FINAL ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) REPORT

FOR

THE PROPOSED CONSTRUCTION OF 125 MWp UTILITY SCALE PV-BASED SOLAR POWER PLANT IN KANKIYA LOCAL GOVERNMENT AREA, KATSINA STATE, NIGERIA

BY

NOVA SOLAR 5 FARMS LIMITED

SUBMITTED TO
THE FEDERAL MINISTRY OF ENVIRONMENT

DECEMBER, 2015

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REPORT NO.: **S-1411A**

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DATE OF REPORT: **DECEMBER, 2015**

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Fugro Nigeria Ltd Quality Assurance:

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List of Abbreviations and Acronyms

AAS	Atomic Absorption Spectrophotometer
AC	Alternating current
ALARP	As Low As Reasonably Practicable
APHA	American Public Health Association
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BAT	Best available technology.
BCG	Bacilus Calmethe Guerin
BMI	Body Mass Index
CB	circuit breakers
CBO	Community Based Organisations
CBR	Crude Birth Rate
CDC	Community Development Committee
CDD	Country Deputy Director
CDR	Crude Death Rate
CITES	**Convention on International Trade in Endangered Species** (of Wild Fauna and Flora)
CLO	Community Liaison Officer
DC	Direct current
DCDB.	DC supply Distribution board
DCQ	Daily Contract Quantity
DO	Dissolved Oxygen
DPT	Diphtheria Pertusis Tetanus
EER	Environmental Evaluation Report
EGASPIN	Environmental Guidelines and Standards for Petroleum in Nigeria
EHS	Environment, health and safety
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMI	Electromagnetic Interface
EMP	Environmental Management Plan
EMS	Environmental Management System
EPC	Engineering , Procurement, and Construction
EPIC	Engineering, Procurement, Installation, and Commissioning
ERC	Emergency Response Procedure
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Management System
EU	European Union
FEPA	Federal Environmental Protection Agency
FGD	Focus Group Discussion
FGDs	Focus Group Discussions

FiT	Feed-in tariff
FMEnv	Federal Ministry of Environment
FNL	Fugro Nigeria Limited
FPIC	Free, Prior, and Informed Consent
GCR	Ground cover ratio
GGDs	General Group Discussions
GIIP	Good International Industry Practice
GPS	Global Positioning System
GRA	Government Residential Areas
GSM	Global system for Mobile Communication
HBV	Hepatitis B vaccine
HEMP	Hazard and Effect Management Process
Hg	Mercury
HSE	Health Safety and Environment
HUB	Hydrocarbon Utilising Bacteria
IDIs	In-depth Discussion and Interviews
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IIF	Incident and Injury Free
IMR	Infant Mortality Rate
ISA	(Instrument Society of America)
ISO	International Standards Organisation
ITCZ	inter-tropical convergence zone
ITD	inter-tropical discontinuity
IUCN	International Union for the Conservation of Nature
JHA	Job Hazard Analysis
KSEPA	Katsina State Environmental Protection Agency
KSG	Katsina State Government
KSMENV	Katsina State Ministry of Environment
KSMENV-HSE	Katsina State Ministry of Environment Health, Safety and Environment
LCOE	levelised cost of electricity
LGA	Local Government Area
LUA	Land Use Act
LV/MV	Low voltage/medium voltage
MCBs	Miniature circuit breakers
MMR	Measles, mumps and rubella
MOS	Margin of safety
MPP	Maximum Power Point
MTBF	Mean Times Between Failures
MW	Megawatts
MWp	Megawatts peak

N	North
NBR	National Bureau of Statistics
NBS	National Bureau of Statistics
NESREA	National Environmental Standards, Regulation and Enforcement Agency
NGOs	Non-governmental organisations
NIMET	Nigerian Meteorological Agency
NPC	National Population Commission
NSF	Nova Solar 5 Farms
NSP	Nova Solar Power
O&M	Operations & Maintenance
OPV	Oral Polio Vaccine
PCR	physical cultural resources
PHCN	Power Holding Company of Nigeria
PMT	Project Management Team
PRA	Participatory Rural Appraisal
PSD	Project Site Director
PSD	Particle Size Distribution
PV	Photovoltaic
PWM	Project Waste Management
QA/QC	Quality Assurance /Quality Control
QHSE	Quality, Safety, Health & Environment
RAM	Risk Assessment Matrix
RAP	Resettlement Action Plan
RCP	Regulatory Compliance Plan
RECA	
SA	Socit Anonyme
SCADA	Supervisory Control and Data Acquisition
SCE	Site Construction Engineer
SPD	Site Project Director
SPM	Suspended Particulate Matter
SWA	Steel Wire Armored
TDS	Total Dissolved Solids
TFR	Total Fertility Rate
THB	Total Heterotrophic Bacteria
TOC	Total Organic Carbon
TOR	Terms of Reference
TPH	Total Petroleum Hydrocarbon
TRC	Traditional Ruling Council
TSS	Total Suspended Solids
TT	Tetanus Toxoid
TWh	Terawatt hour

U5	Under 5 years old
U5MR	Under-five mortality rate
UAT	Unit Auxiliary Transformer
UPS	Uninterruptable Power Supply
URTI	Upper Respiratory Tract Infection
UV	Ultraviolet
WHO	World Health Organisation
YF	Yellow Fever
Symbols	
Cd	Cadmium
CdTe	Cadmium Telluride
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
Cr	Chromium
Cu	Copper
Fe	Iron
H_2S	Hydrogen Sulphide
Mn	Manganese
Ni	Nickel
NO^{3-}	Nitrate ion
Pb	Lead
PO_4^{3-}	Phosphate ion
SO_2	Sulphur dioxide
SO_4^{2-}	Sulphate ion
Zn	Zinc

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EXECUTIVE SUMMARY

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Introduction
NOVA Solar 5 Farms Limited (NSF) intends to develop a 125MWp Solar Photovoltaic Power Plant in Katsina State. The proposed project is expected to contribute to providing daytime power supply to Katsina State, and Nigeria at large.

In fulfillment of the International Finance Corporation (IFC)/ World Bank Standards, in compliance with statutory requirements and in line with good environmental management practices in Nigeria together with commitment of the Katsina State Government to sustainable project development, an Environmental and Social Impact Assessment (ESIA) of the proposed utility scale PV based solar power plant project has been carried out. Fugro Nigeria Limited (FNL) conducted the study in line with the EIA Guidelines for Infrastructure projects in Nigeria (FEPA 1995). This document is the ESIA report.

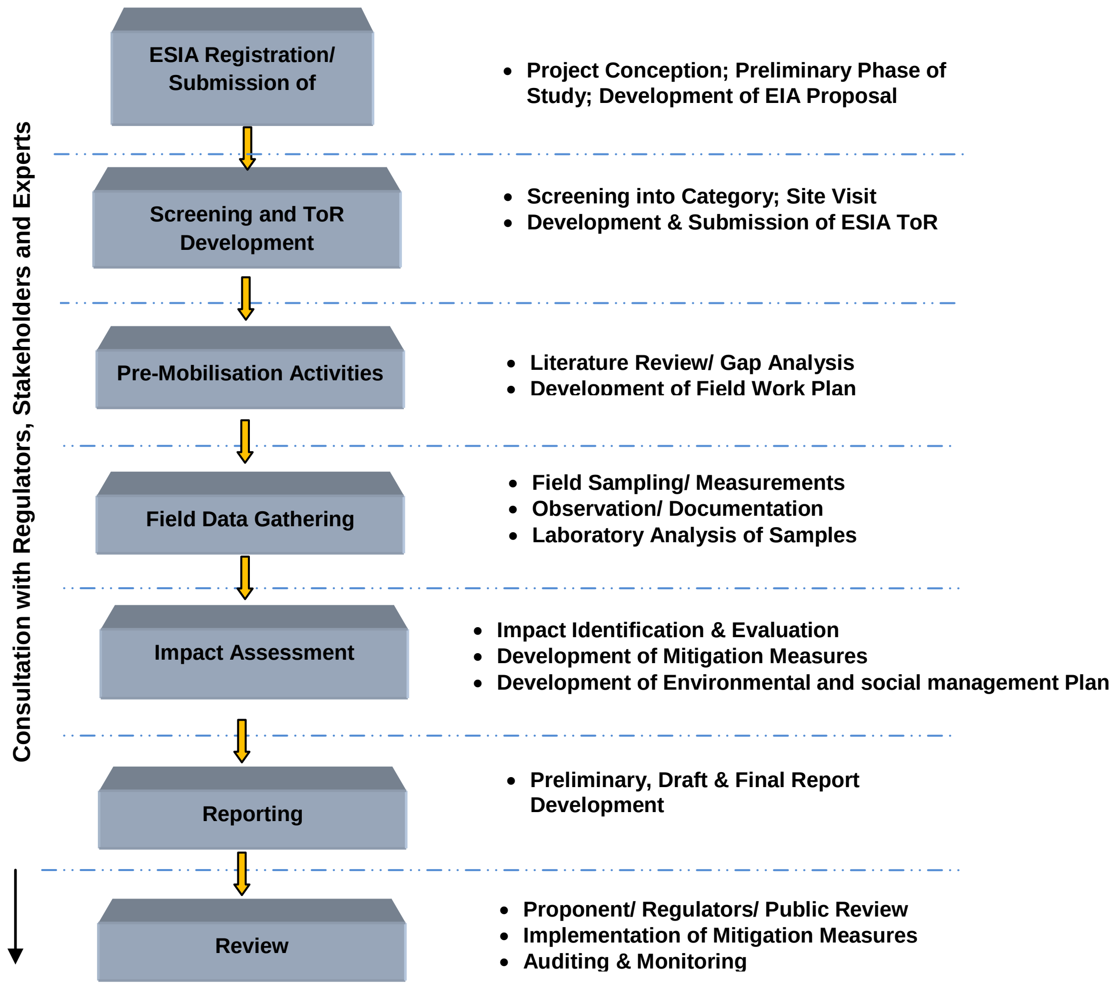
Study Area
The site is situated about three kilometres in the northwest of the city of Kankiya in Kankiya Local Government Area (LGA) of Katsina State. The proposed site is a 200 hectares land located on the northeast side along Kankiya – Katsina A9 highway about 60km from the state capital, Katsina. The southeast point of the area is delineated by geographic coordinates; 32P, 1389728.530mN; 3272271.500 mE.

Objectives of the Study
The objectives of the ESIA for the proposed project are to;
- obtain all necessary information/data to satisfy regulatory requirements of federal, state and local authorities on environmental matters, and stakeholders;
- show that a systematic assessment of the impacts of the proposed project have been carried out using standard procedures;
- develop an Environmental and Social Management Plan (ESMP) for all phases of the proposed project's life cycle; and
- provide necessary information and evidence for developing an Environmental Impact Statement (EIS) for the proposed project in its entirety.

Scope of Work
The approved work scope for the ESIA covered the following:
- review of national and international environmental regulations, standards, codes and conventions relevant to the proposed infrastructure/logistic development project activities;
- generate data that would establish the existing social, and ecological status of the proposed project site and environs through desktop research;
- carry out two (2) seasons (wet and dry) field data acquisition campaign and laboratory analysis of field samples;
- consultation with all stakeholders including regulatory agencies;
- impact identification, prediction, interpretation and evaluation;
- development of cost effective mitigation measures, monitoring programmes and ESMP covering the project life cycle; and
- preparation of draft and final ESIA reports that meet regulatory requirements.

