Continued coordination with FUE Zaria management will be maintained throughout Project implementation.
FUE Zaria Physical	Project siting; existing and planned	The relevant departments and units provided institutional and	Information obtained from the relevant departments and units has

Stakeholder Group	Priority Issues/Areas of Interest	Consultation Findings and Stakeholder Perceptions	Project Response/ESIA Measures
Planning, Works and other associated technical and administrative units	land uses; campus infrastructure; access arrangements; electricity distribution; construction activities; environmental and social management	technical information concerning the proposed Project sites, campus infrastructure, existing and planned land uses, access arrangements and other site-specific considerations relevant to Project development.	informed the Project description, baseline assessment, impact assessment and ESMP. Continued technical coordination will be maintained during Project design, construction and operation.
Students and members of the FUE Zaria community	Electricity supply; educational activities; campus security; Project awareness; employment and economic opportunities	Respondents generally perceived the proposed Project positively, particularly in relation to improved electricity supply, enhanced teaching and learning conditions, improved institutional productivity, increased security through street lighting, and potential employment and economic opportunities.	The Project is designed to provide reliable and sustainable electricity to support academic, research, administrative and other institutional activities. Appropriate measures for community health and safety, information disclosure, employment management and continued stakeholder engagement have been incorporated into the ESMP and Stakeholder Engagement Plan.
Male and female respondents within the Project Area of Influence	Potential environmental and health impacts; employment opportunities; community benefits; social inclusion; safety and security	Respondents provided information regarding existing socio-economic conditions, perceived environmental and social impacts, anticipated benefits, existing infrastructure and services, and expectations regarding Project implementation. The engagement included both male and female respondents to support inclusive participation.	Potential environmental and social impacts have been assessed within the ESIA, and corresponding mitigation and enhancement measures have been incorporated into the ESMP. The Project will promote non-discrimination, gender inclusion, worker codes of conduct and appropriate mechanisms for addressing grievances.
Gyellesu host community and other persons	Project awareness; electricity supply; employment; local economic	The socio-economic assessment indicated generally positive perceptions of the Project and expectations that improved	Continuous stakeholder engagement shall be maintained throughout Project implementation. Local employment opportunities shall be

Stakeholder Group	Priority Issues/Areas of Interest	Consultation Findings and Stakeholder Perceptions	Project Response/ESIA Measures
within the Project Area of Influence	development; environmental and social impacts; community health and safety	electricity infrastructure could support educational activities, entrepreneurship, employment opportunities, security and wider local economic development.	promoted where feasible, while community health and safety measures, traffic management, grievance mechanisms and information disclosure procedures shall be implemented.
Women and other potentially vulnerable stakeholders	Equal access to opportunities; GBV/SEA/SH risks; workplace safety; grievance reporting; social inclusion	The socio-economic survey considered gender-related conditions, access to economic opportunities, perceptions of GBV and the availability of support mechanisms. Female respondents participated in the baseline socio-economic survey and stakeholder engagement activities.	The Project shall implement applicable GBV/SEA/SH prevention measures, worker Codes of Conduct, gender-sensitive grievance channels, awareness programmes and non-discriminatory recruitment practices.
Interested persons encountered during field surveys	Project information; potential impacts; employment; safety; environmental protection and Project benefits	Direct field interactions and questionnaire administration enabled individuals within the Project Area of Influence to provide information on their existing conditions, concerns, perceptions and expectations regarding the proposed Project.	Relevant issues identified through the socio-economic assessment have informed the impact assessment, mitigation measures, ESMP, Stakeholder Engagement Plan and Grievance Redress Mechanism.

Overall, the stakeholder engagement and socio-economic consultation activities demonstrated generally positive perceptions of the proposed 2 MW Solar-Hybrid Power Plant at FUE Zaria. The University's top management and relevant associated departments and units expressed support for the proposed development and recognized its strategic importance in improving the reliability and sustainability of electricity supply to the institution. The anticipated benefits most relevant to stakeholders include improved electricity supply, enhanced teaching and learning conditions, improved research and institutional productivity, employment and economic opportunities, improved campus security, and the promotion of renewable energy development.

The engagement process also highlighted the importance of managing potential environmental and social risks associated with construction and operation, particularly those relating to existing land-use activities, community health and safety, occupational health and safety, traffic movement, waste generation, employment expectations, labour-related risks, GBV/SEA/SH, and access to effective grievance mechanisms.

The findings of the stakeholder engagement and socio-economic assessment have therefore been incorporated into the Project's impact assessment, mitigation measures, Environmental and Social Management Plan (ESMP), Stakeholder Engagement Plan (SEP), and Grievance Redress Mechanism (GRM). Continued stakeholder engagement will be maintained throughout the pre-construction, construction, commissioning, operational and decommissioning phases of the Project to ensure timely information disclosure, inclusive participation, identification of emerging concerns and effective resolution of grievances.

7.8 Management Function and Grievance Mechanism

Management Commitment

REA is committed to implementing stakeholder management as part of its operations. As such REA will ensure that the responsibility for implementing the SEP is duly assigned and all components of the plan are well-defined within its organizational processes. REA shall also commit to providing the necessary support to implement the SEP. The management structure for the SEP shall include the following elements.

Systems: REA will pursue its Stakeholder engagement activities as scheduled in a systematic manner that creates predictability in the eyes of the stakeholder in order to support and foster a relationship that is based on trust.

Structure: REA will establish a Stakeholder focused-structure within its organizational processes to provide the needed decision-making authority to enable quicker turnaround time on Stakeholder engagement activities and grievance feedback.

Skills: REA will ensure that the required internal capacity for effective Stakeholder engagement is provided for the implementation of the stakeholder engagement plan. Roles and Responsibilities

REA shall assign the responsibilities of conducting and organizing stakeholder consultation and involvement to competent individuals. The individuals shall be qualified professionals with relevant skills and experience. The REA Project Management Unit shall have the overall responsibility of overseeing the implementation of the SEP. The role of managing stakeholder engagement shall be given to the University's Community Liaison Officer (CLO). The CLO shall monitor the implementation of the Project's stakeholder engagement program and report findings to the REA Project Management Unit.

7.9 Grievance Redress Mechanism (GRM)

A grievance redress mechanism (GRM) has been developed by REA which is applicable to all components of the NEP; including the EEP Projects (Available in Appendix 9.3). The NEP GRM was developed to provide project affected persons (including interest groups) directly affected by its development activities with access to mechanisms for them to present their grievances and find solutions through avenues that are legitimate, reliable, transparent, cost-effective and easily accessible at the lowest level, without allowing them to escalate into unmanageable levels. This access will be all inclusive with consideration for people living with disabilities and vulnerable groups.

With respect to the EEP component of the NEP, the GRM has identified potentials for grievance associated with the proposed project. The GRM also outlines the following:

- Identification of core institutional blocks for the EEP;
- Provision of grievance uptake points, including a description of communication channels, actions, and timeframe;
- Composition of the Project Management Unit (PMU) Grievance redress committee, with details about their activities;
- Composition of the community based Grievance redress committee; and
- GRM structure to be implemented for the EEP Projects.