ESIA Methodology
The methodology adopted basically follows the following steps and flowchart:
- Desktop Studies/Literature Review
- Consultation
- Field Research

- Potential and Associated Impact Assessment
- Reporting



Administrative and Legal Framework

The study has been undertaken in line with guidelines/standards of national agencies responsible for environmental management and saddled with enforcing existing statutes and regulations in Nigeria on power generation industries as well as with those of international organisation concerned with environmental matters. These bodies include the Federal Ministry of Environment (FMENV), the National Environmental Standards and Regulations Enforcement Agency (NESREA), and Katsina State Ministry of Environment. The local laws applicable to this project include:

- Land Use Act;
- Criminal Code;
- Electricity Act;
- Forestry Act;
- Katsina State Forestry Laws & Policies;
- Katsina State Environmental Protection Agency (KSEPA) Edict;
- Electric Power Sector Reform Act (EPSRA); and
- The Environmental Impact Assessment Act.

International guidelines used during the study are:

- World Bank/IFC Performance Standard on Social, Environmental Assessment and Management Systems;
- IFC Environmental, Health, and Safety Guidelines for Thermal Power Plants;
- United Nations Guiding Principles on the Human Environment; and
- Rio Declaration on Environment and Development;

International Best Practice Standards and Guidelines used include:
- Equator Principles;
- IFC Performance Standards;
- Environmental, Health and Safety (EHS) Guidelines;
- Convention on International Trade in Endangered Species (CITES); and
- Basel convention on the control of transboundary movement of hazardous wastes and their disposal.

Project Justification
The proposed Kankiya 125MW power station is a large-scale photovoltaic system designed for the supply of merchant power into the Nigerian electricity grid. It is differentiated from most building-mounted and other decentralized solar power applications because it will supply power at the utility level, rather than to a local user or users.

Benefits of the Proposed Project
The most significant accruable benefit is the expected improvement in power supply. Other benefits are to:
- At the national level, construction of the power plant will result in an increase in grid based power generation capacity. At the local level, it directly contributes to development of Kankiya area and Katsina state as a whole (through the employment opportunities it will directly create and through multiplier effects that will flow from the increased availability of power within the region;
- The selection of world-class expertise enlisted for the project will bring a wealth of skills and technology not only to the project but the wider solar energy sector within Nigeria;
- Increased revenue/derivations to local and state governments as well as other mandated agencies/commissions.
- Decrease environmental emissions associated with private power generators and other thermal fossil fuel based power plants, thereby encouraging renewable energy form as better option to sustainable power sector development.

Envisaged Sustainability
Economic and Commercial Sustainability
The project is envisaged to be economically and commercially sustainable throughout its designed life span because of:

- availability of constant sunlight at the site of the proposed Independent Power Plant;
- the close proximity of the proposed power plant to existing PHCN power evacuation infrastructure (sub-station) in the host community (Kankiya) area assures overall project cost (in terms generated power evacuation system, etc);
- project site is accessible by good road network for delivery of bulky plant parts for initial installation and maintenance; and
- the revenue that would accrue from power distribution, which would serve for payment of staff and procurement of maintenance facilities.

Technical Sustainability

Nova Solar 5 Farms Limited, the proponent of the proposed 125MWp photovoltaic solar power plant plans to carry out the development activities using best available technology (BAT). The technology to be applied would be International Standard that has been tested in countries with similar weather conditions including parts of the United States of America and Europe.

Photovoltaic (PV) is a method of converting solar energy into current electricity using semiconducting materials that exhibit the photovoltaic effect. The direct conversion of sunlight to electricity occurs without any moving parts or environmental emissions during operation. Nova Power possesses required skills, experience and requisite expertise and financial capability to develop and operate utility-scale PV Based Solar Power Plant Projects. The proposed power plant will be an indoor / outdoor installation.

Environmental Sustainability

Construction of the 125MWp photovoltaic Solar Farm shall be executed in line with the best environmentally acceptable techniques/methods to ensure minimal negative impacts on the environment. The Federal Ministry of Environment guidelines and standards for EIA as well as and other International standards shall guide the project. The incorporation of the findings and recommendations of this EIA at the various stages of the project activity, and adherence to the EMP will ensure environmental sustainability. Furthermore, the fact that the project source is renewable energy makes the project environmentally sustainable. The project will be environmentally sustainable because of the inherent environmental advantages of the mitigation measures that would be designed into the project as documented in this EIA. The monitoring and management programmes to be implemented as recommended in the EMP will help ensure environmental sustainability of the project.

Project Development Options

No Development Option (Do Nothing)

Do nothing option implies that the proposed 125MWp Photovoltaic Solar Farm development project should not be implemented. This means that the Nova Solar Power objective of addition of electricity power to the national grid would not be met and the overall 2017 target of achieving 12,500MV electricity generation in Nigeria would be jeopardised. Also, job creation and skill acquisition as a result of executing this project would not be possible. Adopting this option would entail continually enduring the frequent outages, excessive low voltages and slowed economic development. This option was not adopted.

The project development options were considered on the basis of engineering judgment, environmental concerns, adaptability, cost-effectiveness and ease of operation and maintenance of the system through its design life. Project alternatives were evaluated as part of the conceptual design process and alternatives that provide cost-effectiveness, environmental friendliness/management were preferred.

Project Site Alternative

Other option considered in the location of this project is site suitability. Several locations within Katsina State were visited including the State Capital Katsina, Musawa, Daura and Dutsenma for this purpose. The reasons why the site in Kankiya has been selected area.

- The site location is devoid of any settlement or existing project that could have hampered the project realization.
- Terrain is suitable for the solar panels inclination and exposure to sunlight;
- Site topography is flat and suitable for installing solar power panels;

Wind Power Option
Wind power is the conversion of wind energy into a useful form of energy, such as electricity, using wind turbines. The wind power plants use the wind to push against the turbine blades, spinning the copper wires inside the generator to create an electric current. This option was not adopted because of cumbersome and delicate equipment parts, dependence on meteorological conditions, and disruption of aesthetic appeal on installation.

Nuclear Power Plant Option
Nuclear generators use nuclear fission to turn water into steam. This drives steam turbine, and spins a generator to produce electricity that is then evacuated through the grid. The energy yield is very high and with very low carbon foot print (with respect to green house gas emission and climate change). The option was not adopted because of concerns associated with nuclear plant safety, nuclear weapons proliferation (uranium enrichment process can also produce higher concentrations of U^{235} suitable for nuclear weapons), and nuclear waste. It produces large amounts of highly radioactive nuclear waste that must be stored / isolated from the biosphere for very long time. Insurance cost and overall cost of high nuclear power stations are very high, including high risk of during accidents.

Hydroelectric Power Plant Option
Hydroelectric Plant use gravitational force of falling (or flowing) water to spin the turbine blades which generates electricity. This option was not adopted because dams for hydroelectric plants lead to siltation, and this damages both the aquatic ecosystem and reduces life span of the plant.

Thermal Power Plant Fuel Alternatives
Bio-fuel
This involves the use of organic materials (plant and animals) as source of fuel. The technology is still being developed and does not, at the moment, have wide applications and expected to compete for scarce food resources. It was therefore not strongly considered.

Coal Power Plant Option
Coal power plant burns coal to generate steam which turns turbine engine to generate electricity which is then distributed through the grid. This is a viable option considering vast coal deposit in Nigeria and the technology of coal power plant is well developed. Energy supply from coal power plant is independent of weather conditions. This option was not adopted because of its environmental footprints (particulates etc.). The carbon foot print is large with environmental concerns (particulate and gaseous pollutants emissions and contribution to global climate change through green house gas emissions). Coal mining is often very destructive to the landscape and to coal miners.

Natural Gas Power Plant Option
This option involves the use of natural gas as source of fuel. This is a viable option that would ensure a stable power generation for the state and its environs considering the availability of natural gas in Nigeria. This was not the preferred option because of the non-existing gas supply infrastructure in and around the state, and fact that this option contributes to atmospheric pollution.

Solar Power Plant Option
It involves harnessing sunlight for generation of electricity. There are two main types, namely solar thermal and photovoltaic panels.

Solar Thermal Source

The solar thermal method involves parabolically shaped mirrors arranged to concentrate sunlight on long steel pipes filled with circulating oil, heating it at 750°F. The heated oil pass through giant radiators (heat exchanger) that extract the heat and boil water into steam. At present, solar power costs several times more than natural gas or coal - which is why it still supplies only a small fraction of the world's energy need (National Geographic, 2009). For this reason this option was not considered.

Photovoltaic Source

Photovoltaic power station, also known as solar park, is a large-scale photovoltaic system (PV system) designed for the supply of merchant power into the electricity grid. They are differentiated from most building-mounted and other decentralized solar power applications because they supply power at the utility level, rather than to a local user or users. The direct conversion of sunlight to electricity occurs without any moving equipment parts and no environmental emissions during operation makes this technology the preferred option.

Power Evacuation Considerations

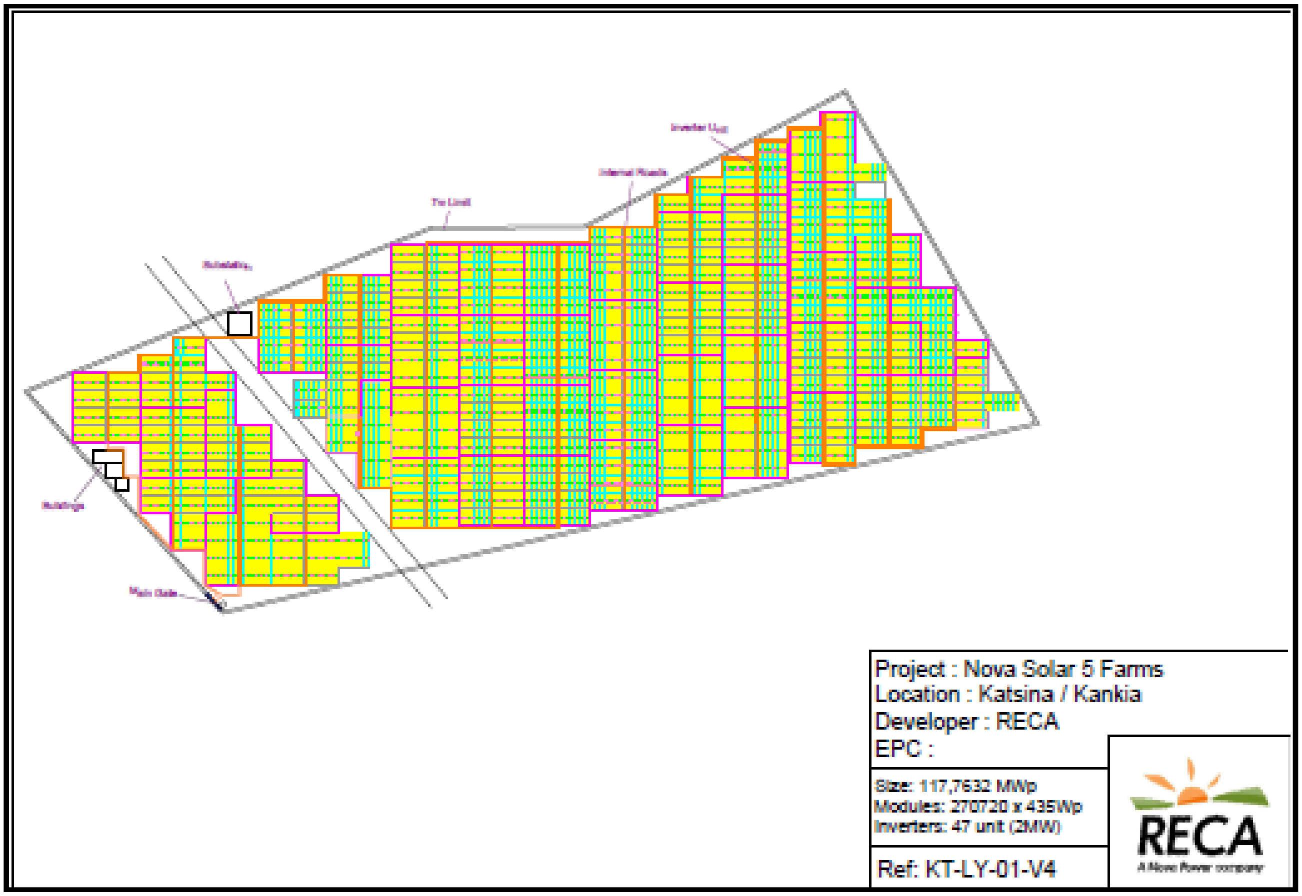
The power to be generated would be evacuated through the Power Holding Company of Nigeria (PHCN) transmission system. The interconnection is required to transmit electricity from the proposed power plant via a new substation to be built on the project land and that will connect the power plant to the existing Kano/Katsina 132 kV transmission line. The system has been assessed to determine its suitability for the evacuation of generated power, taking into consideration the present configuration of the transmission infrastructures and possible future configuration and expansions.