CHAPTER EIGHT

REMEDIATION PLAN AFTER DECOMMISSIONING / CLOSURE

8.0 Introduction

This chapter discusses the activities associated with the decommissioning of the proposed Project, including the potential impacts associated with the decommissioning activities as well as the environmental and social measures to address the issues. In addition, the overview of remediation plan after the decommissioning/closure of the Project is provided.

8.1 Decommissioning Activities

Decommissioning refers to the process of removing all the operating assets of a project after completion of its life cycle. The average life span of the solar Photovoltaic (PV) power plant to be provided as part of the proposed Project is 25 years (which can be extended through regular maintenance) while the training centre can last for 40 years or more. Even after the 25 years, the PV panels can still generate up to 90% of the design capacity.

The decommissioning activities will typically include the following:

- Dismantling and removal of PV panels and associated infrastructure (mounting structure, power evacuation cable, inverters, transformers, batteries, etc.);
- Removal of any sub-surface installations (e.g. underground cables);
- Waste generation and management;
- Rehabilitation of any impacted environmental component (e.g. soil).

8.2 Management of Decommissioning Activities

In the event of decommissioning, REA, in conjunction with the leadership of FUE, Zaria, shall ensure that the Project site is left in a safe and environmentally acceptable condition. A standard decommissioning, abandonment and closure programme shall be invoked. The tasks will include, amongst others:

- Evacuation of the dismantled PV panels and other related items (such as inverters, and control devices) to the manufacturers for recycling.
- Transportation of spent batteries to recycling facilities.
- Restoration of the Project site to baseline conditions (as much as practicable) in line with legislative and regulatory requirements.
- Assessing the residual impact, if any, the project has on the environment.
- Monitoring the abandoned project environment as necessary.

Decommissioning activities will only begin after due consultation with the relevant stakeholders including the regulatory authorities. The decommissioning activities shall be carried out in line with the relevant provisions of the National Guidelines for Decommissioning of Facilities in Nigeria (2017) issued by the FMEnv.

Typically, the following actions shall be undertaken for decommissioning:

- An updated plan which takes into account the most cost-effective and best practicable methods, legal requirements and industry practices at that time for the facility decommissioning shall be developed and submitted to the FMEnv and other relevant regulatory authorities for approval. The plan shall include, but not limited to the following:
    - Description of the site and components to be decommissioned.
    - Description of the decommissioning scope, objectives, end state and strategy;
    - Activities to be performed during the decommissioning;
    - Schedule of decommissioning activities;
    - Estimate of the decommissioning cost;
    - Estimated inventory of waste streams to be generated during the decommissioning and handling techniques;
    - Decommissioning team (qualifications, roles and responsibilities)
- To ensure that due consideration is given to all options a detailed evaluation of facility decommissioning options shall be carried out. The options will include facility mothballing, partial facility decommissioning or complete site decommissioning. The evaluation will consider environmental issues in conjunction with technical, safety and cost implications to establish the best practicable environment friendly options for the Project decommissioning.
- A risk assessment shall be conducted to ensure that nothing, which could be constituted as a hazard for other users of the site or for the environment in general, will be left at the site. The Project site shall be left in a safe and environmentally acceptable condition.
- Hazard identification and analysis shall be conducted to determine special safety concerns to be addressed.
- An appropriate Health, Safety and Environment (HSE) plan shall be implemented to ensure that the decommissioning activities are carried out in an environmentally sound manner and in conformity with relevant laws and regulations guiding such operations
- Third party notifications shall be carried out before any demolition and shall be conducted in a

phased sequence.

- Socio-economic considerations of facility decommissioning shall be carried out. These will include assessment of potential effects associated with termination of employment (at the end of operational phase) and the measures to minimize the effects by:
  - Ensuring that employees are fully informed about the decommissioning and how it will affect them before the project finally closes.
  - Building community capacity to manage opportunities and impacts arising from the decommissioning and post-decommissioning phase of the Project.
  - Providing training to build local skills tailored to project decommissioning and post-decommissioning activities (e.g. equipment dismantling, rehabilitation activities, monitoring, etc.).
  - Providing training to transfer project-learned skills to alternative and secondary industries tailored to respond to market economy.
- An effective waste management plan shall be developed for the decommissioning activities. The decommissioning options for redundant structures and equipment will include: the complete dismantling of structures and equipment and the return of all components to the equipment manufacturer for recycling. A detailed record of all suitable recycling materials shall be maintained.

The environmental and social management measures for the identified potential impacts of the decommissioning activities are presented in Table 8.1.

8.2.1 Used Battery Management at Decommissioning Phase

Lithium-ion batteries that have reached the end of their life spans are classified as hazardous waste. The used batteries decommissioned from the power plant shall be packed separately from other materials. Damaged batteries in a critical stage, in particular, require special expertise in handling, as they can be flammable. Currently, Lithium-ion battery recycling in Nigeria is at the infancy stage as most local recycling companies specialize in recycling lead-acid batteries. This presents a challenge to the recycling of used batteries locally. Therefore, the Extended Producer Responsibility (EPR) policy shall be adopted for the project. It includes the take- back, recycling and final disposal of the product including its packaging. The manufacturers / suppliers of the batteries shall be responsible for the recycling and safe disposal of the used batteries. The costs of recycling and disposal will be internalized in the price of the batteries or take-back agreements will be provided. During decommissioning activities, the batteries shall be removed, discharged, and packaged according to the manufacturer / supplier's instructions before transportation to the endpoint. Conversely, the University shall be encouraged to develop end-of-life management plans for the batteries and other electrical components. The plan shall include the development of procedures for safe handling, storage, and transport of the used batteries generated during Project operations. Also, procedures for identification and engagement of NESREA certified battery recycling companies based in Nigeria shall be developed and implemented for the Project.

8.2.2 Abandonment Plan

Prior to site abandonment, REA shall establish a standard procedure for incorporating the following practices:

- Identification of the components of the Project that will be abandoned and/or removed;
- The proposed methods for abandonment or re-use of the Project equipment/material applicable;
- Processes put in place to mitigate potential environmental impacts associated with the abandonment process; and
- Appropriate site rehabilitation programs (including re-vegetation of the site with native plant species) to return the Project site to its original status (as much as possible).

The decommissioning, abandonment and/or closure programme shall generally be managed by a team of competent personnel from REA-Project Management Unit, the Department of Works and Physical Planning in FUE, Zaria, the Federal Ministry of Environment and the Kaduna State Ministry of Environment. A close out report shall be prepared and archived for future reference.

8.3 Roles, Responsibilities and Accountabilities for Decommissioning Phase

The key personnel and institutions with major roles in the implementation and monitoring of environmental and social measures for the Project decommissioning/closure are as follows:

<u>Contractor(s) Engaged for Decommissioning Activities</u>

- Implement environmental and social measures and management actions put in place for the decommissioning activities.