PROJECT DESCRIPTION

The proposed solar power project is a photovoltaic solar farm installation. It will use Aluminum or galvanized steel Poles of about 3m long in height with about 1.4m of the length buried beneath the ground surface. The panel dimension will be around 70 cm by 150 cm. The proposed project is expected to generate 125MW of electricity.

Power Plant Site Layout

The total land area for the proposed PV based solar power plant is 200 hectares. The site layout is crossed by three existing Power Holding Company of Nigeria (PHCN) transmission lines along adjoining road (Kankiya – Katsina A9 highway). The site layout is presented below.



PV Based Solar Power Plant Process

Photovoltaic (PV) is a method of converting solar energy into direct current electricity using semiconducting materials that exhibit the photovoltaic effect. It is the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons which are the carriers of electric charge. The direct conversion of sunlight to electricity occurs without any moving parts or environmental emissions during operation. As light hits the solar panels, the solar radiation is converted into direct current electricity (DC). The direct current flows from the panels and is converted into alternating current (AC) used by local electric utilities.

The basic unit of a PV system is a solar cell. A solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light. Solar cells are the building blocks of photovoltaic modules, otherwise known as solar panels.

Photovoltaic Plant Constituents

The proposed project is to utilize solar energy to generate electric power with a capacity of 125 MWc to be connected to the national grid in Katsina. The proposed photovoltaic plant consists of the following main components:

1. Solar field;
2. Steel Structure;
3. Tracking, if any;

4. Other electric and/or electromechanical system components such as junction boxes; cables, DC/AC Converters, transformers and switchgear; and
5. Connection to the grid.

Module Components Assembly
A typical solar module consists of several individual cells wired together and enclosed in protective material called encapsulant, commonly made of ethylene vinyl acetate. To provide structural integrity, the encapsulated cells are mounted on a substrate frequently made of polyvinyl fluoride.

PV plant Infrastructure
The infrastructure of the PV plant component of the project comprises the followings:

- Energy source;
- Water supply source;
- Septic pool for containing the sewage water;
- Water distribution network;
- Sewage water network;
- Access Roads and Site Access;
- Communication network;
- Warehouse;
- Site fencing; and
- bund walls around transformers or any other oil containing equipment to ensure full containment in the event of any oil leakage.

The Connection Works Components
Transmission line Technology:
The electric power transmission system is often referred to as a grid. Redundant paths and lines are provided so that power can be routed from any generation facility to any customer area through a variety of routes, based on the economics of the transmission path and the cost of power. The redundant paths and lines also allow power flow to be re-routed during planned maintenance and outages due to weather or accidents.

Expected Pollution
The expected water pollutants from the plant shall be:

- Rain water from drainage; and
- Sewage from various buildings in the plant.

Connection Works Personnel Requirements
Construction phase
The construction process is put into practice by groups of single purpose workers that execute their particular front of work. The construction teams will be about 500 people divided to crews, working one after another, with each crew responsible for one of the construction assignment (laying the foundations for the poles and trenching for cables, assembling the poles on the ground, erecting of the poles and installing of trenching cables and wires and testing and commissioning the line). Workers involved in the construction will have working camp dwell within the PV plant for the workers in the two project components. There will be transport (Pick-Up) link arranged between the construction sites and the places of residence of the construction bridges.

Operation phase
During the operation phase of the project, way leaves will be maintained through manual vegetation clearing. Once the poles and the other components are erected and structural

integrity established, minimal maintenance is required and a routine aerial inspection and ground inspection will however be done annually.

Decommissioning phase
The connection works will not be decommissioned, as more users will be connected to those facilities.

Equipment Requirements for Construction Phase

Equipment	Quantity	Function
Dozer	10	Will be used for land digging, and removing of the dislocated material
Jack hummer	20	Will be used for material dislocation from the bed rock, removal, and breaking to smaller size
Loaders	10	Will be used for material removal, cleaning, collection, and loading on the large transport trucks
Compressors	20	Will be used for excavation in the bedrock
Trucks	20	Will be used for loading, transport, and unloading earth works material at allocated disposal sites
Pick Up (Double Cabin)	20	Will be used as a supportive vehicle needed for the work on site
Lifting Crane	10	Will be used to install the conductors to unwind them from the cable holders

Man Power Requirements for Construction Phase

Position	Number
PV Plant	
Engineer	10
Skill labor	50
Forman	20
Loader Operator	20
Dozer Operator	20
Jack hummer driver	20
Mechanics	40
Pick Up Driver	20
Site Labor	250
Connection Works	
Engineer	2
Skill labor	5
Forman	4
Compressor Operator	5
Packhole Operator	4
Crane Operator	4
Mechanics	2
Pick Up Driver	4
Site Labor	20
Total	500

The equipment machinery and manpower required for the operation and maintenance phase for the two project components are shown below.

Equipment Requirements for Operation and Maintenance Phase

Equipment	Quantity	Function
Lifting Crane	3	Will be used to lift up workers to the isolators' level
Mobile Water Tanks	3	Will be used for washing isolators and PV cells
Pick Up (Double Cabin)	3	Will be used for inspection visits and transporting the working crew

Manpower Requirements for Operation and Maintenance Phase

Position	Number
PV Plant	
Security	20
Cleaning staff	8
Technicians	16
Managers	3
Connection Works	
Engineer	1
Technicians	2
TOTAL	50

ENVIRONMENTAL BASELINE CONDITION

The environmental baseline conditions of the area within which Nova Power proposes to build the new utility scale power plant project is presented below. The environmental components described include:

Baseline Environmental Status

Aspects	Baseline Status
Climate	The project area is within the tropics, it is dominated by two contrasting seasons, the dry and wet (rainy) seasons. The two season regimes are dependent on the two prevailing air masse blowing across the country at different times of the year, the south-westerly humid maritime air mass blowing from across the Atlantic and the north-easterly air mass of Saharan origin
Temperature	the highest mean maximum temperature was recorded during the month of April (44.5°C) while the lowest mean maximum temperature value was recorded in August (31°C). The highest mean minimum temperature value recorded was 39.4^0C in April and the lowest was 17.1^0C in November.
Relative Humidity	The least mean (10.0%) monthly relative humidity was recorded in the month of March while the highest recorded mean monthly relative humidity (61.0%) was in August.
Rainfall	Mean monthly rainfall recorded in Katsina was zero in the months of January, February, March, November, and December and highest in the month of August (214.8mm).
Wind Speed	Winds speed of up to 7.2 metres/second (m/s) and above were recorded in January, April, May, June, and July for the period, 1990 – 2009. The lowest wind speed recorded (4.6m/s) was in the month of November.
Air Quality	Ambient air quality parameters measured includes SPM, NO_2, H_2S, CO and SO_2, values obtained were lower that regulatory limits
Noise Level	Noise level measured in the proposed plant site was between 25.3 and 48.7dB
Geology	Katsina State forms part of the extensive plains known as the High Plains of Hausaland. The state is composed of undulating plains which generally rise gently from 360m in the northeast around Daura, to 600m around Funtua in the southwest. Generally, the state has two geological regions. The south and

Aspects	Baseline Status
	central parts of the state are underlain by crystalline rocks of the Basement Complex (from Funtua to DutsimMa), but in the northern parts cretaceous sediments overlap the crystalline rocks.
Soil	Physico-chemical characteristics from the study area were consistent across sample stations. The pH value ranged between 4.95 and 7.92 (dry season). Heterotrophic bacteria present was Pseudomonas sp, Bacillus sp, Proteus sp, Staphylococcus sp, Micrococcus sp while heterotrophic fungi present were Rhodotorula sp, Mucor sp, Penicillium sp.
Ground water	Physico-chemical characteristics from the study area were consistent across sample stations. The pH value ranged between 6.18 and 6.8 (dry season) indicating a slightly alkaline medium. Values obtained were also compared with WHO limits, and were compliant.
Vegetation	Vegetation type in the area is the Sudan Savannah Vegetation and consists largely of shrubs, short grasses with a few scattered wooded savanna trees.
Wildlife	The area is characterised with abundant number of fauna composition. Fauna discussed include mammal, reptile and aves.

Socio-Economics and Health Studies/ Consultation

The study was designed to obtain all relevant socio-economic and health data on the community from primary and secondary sources. The household questionnaire was administered on 150 households in the study area and 141 of these were retrieved. The questionnaire was administered on willing households, selected randomly from the community. FGDs and interviews were also held in the study area. Respondents to the questionnaire and participants in the FGDs and interviews were all 18 years and above.

Members of these communities expressed their concerns on the proposed project. These concerns bordered on perceived effects on their environment, livelihood and health. They also acknowledged that the project would bring development to the area.

POTENTIAL IMPACT ASSESSMENT AND MITIGATION

The potential and associated impacts of the proposed project were identified and evaluated using standard procedures. Various source references including past project experience, professional judgment and knowledge of both the project environment and project activities were used in the assessment. The associated and potential impacts of the proposed project as well as the proffered mitigations are summarised in the table on the next page.

Associated/ Potential Impacts and Mitigation Measures

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation / Enhancement Measures	Residual Ranking
Pre-Construction Phase					
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Employment opportunities arising from recruitment of workers	Formal, informal control	Beneficial	NSF shall: • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented and signed • Make transparent communication on hiring policies amongst local communities	Beneficial
	Business opportunities for local contractors through sub-contracting activities			NSF shall: • Ensure local suppliers and contractors implement local employment and local procurement policies to the benefit of host community • Continually encourage local contractors through the award of contracts, according to their competence levels • Carry out periodic review of jobs, supplies and contract awards • Ensure consultation throughout project life span	
	Skill acquisition and enhancements to locals and future workforce	Formal control and training	Beneficial	NSF shall: • Ensure employed staff are trained to develop local workforce capacity; • Make sure payment, royalties etc are paid to eligible, and benefiting individual as appropriate	Beneficial
	Improvement in quality of life for adequately compensated individuals	Formal and informal control			
	Conflicts/ community agitations over employment issues (quotas and methods)	Formal, informal control	Major	NSF shall: • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented, signed, and implemented in timely manner. • Engage in due consultation with relevant groups within host community at all phases of the project • Ensure that its workers are briefed on the socio-cultural norms and sensitivity of the host communities • Explore ways of encouraging goodwill and friendly relationship between its workers/ service contractors and members of the community • Establish, implement, and publicise grievance management procedure	Minor
	Influx of people (migrant workers, sub-contractors and suppliers) and increased pressure on existing social infrastructure	Informal and avoidance control	Medium	NSF shall: • In the future, promptly construct infrastructural facilities in the area to ease pressure on the existing amenities/ infrastructure • Encourage personnel to participate in community development affairs • Ensure that workers are educated on health issues	Minor
	Increase in social vices (like theft, prostitution) resulting from increased number of people in the area				

Associated/ Potential Impacts and Mitigation Measures

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation / Enhancement Measures	Residual Ranking
Pre-Construction Phase					
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Dust particles and vehicular emissions from increased movement	Formal and avoidance control	Medium	NSF shall: • Ensure site preparation and clearing are conducted in favourable weather conditions, when risk of dust is low. • Maintain all its work equipment at optimal operating conditions • Minimise venting from vehicle and equipment through the use of venturi or impingement scrubbers to control particulate matter emissions	Negligible
	Generation of wastes such as scrap metal, wood, sand, concrete, paper, domestic waste etc	Formal, training and physical control	Major	NSF shall: • Make sure all waste generated are separated at source to enhance efficiency in waste handling and disposal • Ensure personnel working at site are trained in the handling and management of wastes • Treat and discharge all effluents (wastewater, sewage) in accordance to regulatory requirements and in line with NSF waste management procedure/ plan	Negligible
Construction and Installation Phase					
• Plant foundation works • Piling, trenching, etc • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Risks of injury/ death and loss of assets resulting from accident associated with road transportation to and from construction site	Formal, training and physical control	Major	NSF shall: • Develop and maintain an effective journey management schedule • Ensure its drivers observe road traffic and speed limits • Make sure vehicle drivers undergo and pass competency training on driving, and identification of road signs and traffic codes before mobilisation • Use road signs at strategic points, sirens and public announcements where necessary to warn people of on-coming heavy duty vehicles • Ensure all its vehicles are certified roadworthy and in good maintenance state • Ensure night movement are avoided	Minor
	Workplace accidents leading to injury or fatalities from burns, cuts, bruises, trips, falls from objects at height	Formal control	Major	NSF shall: • Ensure that HSE briefings are conducted prior to work commencement • Ensure personnel wear adequate PPE • Design work area to meet best industrial standards recognizing all ergonomic factors • Encourage employees to maintain good house keeping	Minor

Associated/ Potential Impacts and Mitigation Measures

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Construction and Installation Phase					
• Plant foundation works • Piling, trenching, etc • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Potential collapse of power plant structures as a result of unsuitable geotechnical conditions	Formal and avoidance control	Major	NSF shall: • Carry out a comprehensive geotechnical study of the project site before construction works • Ensure geotechnical report provide all strength values and settlement potential required for adequate foundation design • Make use of experts with requisite experience in plant design and construction	Negligible
	Hazards from construction of base camp and electric evacuation lines	Formal, training and informal control		NSF shall: • Ensure personnel wear appropriate PPE (eye goggles, nose masks etc) • Make use of competent and well trained personnel for construction works	
	Cement dust and toxic fumes inhalation by onsite workers during foundation works and welding of plant components	Formal and training control	Major	NSF shall: • Ensure personnel wear appropriate PPE (eye goggles, nose masks etc) • Make use of competent and well trained personnel for construction works • Ensure periodic medical checks are carried out on personnel	Minor
	Risk of electrocution and burns during welding		Major	NSF shall: • Ensure strict adherence to standard work operations including the use of PPE (nose masks, hand gloves, etc) are maintained as stated in the company's HSE policy • Ensure all electrical and welding equipment are maintained at optimal working conditions • Make sure first aid facility are in place at construction site	
	Noise nuisance (including impulsive noise) from construction activities (e.g. piling, digging) resulting to temporary migration of mammals and rodents	Formal, physical and avoidance control	Medium	NSF shall: • Make sure machinery, vehicles and equipment that produce high levels of noise are avoided • Personnel working with machinery, vehicles and instruments that produce high levels of noise should be supplied with ear plugs and ear muffs • Ensure construction works are avoided at night time	Negligible

Associated/ Potential Impacts and Mitigation Measures

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Decommission Phase					
• Mobilisation of personnel and equipment • Power plant decommissioning • Abandonment/ restoration	Loss of employment, business opportunities and decreased economic activity	Formal and informal control	Medium	NSF shall ensure: • Plans are developed to integrate disengaged workers from the plant into other projects (if any) • That host communities are informed prior to decommissioning	Minor
	Reduced power generation to national grid and low power supply	Formal control	Medium	NSF shall ensure: • Plans are made for another plant to continue generating electricity	Minor
	Risk of accident and injury to workers during demolition of structures	Formal control	Major	NSF shall: • Ensure that HSE briefings are conducted prior to demolition activities • Ensure personnel wear adequate PPE while carrying out demolition • Encourage employees to maintain good housekeeping within work site • Make sure trees or shrubs are re-grown on project site to restore its original form	Minor
	Increased dust and vehicular emissions from decommissioning activities	Formal and physical control	Medium	NSF shall: • Ensure demolition activities are conducted after sprinkling of water to prevent dust build up • Ensure personnel wear adequate PPE (i.e dust mask) while carrying out demolition • Maintain all its vehicles at optimal working conditions	Negligible
	Availability of land for alternative uses	Formal and Informal control	Beneficial	To enhance this impact, NSF shall: • Develop a detailed Decommissioning /Abandonment Plan ensure alignment of all stakeholders (state, local, community) • Clean all excavations to acceptable limits and have then backfilled • Remove all wall fences and structures as advised by the abandonment team • Clean contaminated soils to acceptable limit	Beneficial
	Loss of site aesthetic qualities due to abandoned and dilapidated structures	Formal and Informal control	Medium	Available structures and building not demolished should be used for other beneficial purposes to prevent decay	Negligible

ENVIRONMENTAL MANAGEMENT PLAN

In order to ensure that the mitigation measures developed for the significant impacts of the proposed project are implemented and maintained throughout the project duration, an Environmental Management Plan (EMP) was developed. The EMP outlines management strategies for managing all associated and potential impacts that could affect the environment and living conditions of people in the area. These plans include:

- Worker Safety and Health Plan;
- Incident and Injury Free (IIF) Plan;
- Emergency Response Plan;
- Communication Plan;
- Environmental Monitoring Plan;
- Waste Management Plan;
- Security plan;
- Resettlement plan;
- Decommissioning and Abandonment; and
- Remediation plans after decommissioning/closure.

CONCLUSION

The environmental impact assessment of the proposed NOVA Solar 5 Farms Limited 125MWp Solar PV Power Plant in Katsina State was carried out in line with statutory requirements for environmental management in Nigeria and findings has been documented in this final draft report (based on two seasons sampling exercise). Information and data provided in this report would form the basis for the preparation of the Environmental Impact Statement.

The existing environmental baseline conditions (biophysical and socio-economic) as well as sensitive components of the study area have been established through field data gathering exercise and complemented with information from literature research.

Interactions between the biophysical and socio-economic components of the environment and the proposed urea plant developmental projects were used to identify, characterize and evaluate the potential and associated impacts of the proposed project. Thereafter, mitigation measures to ensure the sustainability of the project based on best industry practices, available technology and level of knowledge were developed for the adverse impacts.

Finally, an environmental and social monitoring plan was developed and documented to ensure effective management of the proposed project impacts as well as the implementation of the environmental and social commitments made throughout the duration of the project.

ACKNOWLEDGEMENT

NOVA Solar 5 Farms Limited is pleased to acknowledge with appreciation, the opportunity granted it by the Federal Government of Nigeria and the Federal Ministry of Environment to conduct this Environmental and Social Impact Assessment (ESIA) study for its 125MWp Utility Scale PV-Based Solar Power Plant in Kankiya, Katsina State.

The contributions of the Environmental Consultant – Fugro Nigeria Limited, contracted to execute this ESIA is sincerely acknowledged and commended. We are grateful to the Katsina State Government and Kankiya Local Government for supporting the project.

We also appreciate the support of Kankiya Community in its entirety, and all our other stakeholders who actively participated in the ESIA process.

CHAPTER ONE

INTRODUCTION

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INTRODUCTION

1.1 General

Nova Power S.A. (Nova Power) is a renewable energy power plant developer as well as advisor to the public and private sectors in the field of sustainable development. Nova Power has been building up its portfolio since May 2012 in Sub-Saharan Africa. Nova Power is based in Casablanca, Morocco and registered in the Casablanca Finance City free trade zone. The NOVA Group currently has offices in Morocco, Nigeria, France, the United States, and Germany. Nova Power America and RECA are subsidiaries of NOVA Power S.A., while Nova Solar Power Nigeria and Nova Power Germany are subsidiaries of RECA. NOVA Solar 5 Farms Limited is a subsidiary of Nova Solar Power Nigeria.

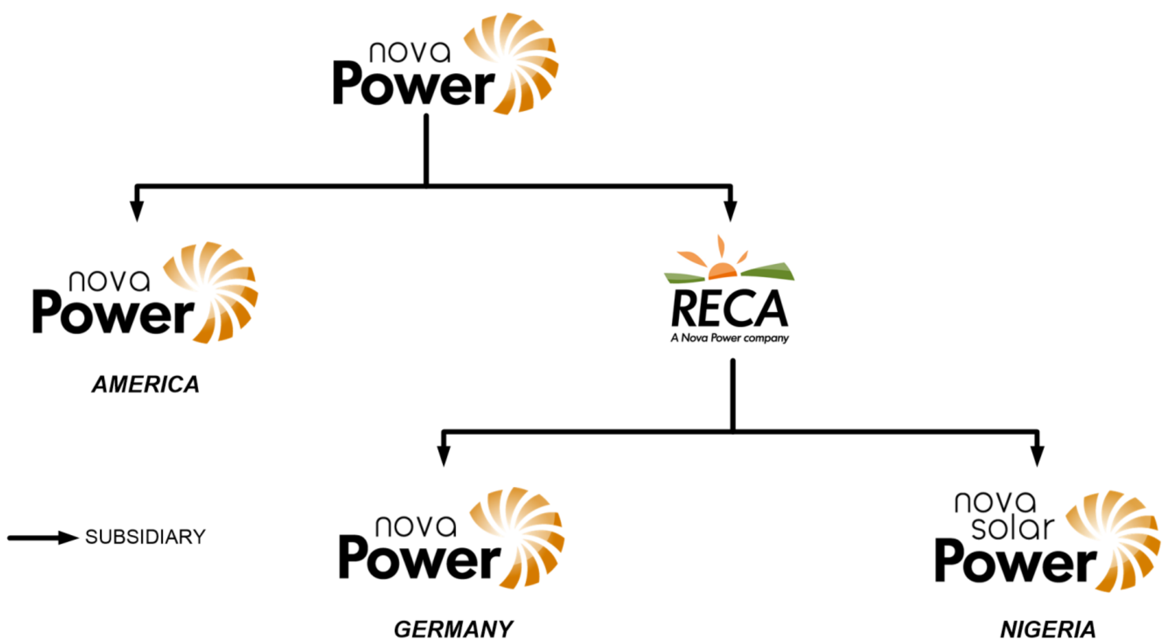

Figure 1.1: NOVA Group Corporate Structure

Nova Power's mission is to develop and construct profitable solar and other green power projects serving local communities and businesses, as well as to generate substantial climate change mitigation benefits by producing electricity that avoids CO_2 emissions. Nova Power provides the energy upon which economic development depends, while improving social conditions and protecting the environment.