<u>REA-PMU</u>

- Supervise the activities of the contractor(s) engaged for decommissioning purpose by ensuring that the recommended environmental and social measures and management actions are implemented.
- Discuss environmental and social management plan improvements with the Director of Works and Physical Planning Department in FUE, Zaria to address non- compliance and upcoming issues.

FUE, Zaria Site Engineer/Manager

- Directly monitor the activities of the contractor(s) engaged for decommissioning and ensure compliance to the implementation of environmental and social measures and management actions put in place to address potential impacts and risks associated with the decommissioning activities.
- Report to the Director of Works and Physical Planning Department in FUE, Zaria on contractor's performance regarding the implementation of environmental and social measures.

Director of Works and Physical Planning Department in FUE, Zaria

- Jointly supervise the activities of the contractor(s) engaged for decommissioning
- Suggest environmental and social management plan improvements to REA- PMU to address non-compliance issues and upcoming issues.

FMEnv/Kaduna State Ministry of Environment Representatives

- Approve the decommissioning plan for the Project
- Monitor the implementation of environmental and social measures and management actions documented in the decommissioning plan.
- Discuss environmental and social management plan improvements to REA- PMU to address non-compliance issues and upcoming issues.

Table 8.1: Environmental and Social Management Measures for Decommissioning Phase

Summary of Potential Impact	Mitigation Measures	Monitoring			Responsible Party		Cost (US Dollars)
		Requirements / Parameters	Frequency	Performance Indicator	Implementation	Monitoring	
Removal of PV panels, batteries and inverters; demolition of buildings and associated facilities							
Soil contamination due to waste generation; soil compaction;	Excavation works shall not be executed under Aggressive weather conditions.	Inspection	Daily	Adherence to measures	Contractor(s) engaged for facility decommissioning	REA-PMU FUE, Zaria (Site Manager and Director of Works and Physical Planning) FMEnv Kaduna State Ministry of Environment	5000
	Stockpiles shall be appropriately covered to reduce soil loss as a result of wind or water Erosion	Inspection	Daily	Adherence to measures			
	Hazardous substances and materials (e.g. fuel, lubricating oil, etc.) shall be stored in appropriate locations with impervious hardstanding and adequate secondary containment (bund wall). Portable spill containment and clean-up kits shall be available onsite.	Inspection	Daily	Adherence to measures World Bank General EHS Guidelines			
	PV panels, batteries and inverters shall be collected and returned to the manufacturer for recycling.	Consignment notes for batteries to recycling plants	Daily	World Bank General EHS Guidelines			
	All impacted soil area shall be re-vegetated with native plant species	Inspection	Daily	Re-vegetated land			

Summary of Potential Impact	Mitigation Measures	Monitoring			Responsible Party		Cost (US Dollars)
		Requirements / Parameters	Frequency	Performance Indicator	Implementation	Monitoring	
	A decommissioning plan approved by the relevant regulatory authorities shall be developed and implemented.	Implementation records of decommissioning plan	Daily	Benchmarks in decommissioning plan			
Air quality impact; increase in dust level.	Dust suppression measures shall be implemented.	Inspection	Daily	Adherence to measures	Contractor(s) engaged for facility decommissioning	REA-PMU FUE, Zaria (Site Manager and Director of Works and Physical Planning) FMEnv Kaduna State Ministry of Environment	1000
	Decommissioning equipment shall be properly serviced and maintained.	Inspection; Maintenance records	Before commence ment of decommissi oning activities	Adherence to measures			
Discomforting noise from decommission, equipment and related activities	Noise suppression equipment (e.g. mufflers) shall be fitted on decommissioning equipment / machinery.	Inspection	Daily	Adherence to measures	Contractor(s) engaged for facility decommissioning	REA-PMU FUE, Zaria (Site Manager and Director of Works and Physical Planning) FMEnv Kaduna State Ministry of Environment	2000
	Decommissioning activities shall be limited to day-time (08.00hr to 17.00hr during weekdays; and weekends 09.00hr-13.00hr).	Inspection	Daily	Adherence to measures			
	Equipment shall be turned off when not in use.	Inspection	Daily	Adherence to measures			

Summary of Potential Impact	Mitigation Measures	Monitoring			Responsible Party		Cost (US Dollars)
		Requirements / Parameters	Frequency	Performance Indicator	Implementation	Monitoring	
	Equipment shall be properly maintained and serviced.	Inspection; Maintenance records	Once before Commence ment	Adherence to measures			
	Noise complaints related to the construction activities shall be assessed and appropriately addressed.	Complaint records	Weekly	World Bank Good Practice Note on Addressing Grievances			
	Noise monitoring at locations with persistent noise complaints shall be maintained.	Noise monitoring records	Monthly	FMEnv Noise limit World Bank Noise Limit			
Groundwater and surface water contamination due to waste generation	Training shall be provided for workers on safe storage, use and handling of hazardous materials (e.g. fuel, lubricating oil) on site.	Training records	Once before commence ment	Certificates of Completion of trainings	Contractor(s) engaged for facility decommissioning	REA-PMU FUE, Zaria (Site Manager and Director of Works and Physical Planning) FMEnv Kaduna State Ministry of Environment	1500
	Hazardous substances and materials (e.g. fuel, lubricating oil, etc.) shall be stored in appropriate locations with impervious hardstanding and adequate secondary containment. ortable spill containment and clean-up kits shall be available onsite.	Inspection	Daily	Adherence to measures World Bank General EHS Guidelines			
	Waste Management Plan shall be implemented.	WMP implementation records	Daily	Benchmarks stated in WMP World Bank General EHS Guidelines			

Summary of Potential Impact	Mitigation Measures	Monitoring			Responsible Party		Cost (US Dollars)
		Requirements / Parameters	Frequency	Performance Indicator	Implementation	Monitoring	
Traffic due to transportation of dismantled equipment and materials from site including wastes	TMP shall be implemented.	TMP implementation records	Daily	Benchmarks stated in the TMP	Contractor(s) engaged for facility decommissioning	REA-PMU FUE, Zaria (Site Manager and Director of Works and Physical Planning) FMEnv Kaduna State Ministry of Environment	2500
	Appropriate barriers and signage shall be provided to demarcate areas in which traffic is active.	Safety signs and barriers	Once before commence ment	Adherence to measures			
	Drivers' competency shall be assessed and where required training shall be provided.	Drivers' competency assessments; training records	Once before commence ment	Passing of competency assessment or training completion Certificates			
	A procedure for recording all decommissioning related traffic incidents/accidents shall be developed and implemented. This will include date/time, location, reason for accident, corrective measures, etc.	Incident forms	Daily	Completed incident forms			
Exposure to injuries, electrical shock, slip, trip and fall	All workers involved in the decommissioning activities shall be sensitized and monitored on the need to be safety conscious. Daily toolbox talks prior to commencement of work activities shall be carried out.	Daily toolbox records	Daily	Benchmarks stated in Health and Safety Plan	Contractor(s) engaged for facility decommissioning	REA-PMU FUE, Zaria (Site Manager and Director of Works and Physical Planning) FMEnv	2500

Summary of Potential Impact	Mitigation Measures	Monitoring			Responsible Party		Cost (US Dollars)
		Requirements / Parameters	Frequency	Performance Indicator	Implementation	Monitoring	
	Appropriate PPE shall be provided for workers.	Availability of PPE	Daily	PPE compliance		Kaduna State Ministry of Environment	
	Onsite safety officer shall be engaged to monitor the compliance of workers to safety rules.	Qualified and dedicated safety officer	Once before commence ment	Adherence to measures			
	Health and safety plans shall be implemented.	Health and Safety plan implementation records	Daily during constructio n phase	Benchmarks stated in Health and Safety Plan			
Total Cost							**14,500**

CHAPTER NINE
SUMMARY AND CONCLUSION

9.1 Summary

The project is part of the Federal Government's Energizing Education Programme (EEP), aimed at providing reliable and sustainable 24-hour uninterrupted electricity to Federal Universities.