Nova Solar Power (NSP) is a project developer of Solar Photovoltaic (PV) Program in Nigeria. The program is focused on the development of solar PV power plants across different locations in Nigeria. NOVA Solar 5 Farms Limited (NSF) is the owner of the proposed 125 MW Solar Photovoltaic Project to be sited in Katsina state by Nova Solar Power.

In view of the above, NSF intends to develop the 125MWp Solar PV Power Plant in Katsina State as the first in its planned program. NSF has therefore commissioned Fugro Nigeria Limited (FNL), a Geotechnics, Quality, Health, Safety and Environment (QHSE) consulting, engineering geophysics, subsea engineering, onshore/offshore survey, and laboratory services company, certified to ISO 9001:2008, ISO 14001:2004 and OHSAS 18001:2007, to carry out an Environmental and Social Impact Assessment (ESIA) study in order to assess the proposed project impacts on the surrounding environment prior to commencement. This is in line with good environmental management practices in Nigeria, together with commitment of NSF to sustainable project development and in compliance with environmental regulatory requirements.

FNL conducted the study under the terms of the Nigerian Environmental Impact Assessment Act Cap E12 LFN 2004, and in fulfillment of the International Finance Corporation (IFC)/ World Bank Standards. This ESIA report has been prepared based on a two-season (dry and wet) baseline data.

1.2 The Proponent

NOVA Solar 5 Farms Limited (NSF) is the project Owner specialized in the design, development, management, coordination and financing of renewable energy projects, and more specifically utility-scale solar photovoltaic (PV) projects in sub-Saharan African markets. NSF office is located 43 Usuma Street, Off Gana Street, Maitama, F.C.T. Abuja, Nigeria.

NOVA Solar Power Limited has been awarded a Presidential Mandate to be the Lead Developer of a 500 MWp PV based Solar Program in Nigeria (hereinafter “Solar Program”). The Solar Program is based on the implementation of PV power plants with a minimum unitary installed capacity of 30 MWp across several States as such NOVA Solar 5 Farms Limited has secured the support of international investors and Development Finance Institutes (DFIs) over the Solar Program as a whole and thus translates into commitments on the financing of feasibility studies, development and construction activities.

In this regard, NOVA Solar Power Limited would be developing the Kankiya, Katsina Solar PV power plant on behalf of NOVA Power.

1.3 Project Area

The project will be located in the Nigerian northern State of Katsina. The site is situated about three kilometers in the north of the city of Kankiya in Kankiya Local Government Area (LGA) of Katsina State.

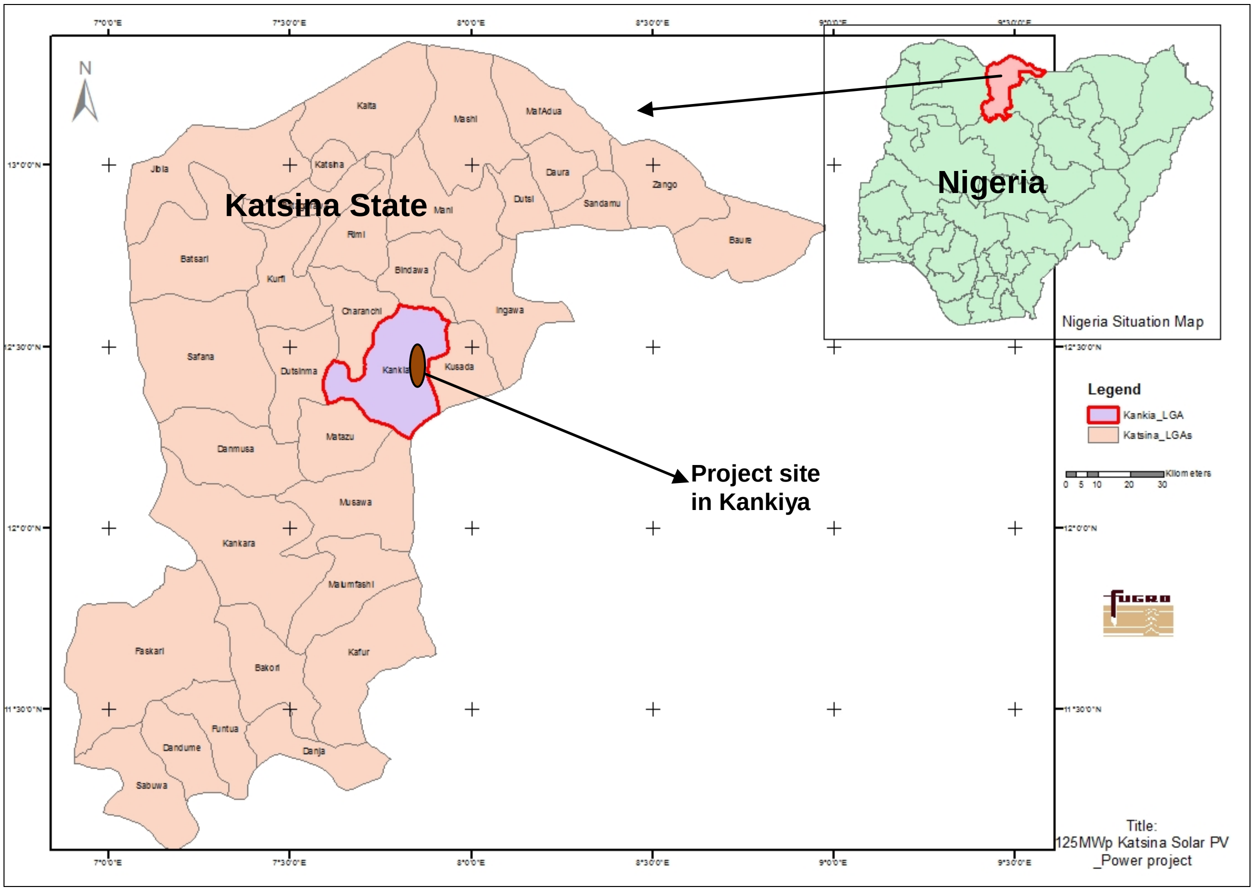

Figure 1.2: Project Area Administrative Map

The proposed 200 hectare land site is located on the east side along Kankiya – Katsina A9 highway about 60km from the state capital, Katsina (**Figure 1.3**). The south-east point of the area is delineated by geographic coordinates; 32P, 1389728.530mN; 3272271.500 mE.

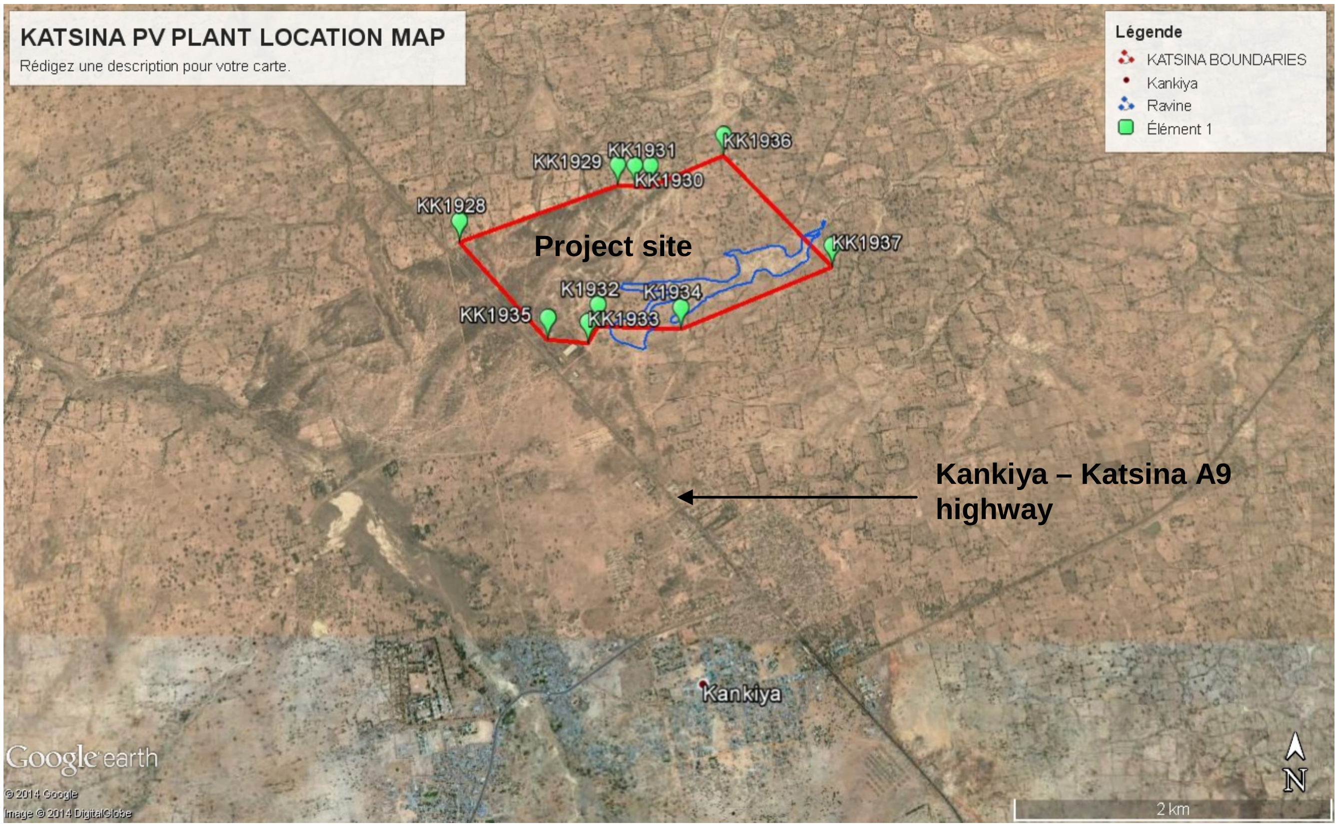

Figure 1.3: Site Location Overview

1.4 ESIA Objectives

In line with the statutory requirements for environmental protection in Nigeria, the proposed EIA study is being carried out to:

- Satisfy Federal, State and Local Governments as well as stakeholders, that proactive environmental actions shall be incorporated in the project design, installation, construction and operation phases;
- Ensure proper consultations with the communities within the project area in line with regulatory requirement;
- Provide all necessary answers to stakeholders, assessors, host community, regulators, financiers, pressure groups and other interested parties
- Establish existing baseline (biological, physical and socio-economic) conditions of the project location;
- Identify all environmental and social aspects of the proposed project that may interact positively or negatively with the environment;
- Make appropriate recommendations to prevent, reduce or control identified potential and other associated negative impacts, and Identify opportunities to enhance positive impacts and project benefits;
- Develop environmental management plan (EMP) and procedures for effective and proactive environmental management of the environment throughout the project life cycle;
- Provide all necessary data, information and objective evidence required for developing an Environmental Impact Statement (EIS) for the proposed Solar Power Plant

1.5 ESIA Scope of Work

In accordance with the EIA Procedural Guidelines in Nigeria (FEPA, 1995), a scope of work for the solar power plant project was developed and submitted to the Federal Ministry of Environment (FMENV) on 10th January, 2015. Following this was site verification exercise carried out by the FMENV team on 21st January, 2015 (and subsequently, approval of the Terms of Reference (TOR). The approved EIA work scope covered the following:

- Review of national and international environmental regulations, and conventions relevant to the proposed development project activities;
- Generation of data that would establish the existing environmental and socio-cultural status of the proposed project site and environs;
- Carrying out two (2) seasons (wet and dry) field data acquisition campaign and laboratory analysis of field samples;
- Consultation with all stakeholders including regulatory agencies;
- Impact identification, prediction, interpretation and evaluation;
- Development of cost effective mitigation measures, monitoring programmes and EMP covering the project life cycle; and
- Preparation of draft and final ESIA reports in line with the federal ministry of environment, IFC Performance Standards, and the World Bank operational policies/guideline.