The scope of the EEP includes provision of off-grid, dedicated and independent power plant, rehabilitation of existing electricity distribution infrastructure, and provision of street lighting (for illumination and improved security) as well as a world class renewable energy training centre for each of the beneficiary universities. FUE Zaria is one of the beneficiary universities under the EEP Phase II.

In compliance with the relevant requirements of the Federal Ministry of Environment (FMEnv.) and other relevant regulatory agencies in Nigeria, as well as the applicable requirements of the African Development Bank Integrated Safeguards System (ISS, 2023), the ESIA of the proposed Project in FUE. Zaria has been conducted. The ESIA study covers the entire life cycle of the Project (i.e. pre-construction, construction, commissioning, operation, decommissioning, and closure) and it involves key issues identification, baseline environmental and socio-economic data gathering, stakeholder consultation, identification and evaluation of impacts, development of mitigation measures and environmental and social management plan.

The proposed 2 MW Solar-Hybrid Power Plant at the FUE Zaria is part of the Energizing Education Programme (EEP) under the Nigeria Electrification Project (NEP). The Project is designed to provide reliable and sustainable electricity to the University in order to enhance teaching, research, technological development, and overall institutional performance. As a University of Technology, FUE Zaria requires stable power supply for engineering laboratories, workshops, ICT facilities, administrative operations, and student hostels. The current dependence on unstable grid supply and diesel generators results in operational disruptions, high energy costs, and environmental emissions. The proposed solar-hybrid system will address these challenges by providing a dedicated and cleaner source of electricity. The Project also supports Nigeria's Nationally Determined Contributions (NDCs) under the Paris Agreement (2016) by promoting renewable energy and reducing greenhouse gas emissions. Furthermore, it aligns with the Power Sector Recovery Programme (PSRP) approved by the Federal Executive Council (FEC) on 22 March 2017, which aims to improve reliability and sustainability in Nigeria's power sector.

9.2 Conclusion

The ESIA of the proposed 2.0 MW solar power plant and associated infrastructure in the FUE Zaria, under the EEP, has been conducted in accordance with the relevant requirements of the FMEnv guidelines and the African Development Bank Integrated Safeguards System (ISS), including applicable Operational Safeguards relevant to the proposed project.

The ESIA study consists of a number of key steps including: desktop review, scoping, consultations with relevant stakeholders including relevant government authorities and potentially affected community in the Project's area of influence, field data gathering, laboratory analysis of field samples, potential impact identification and evaluation, development of mitigation measures and environmental management plan, report writing and disclosure.

The essence of the ESIA process is aimed at ensuring informed decision-making and environmental accountability, and to assist in achieving environmentally sound operation and social acceptance throughout the life cycle of the proposed Project.

Consistent with the regulatory standards, the assessment of the environmental status and the socio-economic aspects of the proposed Project's area of influence have been carefully carried out using accepted scientific methodology. Evaluation of associated and potential impacts of the proposed Project identified both positive and negative interactions with the receiving biophysical and socio-economic environment.

The positive impacts associated with the Project include:

- Stimulation of academic and research activities within the University as a result of access to constant and reliable power supply, thereby promoting educational advancement.
- Reduction in fossil fuel consumption by the University thereby leading to reduction in carbon emissions and improvement in eco-balance.
- Significant reduction in the cost of power generation by the University through diesel-fuelled generators. Such savings would be used for other undertakings that will benefit the University.
- Increase in social interactions within the University. There will be enhanced security in the University as a result of more streetlights for illumination which would help keep off opportunistic crimes and gender-based violence.
- Enhancement of learning in renewable energy leading to certification as a result of training centre to be provided as part of the Project.
- Improvement in livelihood enhancing activities within the University.
- Direct and indirect employment opportunities during Project development and operation. The employment opportunities will lead to acquisition of new skills and introduction of all manners

of income generating spill-over effects.

- Increase in local and regional economy through award of contracts and purchase of supplies for Project development.
- Increase in financial and technical collaborations between the FGN, the University, REA, World Bank and other relevant Ministries, Departments and Agencies (MDAs).
- Contribution to the Nigeria's NDC to cut carbon emission by 20 % to 30 % by the year 2030, under the Paris Agreement.

The identified negative impacts of the proposed Project were mostly of minor to moderate significance, and they are largely site-specific and localized. The preferred site for the proposed Project within the University campus does not trigger any physical and economic displacement. In addition, there are no cultural resources within and around the Project site that would be affected during the Project development and operation. The identified potential negative impacts include:

- Decreased in ambient air quality due to construction and decommissioning activities.
- Increase in ambient noise level due to construction and decommissioning activities.
- Decrease in soil quality due to improper management of generated wastes during construction, operation and decommissioning.
- Minimal loss of terrestrial flora species during site preparation for construction activities.
- Environmental nuisance due to improper disposal of e-waste especially spent/damaged batteries.
- Influx of potential job seekers during construction which could pose indirect impacts on the nearby local community.
- Occupational health and safety issues during construction, operation and decommissioning.

Based on the nature and extent of the proposed Project and the findings of the ESIA study, it is believed that the potential negative impacts associated with the proposed Project can be mitigated to as low as reasonably practicable through the implementation of the proffered mitigation measures documented in Chapter 6 of this report, while the positive impacts can also be enhanced. In addition, an ESMP has been established (refer to Chapter 7 of this report) to assess the efficiency and effectiveness of the recommended mitigation measures and ensure long-term monitoring of the Project.

REFERENCES

Abubakar, F., Ahmed, I. I., Idogbe, E. A., Usman, M. T., & Momoh, K. O. (2020). Site Characterization of the Proposed Agricultural Complex, Ahmadu Bello University, Zaria, Northern Nigeria, using Multi-Channel Analysis of Surface Waves. *Minna Journal of Geosciences*, *4*(2), 52-63.

Federal Ministry of Environment (1999). *National Guidelines and Standards for Water Quality in Nigeria*.

Federal Ministry of Environment (FMEnv) (1999). *Green Book: Guidelines and Standards for Environmental Pollution Control in Nigeria*. FMEnv. 298.

National Guidelines and Standards for Water Quality in Nigeria (1999).