1.6 ESIA Methodology

EIA Registration and Screening

An EIA registration form for the project was filled and forwarded to the FMEnv on the 10th of January, 2015 by NSF. Subsequently, a screening process was conducted by FMEnv and the EIA placed in Category One (1), equivalent to Category A for World Bank.

Site Visit and EIA Terms of References

The ESIA terms of reference (ToR) was defined and prepared in line with the EIA Procedural Guidelines (FEPA, 1995). It was submitted to the FMEnv for approval after site visit carried out on the 21st January, 2015. The approved ToR (**Appendix 1.1**) outlined the general scope of the EIA study and requirements for data collection.

Desktop Studies/Literature Review

Desktop studies were undertaken to acquire an environmental database required for the ESIA studies. The literature search included information from previous studies around areas with similar environmental characteristics. Materials consulted include textbooks, articles, reports, maps, and photographs, acquired at state, national and international levels.

Field Research

Field research was undertaken so as to complement/verify information gathered from desktop studies. Specific information on the ecological and socio-economic conditions of the project environment was gathered during fieldwork execution. In particular, the survey covered the following environmental components:

- the physical environment – surface and groundwater characteristics, soil characteristics, air quality, noise and potential natural hazards;
- the biological environment – water, and soil microbiology, flora and fauna (particularly rare and endangered species);
- the socio-economic and health environment - population, land-use and patterns of land ownership and tenure, community structure, employment, distribution, public health, cultural heritage, customs, aspirations and attitudes, etc.

Field Data Gathering

The ESIA study provides a description of the existing environmental and socio-economic conditions as basis against which the impacts of the proposed project can be assessed. The main objective of the baseline description is to identify environmental and socio-economic resources and conditions in areas potentially affected by the project (such as air quality, groundwater, surface water, fauna and flora etc) and other key receptors.

Data gathering also involved desktop studies of climatic conditions as well as obtaining information from journals on the project area. Project engineering studies were also obtained for quantitative information on environmental elements.

Field data gathering campaign was carried out in two seasons (dry and wet) to acquire information on the baseline condition of the area. Field survey was conducted within FMEnv guidelines and standards. Field survey was carried out in the presence of FMEnv representatives for dry season (between 05th and 09th February, 2015) and wet season (from 3rd to 6th August, 2015). Sampling requirements investigated include air quality and noise, soil, groundwater as well as socio-economic and health profile of host community.

Data Analysis and Interpretation

Samples collected from the field visit were transferred to FNL laboratory, (accredited by Federal Ministry of Environment), located at 91, Odani Street, Elelenwo, Port Harcourt, Rivers State for analyses. Results obtained were interpreted and used to describe the existing baseline of the study area as documented in **chapter four** of this report.

Reporting and Disclosure

The overall findings of the study were documented as contained in this report. A draft report was first issued, and inputs made by client. The report was then forwarded to the FMEnv for the 21 days mandatory public disclosure and an expert review session organised by FMEnv to review the report.

In line with World Bank and IFC requirements for stakeholder consultation, the draft ESIA report is submitted to the World Bank's InfoShop to allow for stakeholder consultation and comments.

Consultations Process

Consultation is a tool used to assess stakeholders concerns and expectations of pertinent issues on environmental, social and health concern for integration into the impact prediction, assessment, evaluation and mitigation. Consultation involved information dissemination and interactions/ dialogues with various stakeholders concerned in the proposed project including professionals/ experts in relevant fields relating to the power project. Consultation was carried out with relevant stakeholders all through the study i.e. during screening, reconnaissance (site) visit, field survey/ data collection, public disclosure, expert review meetings.

Consultations with project stakeholders are still being carried out. Stakeholders' views and opinions concerning the proposed project and its associated/potential impacts have been integrated into the ESIA process. Consultations will continue throughout the project life-cycle and issues raised by concerned and affected parties will be considered. The results of all concluded consultations are included as bases for potential impact assessment and as such have been clearly documented in this ESIA report. The stakeholders consulted included:

- Federal Ministry of Environment (FMEnv);
- Katsina State Ministry of Environment (KSMENV);
- Katsina State Ministry of Lands and Housing;
- Katsina State Surveyor-General

- The host community (Kankiya);
- Relevant non-governmental organisations (NGOs) as well as interested and affected parties.

The overall schedule for the ESIA study is provided in **Table 1.1** below.

Table 1.1: NSF- ESIA Activities Timeline

Activity	Timing
EIA Registration	10th January, 2015
Site Visit	20th /21st January, 2015
ToR Approval	13th February, 2015
Field Survey-dry/ Consultation	05th to 09th February, 2015
Mandatory disclosure public forum	3rd August, 2015
Field Survey –wet season	3rd to 6th August, 2015
EIA Draft Report -Completed	10th September, 2015
Draft Report Submitted to FMEnv	12th October, 2015
21 Days Public Disclosure	19th October to 16th November, 2015
FMEnv Interim Approval	10th December, 2015
Expert Review Meeting	20th November, 2015
Received Expert Comments	10th December, 2015
EIA Final Report -Completed	11th December, 2015

The ESIA study has been done in accordance with the flow scheme shown in **Figure 1.3** below.

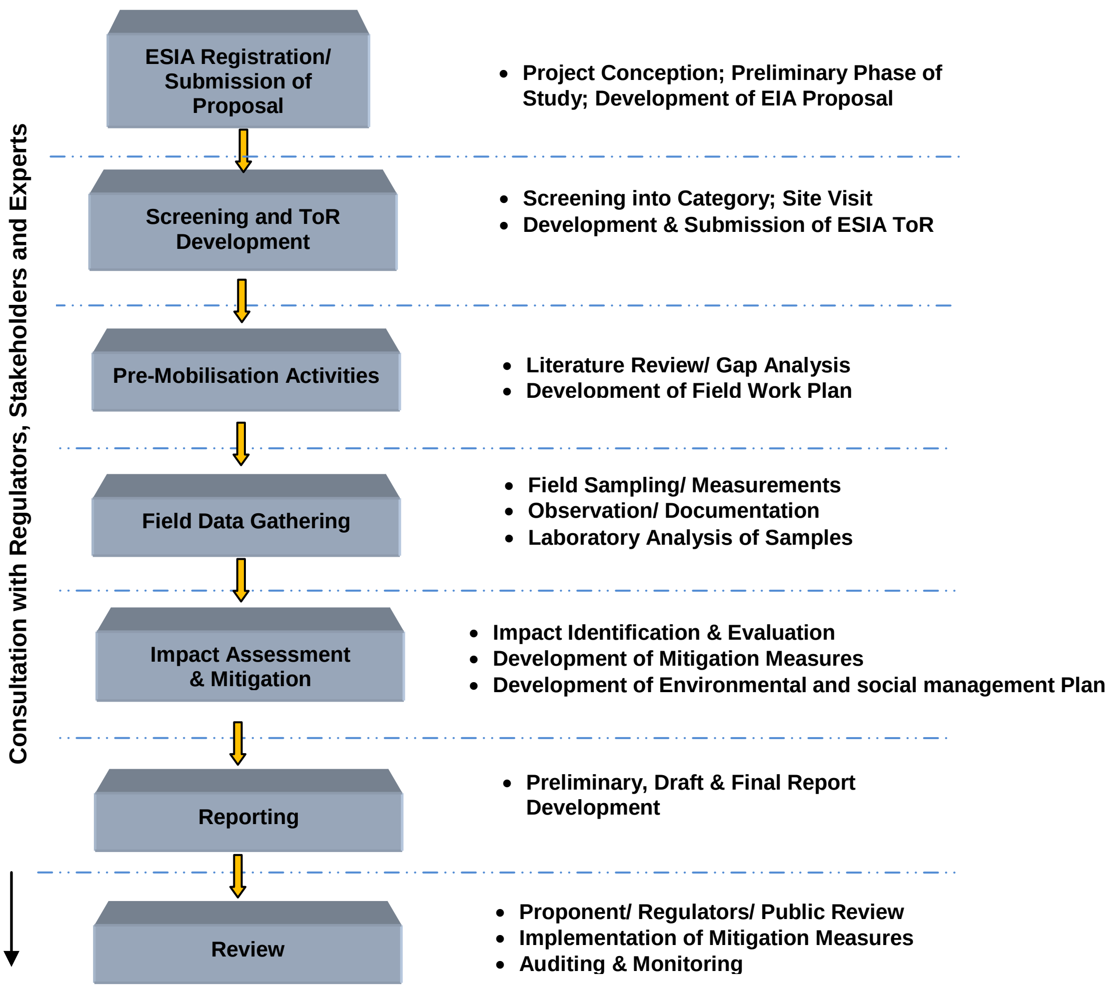

Figure 1.4: ESIA Procedural Flowchart

1.7 Administrative and Legal Framework

1.7.1 National Guidelines

In Nigeria, existing statutes on environmental protection contains specific provisions designed to prohibit or control environmental pollution/ degradation and also to prescribe sanctions to be enforced against persons or companies who infringe on these provisions. The legal, regulatory and administrative framework upon which the ESIA of the proposed utility scale PV-based solar power Plant project was carried out includes:

- Various national and state statutes, regulations, standards on environmental protection in Nigeria; and
- Applicable international agreements, guidelines and conventions to which Nigeria is signatory.

The principal bodies responsible for environmental matters and saddled with enforcing existing statutes and regulations in Nigeria are the Federal Ministry of Environment (FMENV). Specific policies, acts and guidelines enforced by FMEnv and relevant to this project are presented in the following sub-sections:

The Federal Ministry of Environment

The defunct Federal Environmental Protection Agency (FEPA) was created by Decree No. 58 of 1988 as a parastatal of the Federal Ministry of Works and Housing.

In 1992, the Agency's authority was strengthened through Decree 59 of 1992 by which the defunct FEPA was transferred to the Presidency. FEPA's goals were to improve and maintain the quality of the Nation's environment, manage its resources and physical characteristics, prepare ecological Master Plan to guide the use of coastal areas rift with diverse and often conflicting economic and social activities.

In same year, Nigeria took a giant step towards the sustainable management of its environment by formulating a decree of Environmental Impact Assessment (EIA). This has become globally accepted as an environmental management tool. June (1999), Nigeria formed a bigger body, "The Federal Ministry of Environment" which include the defunct FEPA and other departments from different Federal Ministries and Parastatals. The Federal Ministry of Environment is charged with the responsibility of all matters concerning the nation's environment and its biodiversity.