National Population Commission (2010). 2006 Population and Housing Census Distribution by Sex, State, Local Government and Senatorial District. Priority Table, Volume III

Nigeria Bureau of Statistics, (2016). *Annual Abstract of Statistics*. Volume 1

Nigeria Bureau of Statistics, (2018). *Demographic Statistics Bulletin*.

Nigerian Bureau of Statistics (NBS) (2016). Data Sheet.

Nigerian Electricity Regulatory Commission (NERC) (2014). Solar Irradiation in Nigeria States.

Nigerian Meteorological Agency (NIMET) (2018). Data for Kaduna State, 2017.

Nigerian Population Commission (NPC) (2010). *NPC Priority Table Vol. IX – Size of Household*. NPC.

Rural Electrification Agency (REA). (2020). *Environmental and social impact assessment (ESIA) of the proposed 2.5 MW solar-hybrid power plant and associated infrastructure in Nigerian Defence Academy (NDA), Kaduna under the Federal Government of Nigeria's Energizing Education Programme (EEP) Phase II.* Abuja, Nigeria: Rural Electrification Agency.

World Health Organization (2016). *World Malaria Report*. ISBN 978-92-4- 151171-1 https://apps.who.int/iris/bitstream/handle/10665/252038/9789241511711-eng.pdf;jsessionid=2BF3F3AC29F8FA5D33C7FBF5AD04FFFC?sequence=1

World Health Organization (WHO) (2000). *World Health Organization, Potable Water Quality Guidelines*. WHO. 71.

World Health Organization (WHO) (2007). *World Health Organization Research Agenda for Extremely Low Frequency Fields*. WHO. 8 pp.

APPENDIX

APPENDIX I: SOCIO-ECONOMIC QUESTIONNAIRE SAMPLE

SOCIO-ECONOMIC IMPACT ASSESSMENT QUESTIONNAIRE OF THE PROPOSED PREPARATION OF ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) FOR THIRTEEN (13) FEDERAL UNIVERSITIES IN THE PROPOSED NIGERIA ELECTRIFICATION PROJECT (DESERT TO POWER) PHASE II UNDER THE RURAL ELECTRIFICATION AGENCY – LOT 1, AT (FEDERAL UNIVERSITY BIRNIN-KEBBI KEBBI STATE)

The Federal Government of Nigeria (FGN), through the Rural Electrification Agency (REA), is implementing the Nigeria Electrification Project Phase II (Desert-to-Power) with financial support from the African Development Bank (AfDB). As part of the exercise, BOLBEN Energy and Environmental Services Limited is saddled with the responsibility of identifying the potential socio-economic impacts of the project on the local communities. Therefore, your assistance is required in filling out this brief survey. The questionnaire can be completed by ticking in the preferred boxes like this √ and providing appropriate answers in the available spaces.

Section A: Background Information

1. Name of Community ....

2.Gender (a) Male ☐ (b) Female ☐

3. Age (a) 18 – 30 yrs. ☐ (b) 31 – 45 Yrs. ☐ (c) 46 – 54 Yrs. ☐ (d) 55 Yrs. and above ☐

4.Marital Status: Married ☐ Single ☐ Separated ☐ Widowed ☐

5.Family Pattern: Joint/Extended ☐ Nuclear ☐ Individual ☐

6. Household size: Large (Above 9) ☐ Medium (5-8) ☐ Small (2 – 4) ☐

7. Religion: (a) Christianity ☐ b) Islam ☐ (c) Traditional ☐ (d) Other (specify)............

8. Education: (a) Informal Education ☐ (d) NCE/ND ☐
(b) Primary School ☐ (e) HND/B.Sc. ☐
(c) Secondary School ☐ (f) Others (Specify) ....

9. Occupation: (a) Farming ☐ (b) Trading ☐ (c) Civil Servant ☐ (c) Student ☐
Others (Specify) ....

10. Monthly Income: (a) #0 - #30, 000 ☐ (b) #31, 000- #60,000 ☐ (c) # 61, 000-#90, 000 ☐
(d) #120,000 and above ☐

11. Duration of stay in the community/institution (a) 1-5 Yrs. ☐ (b) 6–10 Yrs. ☐ (c) 11–19 ☐
(d) 20 and above ☐

12. Types of language spoken in the communities; Hausa ☐ Zarma/Dendi ☐ C'lela, Fulfulde, ☐
Reshe/Cishingini, ☐ English, ☐ Others..

Section B: Health Status

13.What is the health facility available in your community/institution (a) Primary Health Centre ☐
(b) General Hospital ☐ (c) Private Hospitals ☐ (d) Sick bay ☐
(e) Others(Specify)...........................

1

Bolben Energy and Environmental Services Limited
Suite B214, Zitel Plaza, Jabi Abuja
ceo@bolben.org

SOCIO-ECONOMIC QUESTIONNAIRE SAMPLE CONTINUE……

14. Condition of the health facility within the community/Institution; Very Good ☐ Good ☐
Fair ☐ Poor ☐

15. How do you manage your conditions when you are sick (a) Attend clinic/hospital ☐

(b) Traditional medicine ☐ (c) Buy drugs from nearby chemist ☐

(d) Others (specify) …………… Please tick the health conditions you experience most frequently.

Health Conditions	Tick	Health Conditions	Tick	Others (specify)
Malaria		Tuberculosis		
Typhoid fever		Hypertension		
Cholera		Asthma		
Rheumatism		Meningitis		
Pneumonia		Rashes		

16. Do you think the proposed project will have a negative impact on your health/environment?
(a) YES ☐ (b) NO ☐

If yes, how? (a) Air Pollution ☐ (b) Noise Pollution ☐ (c) Ground water contamination

(d) Surface water contamination ☐ (e) others (specify) ……………………………………………….

17. How do you think these impacts can be averted …………………………………………………….,

………

Section C: Gender Based Violence

18. Have you or anyone in your household had experienced gender-based violence?
(a) YES ☐ (b) NO ☐

19. Do you think men and women have equal access to economic opportunities in your community/institution? (a) YES ☐ (b) NO ☐

20. Do you believe that cultural norms in your community/institution influence the prevalence of GBV? ?

(a) YES ☐ (b) NO ☐

21. Are there adequate support services available for survivors of GBV in your community/institution?
(a) YES ☐ (b) NO ☐

Section D: Public Services

22. What is the source of water supply in your community/institution? (a) Well ☐ (b) Borehole ☐ (c) River/Stream ☐
(d) Others (specify) …………………………………………………
23.Condition of portable water within the community/Institution: Very Good, Good, Fair, Poor

24.What is the available source of power in the community/institution? (a) Discos ☐ (b) Generator ☐
(c) Lantern ☐ (d) Candle ☐ (e) Solar power ☐ (f) Others (specify) ……………………

25.Condition of Public electricity within the community/Institution: Very Good, Good, Fair, Poor
26.Sanitation facility in the community/institution; Water closet, pit latrine, open defecation others

27.What is the most available/affordable source of cooking? (a) Firewood ☐ (b) Gas cooker ☐

2

SOCIO-ECONOMIC QUESTIONNAIRE SAMPLE CONTINUE......