It has developed instruments of intervention to halt environmental degradation in form of policies, standards, guidelines and regulations and programmes. With the initiation of these instruments, enforcement by FMEnv has become the most effective tool to bring industries and regulated community into compliance through compliance promotions. The relevant policies, guidelines and regulations of the ministry are outlined below:

National Policy on Environment

The National Policy on Environment, 1989 (revised 1999), provides for "a viable national mechanism for co-operation, co-ordination and regular consultation, as well as harmonious management of the policy formulation and implementation process which requires the establishment of effective institutions and linkages within and among the various tiers of government – federal, state and local governments". Prior to the launching of this policy, there was no unified co-ordination of activities of the 3-tiers of government responsible for the environment.

The thrust of the policy is the achievement of sustainable development in Nigeria. Guidelines and strategies are therefore defined for:

- Securing for all Nigerians a quality of environment adequate for their health and well-being;
- Conserving and using the natural resources for the benefit of present and future generations;
- Restoring, maintaining and enhancing the ecosystem and ecological processes essential for the preservation of biological diversity;
- Raising public awareness and promoting understanding of the essential linkages between the environment, resources and development; and
- Co-operation with other countries, international organisations and agencies to achieve optimal use of trans-boundary spaces in order to prevent environmental recourses.

Further, the defined guidelines and strategies provide for the effective management of the environment in the following areas:

- Human population;
- Land use and soil conservation;
- Water resources management;
- Forestry, wildlife and protected areas;
- Air pollution;
- Toxic and hazardous substances;
- Noise pollution;
- Marine and coastal area resources
- Mining and mineral resources
- Working environment (occupational health and safety); and
- Settlements, recreational space, greenbelts monuments and cultural property.

National Environmental Protection Regulations

S. I. 8 -National Environmental Protection (Effluent Limitation) Regulations 1991

The National Effluent Limitation Regulation, S.I.8 of 1991, makes it mandatory for industries as waste generating facilities to install anti-pollution and pollution abatement equipment on site. The regulation is specific for each category of waste generating facility with respect to limitations of solid and liquid discharges or gaseous emissions into the ecosystem. Appropriate penalties for contravention are also prescribed.

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

National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes) Regulations, S.I.9 of 1991, imposes restrictions on the release of toxic substances and stipulates requirements for pollution monitoring units, machinery for combating pollution and contingency plan by industries; submission of lists and details of chemicals used by industries to Federal Ministry of Environment (FMEnv); requirement of permit by industries for the storage and transportation of harmful or toxic waste; the generator's liability; strategies for waste reduction; permissible limits of discharge into public drains; protection of workers and safety requirements; environmental audit (or environmental impact assessment for new industries) and penalty for contravention.

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

The Management of Hazardous and Solid Waste Regulation, S.I.15 of 1991, defines the requirements for groundwater protection, surface impoundment, land treatment, waste piles, landfills, incinerators etc. It also describes the hazardous substances tracking programme with a comprehensive list of acutely hazardous chemical products and dangerous waste constituent. It also states the requirements and procedure for inspection, enforcement and penalty.

The Environmental Impact Assessment Act

The EIA Act Cap E12 LFN 2004 requires that for all new major public and private projects in Nigeria, where the extent, nature or location of a proposed project or activity is such that it is likely to significantly affect the environment, its EIA is undertaken in accordance with the provision of the Act. The EIA Act sets out to:

- consider the likely impacts, and the extent of these impacts on the environment before embarking on any project or activity;
- promote the implementation of appropriate policy in all Federal Lands consistent with all laws and decision making processes through which the goal of this Act may be realized; and
- encourage the development of procedures for information exchange, notification and consultation between organisations and persons when the proposed activities are likely to have significant environmental effects on boundary or trans-state or on the environment of bordering towns and villages.

The Act gives specific powers to the FMEnv to facilitate environmental assessment of projects. In 1995, the then Federal Environmental Protection Agency (FEPA, now FMEnv) published *EIA Procedural Guidelines.* The guideline is intended to assist in the proper and detailed execution of EIA studies in Nigeria.

Nigerian Content Act

The Nigerian Local Content law was created to enhance utilisation of the country's human and material resources for the provision of goods and services:

The Factories Act, 1990

The Factories Act 1990 (FA) is the primary law regulating the health, safety and welfare of workers in the country's factories. The law holds management and staff personally responsible for violations of the provisions in the Act.

With respect to safety, there are general provisions as to the securing, fixing, usage, maintenance and storage of prime movers, transmission machinery, other machinery, unfenced machinery, dangerous liquids, automated machines, hoists and lifts, chains, ropes and lifting tackle, cranes and other lifting machines, steam boilers, steam receivers and containers, and air receivers. There are, in addition to these, standards set for the training and supervision of inexperienced workers, safe access to any work place, first aid boxes, prevention of fire, and safety arrangements in case of fire.

The law requires that all accidents and industrial diseases be notified to the nearest inspector of factories and be investigated. The Act also prohibits the owner or occupier of a factory from making any deductions from the wages of any employee in respect of anything to be done or provided in pursuance of the FA.

NESREA Requirements

The National Environmental Standards and Regulations Enforcement Agency (NESREA) was established in November 2006 by the federal government. It is charged with the responsibility of enforcing all environmental laws, guidelines, policies, standards, and regulations in Nigeria. It also has the responsibility for enforcing compliance with the provisions of international agreements, protocols, conventions and treaties on environment to which Nigeria is signatory.

NESREA Act
Administered by the Ministry of Environment, the National Environment Standards and Regulation 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 of the act 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 monitory and regulatory measures.

Section 8: 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. Other sections include:

Section 1: requires industry facilities to have anti-pollution equipment for the treatment of effluent.

Section 3: requires a submission to the agency of a composition of the industry's treated effluents.

Section 4 and 5: requires industries to report a discharge if it occurs and to submit a comprehensive list of chemicals used for production to the Agency.

Electricity Power Sector Reform Act
The Nigeria Electric Power Sector over the years witnessed a slow and steady decline leading to a near complete failure of the system. The Government therefore, as a matter of dire necessity embarked on an Electric Power Sector Reform Program, which led to the establishment of the Nigerian Electricity Regulatory Commission (NERC) in 2005 and the Sector Reform Act.

This Act provides for the formation of initial and successor companies for the transfer of assets and liability of the National Electric Power Authority (NEPA), development of a competitive electricity market, establishment, functions and powers of the Nigerian ***Electricity Regulatory Commission (NERC)*** licenses and tariffs, acquisitions of land and access rights, consumer protection and licensee performance standards, completion and market power, the power consumer assistance fund, etc for the regulation and control of electrical installations, and the generation, supply and use of electrical energy in Nigeria. Sections/parts of the Electricity Act relevant to the IPP project are:

Part III: Establishment of the Nigerian Electricity Regulatory Commission; objects and functions of the commission are as follows:

- to create, promote and preserve efficient industry and market structures and to ensure the optimal utilisation of resources for the provision of electricity services;
- to maximise access to electricity services, by promoting and facilitating consumer connections to distribution systems in both rural and urban areas;

- to ensure that an adequate supply of electricity is available to consumers;
- to ensure that the prices charged by licensees are fair to consumers and are sufficient to allow the licensees to finance their activities and to allow for reasonable earnings for efficient operations;
- to ensure the safety, security, reliability and quality of service in the production and delivery of electricity to consumers;
- to ensure that regulation is fair and balanced for licensees, consumers, investors and other stakeholders;
- to present quarterly reports to the President and National Assembly on its activities;
- promote competition and private sector participation, when and where feasible;
- establish or, as the case may be, approve appropriate operating codes and safety, security, reliability and quality standards;
- establish appropriate consumer rights and obligations regarding the provision and use of electricity services;
- license and regulate persons engaged in the generation, transmission, system
- operation, distribution and trading of electricity; approve amendments to the market rules;
- monitor the operation of the electricity market; and

- undertake such other activities which are necessary or convenient for the better carrying out of or giving effect to the objects of the commission.

Part IV: Licensing requirement (for generation, transmission, system operation, distribution and trading), tariffs, fines and penalties;

Part V: Acquisition of land and access rights. Regulation 77 of this part stipulates a special provision for companies that require land for purposes of generation, transmission and distribution of electricity and notice to construct or extend any railway, road or any works for telecommunications is also provided for in regulation 79 of this part;

Part VI: Regulation 80 of this part stipulates that the commission shall develop, in consultation with the licensee the following materials for the protection of the consumer:

- customer services standards;
- customer complaint handling standards and procedures;
- codes of practice for the provision of assistance to special needs customers, such as the blind or disabled, the elderly or severely ill;
- procedures for dealing with, and assisting where necessary, customers who have difficulty in paying bills;
- procedures for applying for electricity service;
- procedures for disconnecting non-paying customers or for. those breach of other terms and conditions of an applicable tariff or contract;
- the information to be provided to consumers and the manner of its dissemination; and
- standards for compensation to consumers who do not enjoy regular power supply.

Part VII: Regulations pertaining to competition and market power; and

Part VIII: Regulations pertaining to establishment of the power consumers' assistance fund. Regulations 93 to 95 of the same Act stipulate conviction for false declarations, penalties for contravention and appointment of inspectors for undertakings and safety operations

Recently, the reform has led to the corporatisation and unbundling of the state owned monopoly, now known as the Power Holding Company of Nigeria (PHCN). The unbundling has lead to the establishment of 18 successor companies from PHCN comprising of six generation companies, one transmission company and 11 distribution companies. The sector has also been deregulated leading to private sector participation in the generation sector and the operation of a number of Independent Power Plants in the country today. The establishment of the Nigerian Electricity Regulatory Commission (NERC) is also in line with the Reform Programme.

Rural Electrification Agency
This is a Federal Government of Nigeria agency saddled with the responsibility of providing electricity to rural communities in Nigeria. The agency was established by Section 88 of the Electric Power Sector Reform Act 2005. On March 16, 2006 the Board and Management of the Agency were inaugurated by the Honourable Minister of Power and Steel.

Federal Government of Nigeria's commitment to aggressive rural electrification is expressed in the following policy documents:

- The National Energy Policy;
- The Electric Power Sector Reform Act 2005;
- Rural Electrification Policy 2005; and
- The National Electric Power Policy 2001.

These policy documents outline the principle for Rural Electrification thus:
- Facilitate the provision of steady and reliable power supply at economic rates for residential, commercial, industrial and social activities in the rural and peri-urban areas of the country.
- Facilitate the extension of electricity to rural and peri-urban dwellers.
- Encourage and promote private sector participation in grid and off-grid rural development using the nation's abundant renewable energy sources while ensuring that Government Agencies, Co-operatives and Communities, participate adequately in enhancing electricity service delivery.

Energy Commission of Nigeria
The Energy Commission of Nigeria (ECN) was established in 1988 with the statutory mandate for strategic planning and coordination of national policies in the field of energy. It was established in line with the declaration of the Heads of The Economic Community of West African States in 1982 for the establishment of an Agency in each member state charged with the responsibility of coordinating and supervising all energy functions and activities. The functions of the ECN include, but are not limited to, the following:

- serve as a centre for gathering and dissemination of information relating to national policy in the field of energy;
- inquire into and advise the Government of the Federation or the State on adequate funding of the energy sector including research and development, production and distribution;
- monitor the performance of the Energy sector in the execution of government policies on energy; and
- serve as a centre for providing solutions to inter-related technical problems that may arise in the implementation of any policy relating to the field of energy.

The ECN is headed by a Director General, who also serves as its Chief Executive.

The Nigerian Urban and Regional Planning
The Nigerian Urban and Regional Planning Act No.10 of 2010 was established to:

- promote co-operation and co-ordination among states and local governments in the preparation and implementation of urban and regional plans;
- formulate urban and regional planning standards in Nigeria;
- ensure effective supervision and monitoring of the execution of projects in urban and regional areas; and
- ensure development control over Nigeria.