(c) Stove (d) Charcoal (e) Others (specify) ....

28.What are the educational institutions available in your community/institution? (a) Primary school

(b) Secondary school (c) Tertiary Institution (d) Others (specify)..............................

29.Waste disposal method; Bush, Burning, Public open dump, Private Open dump, Organized collection, Burying, others

Section E: Existing Socio-Economic Condition of the Study Area

30. Indicate the traditional economic activity practiced by member so the community/institution:
   (a) Traditional Craft Work
   (b) Farming
   (c) Mining
   (d) Fishing
   (e) Others (specify) ....

31. Traditional laws/ Spiritual (Sacred) places are still observed strictly in the local communities/institution
(a) YES (b) NO

32. Do you think the proposed project will affect any valued resources/ cultural assets / archeological sites within the community/institution? (a) YES (b) NO

If yes, mention the name(s) of the resources..

33. How will the valued resources / cultural assets/ archeological sites be affected? (a) displacement of such cultural assets (b) vandalization of sacred items/locations (c) possible theft of sacred/ archeological items (d) other (specify)...

Section F: Potential Socio-Economic Impact of the Proposed Project

34. Do you think the community/institution members are fully aware of the new project to be developed in their locality? (a)YES (b) NO

35. What do you think is the socio-economic benefit of the project? (a) Easy access to Clean, reliable and sustainable electricity (b) Employment opportunity (c) Economic growth
(d) Other(specify)...........................

36.Indicate the social associations existing in your community/institution: (a) Youth Association
(b) Women Association (c) Farmers Association (d) Others Specify ....

37.Which neighboring communities/institution do you think will benefit from the new developmental project?
....

Bolben Energy and Environmental Services Limited
Suite B214, Zitel Plaza, Jabi Abuja
ceo@bolben.org

APPENDIX II: LABORATORY ANALYSIS RESULTS (WATER SAMPLES)

CENTRE FOR DRYLAND AGRICULTURE
BAYERO UNIVERSITY, KANO

P.M.B. 3011, BUK, KANO
Vice-Chancellor: Prof Haruna Musa fsi, Phd (Bristol), MSc, BSc (BUK) Tel:+234 9090999996
FICCON, FPIN, FTRAN, Email: cda@buk.edu.ng
Director: Professor Sanusi Gaya Muhammed, B. Agric ABU, Msc BUK, Phd ABU Web: www.cda-buk.edu.ng

6th March 2026.

Client: Bolben Energy and Environmental Services Ltd.
Address: Federal University of Education, Zaria, Kaduna (Project Site)
Type of samples: Soil and Water
Type of analysis: Physico chemical, Heavy metals, Microbial.
Number of samples: Soil (18), Water (5)

RESULTS OF ANALYSIS

Anions and Cations results:

SOIL

S/N	S ID	PO_4 (mg/kg)	SO_4 (mg/kg)	CO_3 (mg/kg)	Cl (mg/kg)	NO_3 (mg/kg)
1	SS7 - B	7.50268	26.27346	246	221.875	8.406
2	SS7 -T	5.894962	56.03217	138	177.5	14.01
3	SS8 - B	24.02644	22.25201	126	177.5	2.802
4	SS8 - T	8.931761	10.72386	96	310.625	11.208
5	SS9 - B	7.234727	12.86863	162	310.625	2.802
6	SS9 - T	8.21722	11.79625	84	488.125	2.802
7	SS6 - B	8.574491	13.80697	78	399.375	8.406
8	SS6 - T	6.609503	16.08579	216	2041.25	11.208
9	SS5 - B	8.485173	14.07507	246	221.875	8.406
10	SS5 - T	5.716327	10.99196	90	177.5	11.208
11	SS4 - B	10.6288	24.26273	138	798.75	5.604
12	SS4 - T	7.681315	14.34316	120	355	5.604
13	SS1 - B	5.894962	11.93029	60	177.5	8.406
14	SS1 - T	8.038585	15.81769	72	221.875	5.604
15	SS2 - B	4.912469	11.12601	114	177.5	8.406
16	SS2 - T	7.056091	18.76676	84	266.25	2.802
17	SS3 - B	9.646302	11.93029	36	133.125	2.802
18	SS3 - T	5.62701	11.6622	150	266.25	8.406

Hashim Abba Yakasai
Coordinating
Technologist CDA

1

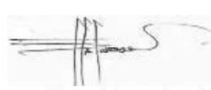
LABORATORY ANALYSIS RESULTS CONTINUES…….. (WATER SAMPLES)

S/N	S ID	PO_4 (mg/l)	WATER SO_4 (mg/l)	CO_3 (mg/l)	Cl (mg/l)	NO_3 (mg/l)	T/Hardness (mg/l)
1	WS1 (GW)	0.893176	12.33244	30	257.375	8.406	30.4235
2	WS2 (GW)	0.74006	21.71582	18	284	5.604	41.8973
3	WS3 (GW)	0.75282	21.58177	48	434.875	8.406	48.1136
4	WS4 (SW)	1.212168	8.44504	66	124.25	11.208	25.4507
5	WS5 (SW)	0.880416	7.640751	66	284	47.634	22.4531

ORGANICS AND MICROBIOLOGICAL ANALYSIS OF SOIL AND WATER SAMPLES

S/N	Sample ID	Oil & Grease	THB (CFU/G)	THF (CFU/G)	HUB (CFU/G)	HUF (CFU/G)	Total Coliform
1	SS7 - B	BDL	$1.04X10^6$	$6.2X10^5$	$1.2x10^5$	9.0x104	Nil
2	SS7 -T	BDL	$7.35X10^5$	$4.7X10^5$	$1.0x10^5$	$2.0x10^4$	Nil
3	SS8 - B	BDL	$5.55X10^5$	$1.35X10^5$	$6.0x10^4$	$7.0x10^4$	Nil
4	SS8 - T	BDL	$6.7X10^5$	$5.15X10^5$	$3.0x10^5$	$1.2x10^5$	Nil
5	SS9 - B	BDL	$3.71X10^6$	$1.295X10^6$	$5.0x10^4$	$8.2x10^4$	Nil
6	SS9 - T	BDL	$2.6X10^6$	$1.75X10^6$	$1.1x10^5$	$6.3x10^4$	Nil
7	SS6 - B	BDL	$3.0X10^5$	$2.9X10^5$	$1.0x10^4$	$1.5x10^3$	Nil
8	SS6 - T	BDL	$8.7X10^5$	$4.2X10^5$	$3.0x10^4$	$1.5x10^4$	Nil
9	SS5 - B	BDL	1.1X106	$5.15X10^5$	$1.0x10^5$	$2.0x10^4$	Nil
10	SS5 - T	BDL	$2.3X10^5$	$4X10^4$	$1.3x10^5$	$3.0x10^4$	Nil
11	SS4 - B	BDL	$3.67X10^6$	$1.25X10^6$	$1.0x10^5$	$4.0x10^4$	Nil
12	SS4 - T	BDL	$1.6X10^6$	$3.8X10^5$	$4.2x10^5$	$6.0x10^4$	Nil
13	SS1 - B	BDL	$9X10^5$	$7.15X10^5$	$3.2x10^5$	$1.2x10^4$	Nil
14	SS1 - T	BDL	$3.9X10^5$	$3.25X10^5$	$1.8x10^5$	$2.0x10^4$	Nil
15	SS2 - B	BDL	$2.85X10^5$	$1.05X10^5$	$6.0x10^4$	$1.3x10^4$	Nil
16	SS2 - T	BDL	$1.8X10^5$	$3X10^4$	$1.3x10^5$	$1.0x10^4$	Nil
17	SS3 - B	BDL	$3.35X10^5$	$1.35X10^5$	$4.0x10^4$	$6.0x10^4$	Nil
18	SS3 - T	BDL	$1.04X10^6$	$7X10^4$	$8.0x10^4$	$3.3x10^4$	Nil
1	WS1 (GW)	BDL	$8.5X10^4$	$6.2X10^4$	-	-	Nil
2	WS2 (GW)	BDL	$4X10^5$	$3.2X10^6$	-	-	Nil
3	WS3 (GW)	BDL	$7X10^4$	$5.1X10^4$	-	-	Nil
4	WS1 (SW)	BDL	$4.48X10^6$	$6.21X10^6$	-	-	21
5	WS2 (SW)	BDL	$4.45X10^5$	$3.72X10^4$	-	-	15

Key: THB =Total Heterotrophic Bacterial Count, THF = Total Heterotrophic Fungal Count and CFU = Colony forming unit.



Hashim Abba Yakasai
Coordinating Technologist CDA

2

LABORATORY ANALYSIS RESULTS CONTINUES……

(WATER SAMPLES)

Physicochemical Analysis of Water Samples

S/N	Sample ID	pH	Temperature °C	ORP (MV)	Conductivity (μs/cm)	Appearance	TDS (mg/l)	Salinity (%)	DO (mg/dm^3)	BOD (mg/dm^3)
1	WS1 (GW)	7.20	30.2	282	393	Clear	196	0.01	6	5.3
2	WS2 (GW)	5.28	28.5	290	416	Clear	208	0.02	5.6	0.4
3	WS3 (GW)	6.75	28.1	265	152	Clear	76	0.00	6	1
4	WS4 (SW)	7.18	26.6	255	154	Turbid	77	0.00	5.6	2.4
5	WS5 (SW)	4.73	27.8	237	580	Turbid	288	0.02	9	2.3

Key: DO= Dissolve Oxygen, BOD= Biochemical Oxygen Demand, TDS = Total Dissolved Solids

Trace Elements and Heavy Metals for Water Samples

S/N	Sample ID	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	Cu (mg/l)	Fe (mg/l)	Zn (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)	Pb (mg/l)
1	WS1 (GW)	1.169	0.251	0.406	3.265	0.023	0.062	ND	0.024	ND	0.100	0.379
2	WS2 (GW)	ND	0.169	0.262	4.772	0.032	ND	ND	0.025	ND	0.092	0.126
3	WS3 (GW)	7.469	4.154	2.603	25.603	0.033	ND	ND	0.027	ND	0.107	ND
4	WS4 (SW)	0.235	0.404	0.592	1.643	0.029	0.845	ND	0.021	ND	0.094	ND
5	WS5 (SW)	2.474	1.281	0.941	2.768	0.024	0.463	ND	0.015	ND	0.076	ND

APPENDIX III: LABORATORY ANALYSIS RESULTS (SOIL SAMPLES)

Trace Elements Result for soil samples:

Sample ID	pH (1:1)	Conductivity (µs/cm)	Colour (TCU)	Sand (%)	Clay (%)	Silt (%)	O.C (%)	N (%)	P (mg/kg)	Ca (cmol(+)/kg)
SS7 - B	6.43	996	Brownish	60.42	16.95	22.63	1.02	0.02	3.05	2.54
SS7 -T	6.00	547	Brownish	66.57	15.42	18.00	1.39	0.09	8.84	3.83
SS8 - B	6.95	693	Brownish	77.14	15.29	7.57	0.50	0.05	8.09	5.31
SS8 - T	5.89	1011	Brownish	63.93	23.95	12.12	1.28	0.05	10.23	4.07
SS9 - B	6.27	757	Brownish	64.29	10.08	25.64	1.35	0.08	5.57	1.75
SS9 - T	5.87	605	Brownish	48.55	9.95	41.50	0.42	0.05	0.47	4.70
SS6 - B	6.85	883	Brownish	58.95	24.33	16.72	0.86	0.07	7.49	1.41
SS6 - T	6.70	471	Brownish	66.11	12.25	21.65	1.33	0.04	5.85	4.17
SS5 - B	6.19	589	Brownish	67.43	21.05	11.52	0.55	0.08	4.32	4.98
SS5 - T	6.44	603	Brownish	53.15	30.18	16.68	0.36	0.06	0.54	5.53
SS4 - B	6.48	1004	Brownish	69.32	19.43	11.56	0.93	0.03	5.65	5.72
SS4 - T	6.57	985	Brownish	71.31	18.97	9.72	1.19	0.02	10.03	5.62
SS1 - B	6.60	762	Brownish	68.81	16.21	14.99	0.71	0.04	7.35	5.12
SS1 - T	5.71	664	Brownish	56.32	18.33	25.35	1.42	0.04	5.57	3.14
SS2 - B	6.46	892	Brownish	60.71	26.57	12.72	1.36	0.06	0.92	4.45
SS2 - T	5.78	763	Brownish	55.13	19.48	25.39	0.59	0.06	3.85	5.68
SS3 - B	5.59	1012	Brownish	58.30	21.79	19.91	0.44	0.06	9.22	1.44
SS3 - T	6.06	970	Brownish	59.82	9.28	30.90	0.42	0.09	5.55	4.71

Hashim Abba Yakasai
Coordinating Technologist CDA

3

Bolben Energy and Environmental Services Limited
Suite B214, Zitel Plaza, Jabi Abuja
ceo@bolben.org
Draft Report, September 2026.

LABORATORY ANALYSIS RESULTS CONTINUES……… (SOIL SAMPLES)

Sample ID	Mg (cmol(+)/kg)	K (cmol(+)/kg)	Na (cmol(+)/kg)	ECEC (cmol(+)/kg)	EA (cmol(+)/kg)	Zn (mg/kg)	Cu (mg/kg)	Mn (mg/kg)	Fe (mg/kg)
SS7 - B	0.94	0.37	0.08	3.93	0.46	18.36	1.85	15.93	194.26
SS7 -T	1.15	0.22	0.08	5.27	0.50	7.93	1.93	20.20	158.97
SS8 - B	0.63	0.13	0.08	6.16	0.61	10.95	1.98	52.39	321.73
SS8 - T	1.01	0.22	0.13	5.44	0.34	10.89	1.86	55.15	113.00
SS9 - B	0.60	0.15	0.06	2.56	0.39	5.91	4.13	20.86	129.75
SS9 - T	1.33	0.20	0.10	6.33	0.15	28.99	3.69	6.56	114.73
SS6 - B	0.78	0.09	0.10	2.38	0.85	17.38	4.30	46.93	358.79
SS6 - T	0.64	0.15	0.06	5.02	0.12	16.85	4.38	6.59	292.56
SS5 - B	0.63	0.35	0.05	6.02	0.46	14.51	3.88	33.52	315.77
SS5 - T	1.27	0.18	0.06	7.04	0.84	16.87	4.55	38.76	170.92
SS4 - B	0.63	0.34	0.90	6.87	0.10	3.25	4.26	39.74	167.74
SS4 - T	0.53	0.30	0.12	6.57	0.08	1.19	4.17	48.94	144.36
SS1 - B	0.73	0.39	0.11	6.35	1.45	10.67	4.17	34.64	192.93
SS1 - T	0.82	0.38	0.09	4.43	0.02	30.94	3.31	6.91	355.11
SS2 - B	0.51	0.19	0.08	5.23	1.45	27.99	2.03	12.93	122.84
SS2 - T	1.00	0.23	0.09	7.00	0.62	22.68	3.31	53.08	187.55
SS3 - B	0.40	0.34	0.14	2.32	1.64	10.10	3.29	27.90	152.99
SS3 - T	0.83	0.16	0.13	5.83	0.82	24.97	4.16	39.93	266.66

Hashim Abba Yakasai
Coordinating Technologist CDA

4

APPENDIX IV: FIELD ACTIVITIES ATTENDANCES

BOLBEN ENERGY
AND ENVIRONMENTAL SERVICES LTD

SITE VERIFICATION/DATA GATHERING ATTENDANCE SHEET

PROJECT TITLE: ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) FOR THIRTEEN (13) FEDERAL UNIVERSITIES IN THE PROPOSED NIGERIA ELECTRIFICATION PROJECT (DESERT TO POWER) PHASE II UNDER THE RURAL ELECTRIFICATION AGENCY – LOT 1

LOCATION: FEDERAL UNIVERSITY OF EDUCATION, ZARIA, KADUNA STATE

DATE: 2/02/2026 / 03/02/2026

S/N	NAME	ORGANIZATION	DESIGNATION	EMAIL ADDRESS	PHONE NO.	SIGN
1	Dr S. Balarabe	FUE, Zaria	DVC	sulaimanbalarabe26@gmail	08037025479	
2.	Shehu Wa Saidu	FUE, Zaria	Registrar		08033584156	
3.	Mohammed Kabir Aliyu	FUE Zaria	Bursar	Kabiraliyu79@gmail	08034525537	
4.	GARBA A. DAHERU	FUE, ZARIA	Director Audit	garba313@gmail.com	08022669146	
5.	Engr. AREO B. O.	FUE. ZARIA	Ag. DW	bo.areo@gmail.com	08056865396	
6	Engr. ALIYU ANGO	" "	Ag DOW	angoaliyu@fuez.edu.ng	08032836694	
7	Engr. Abubakar Hassan	" "	Chief Engr.	abuhassan@fuez.edu.ng	08071631158	
8	Engr. Dr. Nuradeen O. Ahmed	Bolben Ltd.		nuradeen.o.ahmed@gmail.com	07063041815	
9	Muhammad Sani	Bolben Energy Ltd		Muhdsanie11@gmail.com	08032586748	
10	Offuah, Kingsley	Bolben Energy Ltd	field manager	offuahkingsley@gmail.com	09163365654	
11	Misbahu Abdulkarim	Bolben Ltd	Geologist	misbahuabdulkarim771@gmail	07013359771	
12	ALIYU KABIR	FMENV KAD.	DSO	aliukabeer67@gmail.com	08030805935	
13	Jamilatu Shamsudeen	FMENV-Abuja	SSO	Jamilablabs@gmail.com	08037016242	

S/N	NAME	ORGANIZATION	DESIGNATION	EMAIL ADDRESS	PHONE NO.
1.	Engr. Aliyu Ango	F.U.E. Zaria	Ag. DOW	angoaliyu@fuez.edu.ng	08032836694
2.	Engr. Areo B. O.	F.U.E. Zaria.	Ag. DW	bo.areo@gmail.com	08056865396
3.	Mariam Mopelola	Bolben Ltd	Team leader	ceo@bolben.org	08100242826
4	Engr. Dr. Nuradeen O. Ahmed	Bolben Ltd.		nuradeen.o.ahmed@gmail.com	07063041815

APPENDIX V: PICTORIAL EVIDENCE OF STAKEHOLDER CONSULTATION

Bolben Energy and Environmental Services Limited
Suite B214, Zitel Plaza, Jabi Abuja
ceo@bolben.org
Draft Report, September 2026.

PICTORIAL EVIDENCE OF STAKEHOLDER CONSULTATION CONTINUES……… (WITH COMMUNITY)

Stakeholders Consultation with the Community.

Bolben Energy and Environmental Services Limited
Suite B214, Zitel Plaza, Jabi Abuja
ceo@bolben.org
Draft Report, September 2026.

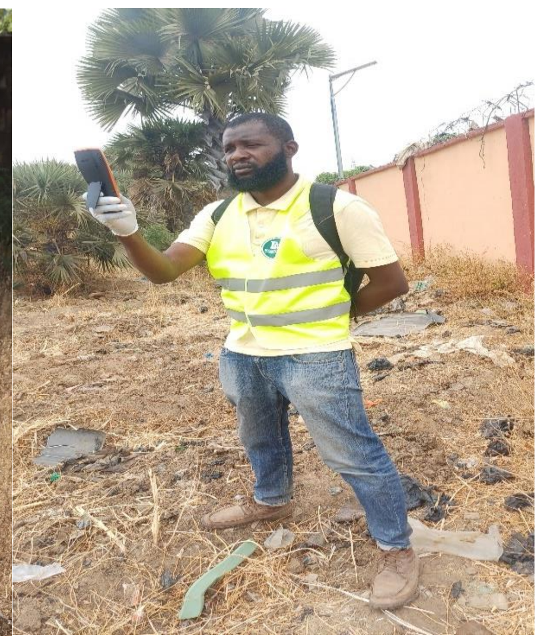
PICTORIAL EVIDENCE OF STAKEHOLDER CONSULTATION (WITH PAPS)

Stakeholders Consultation with the Community.

APPENDIX VI: PICTORIAL EVIDENCE OF DATA GATHERING ACTIVITIES CONTINUES (SOIL EXTRACTION)

Bolben Energy and Environmental Services Limited
Suite B214, Zitel Plaza, Jabi Abuja
ceo@bolben.org
Draft Report, September 2026.

APPENDIX VII: PICTORIAL EVIDENCE OF DATA GATHERING ACTIVITIES (AIR/NOISE SAMPLING)



APPENDIX VIII: PICTORIAL EVIDENCE OF DATA GATHERING ACTIVITIES (WATER COLLECTION)