The specific requirements of the Act pertinent to the proposed Industrial Park project as contained in Part II of the Act are as follows:

Planning Authority Approval

- it is mandatory for a developer to submit a development plan which would be approved by the Development Control Department (department under the commission);
- it is mandatory for a developer (whether private or government) to apply for development permit by using specified forms and providing information such as plans, design drawings and other information as may be prescribed by regulation made pursuant to this section.
- no development shall commence by any Government or its agencies without obtaining an approval from the relevant Development Control Department.
- plan required to be made under this Act shall be prepared by registered Architect of Town Planner or Engineer and shall be in accordance with the provisions of this Act.

Submission of Detailed Environmental Impact Statement

A developer shall at the time of submitting his application for development submit to an appropriate Control Department a detailed environmental impact statement for an application for:

- residential land in excess of 2 hectares; or
- permission to build or expand a factory or for the construction of an office building in excess of four floors or 5,000 square meters of lettable space as in the case of this project;
- permission for a major recreational development.

Validity of Development Permit:

A development permit granted to a developer shall:

- remain valid for the years from date of communication of the plan to the approval of a developments permit to a developer; and
- where a developer fails to commence development within two years the development permit shall be subject to re-validation by the Control Department which issued the original permit.

Acquisition of Land and Compensation

Part IV of the Act requires that where it is necessary to obtain any land in connection with planned urban or development in accordance with the policies and proposals of any approved plan, any right of occupancy subsisting on that land shall be revoked on the recommendation of the appropriate authority. All matters connected with the payment of compensation for the revocation of the right of occupancy under the Act shall be governed in accordance with the relevant provision of the Land Use Act. Any compensation payable as a result of the revocation of the right of occupancy shall be paid within a reasonable period.

In this regard, the land for the proposed utility scale PV-based solar power plant project was acquired by Katsina State Government (KSG) from indigent individuals. These individuals will be compensated by KSG in line with the dictates of Katsina State Land Use Gazette KT. S.L.N.

NO.1. It should be noted that a Resettlement Action Plan is not required on this project since the land was not being used for residential purpose, but primarily for farming.

Landuse Act

The Landuse Act promulgated in 1978 places the ownership, management and control of land in each state of the federation in the Governor. Land is therefore allocated with his authority for commercial, agricultural and other purposes. Since the Landuse Act deals primarily with the acquisition, use and enjoyment of land, in accomplishing these objectives, the activities of an individual, government or organisation either private or public, is likely to create environmental problems. For example, where permission was given for land to be used for mining purpose or for industrial purpose or for a town and country planning purpose or for any other commercial or public work or convenience, environmental problems are surely going to crop up in the and use enjoyment of any of these services or purposes.

Essentially, the Landuse Act is not strictly an Act for environmental protection. However, environmental protection is one of those considerations which a holder of certificate of occupancy has to observe, though it is not explicitly provided for in any of the provisions of the Act. If the Act is read without such importation, the result is bound to be absurd and environmentally unsound.

The Landuse Act of 1978, the Constitution of 1999 and the Public Lands Acquisition Laws of the relevant states constitute the governing policy for land acquisition in Nigeria. As is the case with most national and state laws on compulsory acquisition of land in the public interest or for a public purpose, the legislation enables the State to acquire land (more precisely, to abrogate leases and other authorizations to occupy land). The Acts also specify the procedures the State must follow to clear the land, and define the compensatory measures the State must implement in order to compensate the people affected.

Under the Act, there are two types of land rights

- *Statutory occupancy rights*: Individuals and entities can obtain a statutory right for occupancy of urban and non-urban land. Recipients of certificates of occupancy are obligated to pay the state for any unexhausted improvements (i.e. improvements with continuing value such as a building or irrigation system) on the land at the time the recipient takes possession and must pay rent fixed by the state. Rights are transferrable with the authorization of the state governor.
- *Customary right of occupancy*: Local governments may grant customary rights of occupancy to land in any non-urban area to any person or organisation for agricultural, residential, and other purposes, including grazing and other customary purposes ancillary to agricultural use. The term for customary rights (which is contained in the application form and not the legislation) is 50 years, and may be renewed for a second 50-year term. Recipients of customary rights of occupancy must pay annual tax on the land and cannot transfer any portion of the rights without approval of the governor (for sales of rights) or the local government (other transfers).

The Act vests all land in the urban areas of each state under the control and management of the governor of the state. The governor of the state holds the land in trust for the people of the state and is solely responsible for the allocation of land in all urban areas to individuals who reside in the state and to organisations for residential, agricultural and commercial purposes. All other land in the state subject to conditions under the Act is under the control and management of the local government.

The act divests traditional owners of land and vests such land in the state governor for the benefit and use of all Nigerians. It provides the processes through which land may be acquired by the federal government. On rural land where there are no formal title deeds and any land rights are customarily held, compensation for land acquisition is only provided for buildings, crops and other 'improvements' to the land as well as rent for the year the land was occupied. Payment is not paid for land itself since customary ownership is not recognised by government. For community-owned land where ownership is not claimed by any one individual or family, the governor will determine who receives the compensation. This might be the community or the chief or a community leader who can make use of the money according to customary law. Alternatively, money can be paid into a community fund. The governor has the power to cancel the right that any person has to live on or make use of any piece of land, if the land is required for use in the interest of the public. This includes mining and oil pipelines. Rights to land cease with immediate effect upon receipt of notice from the governor.

National Building Code

The national building code is aimed at setting standards on building pre-design, designs, construction and post-construction stages with a view to ensuring quality, safety and proficiency in the building industry.

The provisions of this code shall, subject to its adoption by the states, apply to and control all matters concerning the design and specification, costing, construction, alteration, addition to, moving, demolition, location, repair and use of any building or structure, for existing or proposed building works within the Federal Republic of Nigeria. The standards specified in this code shall constitute the minimum requirement from which other regulations may be derived.

The Forestry Act

The principal legislation in force for the regulation of the forest sector is the Forestry Act 1958. The Forestry Act CAP 51 LFN of 1994 prohibits any activity that may lead to the destruction of or cause injury to any forest produces, forest growth or forest property. The project area does not fall within any protected or reserved forest.

EIA Procedural Guideline on Infrastructure Projects

The EIA process is the various stages a project undergoes from proposal to approval for implementation, resulting in the issuing of an Environmental Impact Statement (EIS) and certificate. The term encompasses several stages, viz:

- Determining if FEPA environmental laws/regulations have been triggered;
- Screening a project for potential environmental effects;
- Scoping to determine the spatial and temporary dimension of environmental effects;
- Carrying out detailed base line studies to determine the environmental condition prior to project implementation;
- Preparing a detailed assessment report;
- Carrying out a panel review of the EIA report if this is necessary; and
- Obtaining authorization/approval, where appropriate. For FEPA, the Director

General/Chief Executive is the responsible officer. The National Procedural Guidelines show practical steps from project conception to commissioning. The steps are:

- project proposal
- initial environmental examination (IEE)/preliminary assessment
- screening
- scoping
- EIA study
- review
- decision making
- monitoring, and

- Auditing

The Labour Act

The Labour Act (1990) (LA) is the primary law protecting the employment rights of individual workers. The LA covers protection of: wages; contracts; employment terms and conditions; and recruitment. It also classifies workers and special worker types. Union membership is governed by the Trade Union Amendment Act (1995). A 1999 constitution includes stipulation of "equal pay for equal work without discrimination on account of sex, or any other ground whatsoever".

Labour will be sourced from a national, regional and local scale depending on project requirements during the construction and full operation of the Industrial Park. The labour Act will guide all labour engagement in line with this.

Endangered Species Act

Section 1 (*prohibition of hunting of or trading in wild animals*) of the Endangered Species Act 11 of 1985 (amended in 1990 as Act, Cap 108) prohibits the hunting, capture and trade on endangered species such as otter shrew, giant / tree / long-tailed pangolin, colobus monkeys, chimpanzee, gorilla, African palm squirrel, lion, leopard, cheetah, hyenas, immature elephant, giraffe, tortoises, crocodiles, etc being animal species threatened with extinction or otherwise deal with animals species which though not necessarily now threatened with extinction may become so threatened except one is in possession of a license issued under the Act.

The Act also stipulates pertinent permits, certificates and the processes for trading of the identified endangered species as well as prescribes penalties for contraventions.

Harmful Waste Act

The Harmful Waste (Special Criminal Provisions) Act Cap H1, LFN 2004 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.

Penal Code

The Criminal Code Act1 is currently a legislation of general application penalizing criminal acts in Southern Nigeria while the Penal Code Act applies in the North. The Penal Code is an Act to supplement the Penal Code of the Northern States in respect of matters within the exclusive legislative competence of the National Assembly, and for purposes ancillary thereto.

In this Act, unless the context otherwise requires, **"**Northern States" means the States of Nigeria formerly known as Northern Region of Nigeria. Every person shall be liable to punishment under the provisions of section 3 of this Act and of the Schedule to this Act for every act or omission contrary to the provisions of the Schedule to this Act of which he is guilty within the Northern States:

The provisions contained in the Schedule to this Act applies in respect of the Northern States and shall be read as the law of that territory and as such form part of the Penal Code contained in the Schedule to the Penal Code Law, 1959, of the Northern States (referred to as the Penal Code of the Northern States).

The provisions of Chapter I to Chapter VI of the Penal Code of the Northern States, applies in respect of the provisions of the Schedule to this Act as fully as though the provisions of such Chapters were enacted in this Act.

Katsina State Ministry of Environment

The Katsina State Ministry of Environment has as its main focus to ensure sustainable development based on pragmatic management of the environment within the State. This demands positive and realistic planning that balances human needs against the bearing capacity of the environment. This requires that every citizen, operating company, organisation or institution shall ensure that:

- The health, the safety, the environment, the well being of citizens of Katsina State communities and the neighbours are integrated into major economic decision-making process of development projects.
- Environmental controls are built into major development projects.
- Environment friendly technologies are applied for health, safety of the Katsina State environment.

Katsina State Environmental Protection Agency (KSEPA) Edict 1988

The edict states the functions of agency which are to:

- Liaise routinely and ensure effective harmonisation with the FMENV in order to achieve the objectives of the National policy on environment;
- Co-ordinate the activities of ministries, parastatals, local government councils, departments, statutory bodies and research organisations on matters relating to environmental protection and conservation;
- Identify the ecological problems of the State including the devastating erosion and flood, brief the government on their sources and effects and find solutions to them;
- Monitor and determine degradations of coastlines, river basins and estuaries and carryout measures to protect and remedy their ecosystems;
- Identify water, air and soil pollution and their sources and carryout measures to prevent them;
- Monitor the implementation of the EIA and environmental audit report guidelines and procedures on all policies and projects within the State; and
- Carry out other activities as are necessary or expedient for the protection and sustainable development of the environment and for the full discharge of functions of the agency.

Katsina State Land Use Gazette KT. S.L.N. NO.1, 2015

The gazette discusses revised statutory land compensation rates payable for farmlands and economic trees as it relates to Katsina State. It stipulates the compensation rates for:

- Farmland per hectare in:
    - Katsina State Capital city (Katsina).
    - Local Government Headquarters of the state.
    - All rural areas (villages); and
    - Fadama Areas.
- Economic trees per piece.

1.7.3 International Conventions, Agreements, and Protocols

In addition to the national laws/regulations, Nigeria is signatory to several international conventions and treaties relating to industry, development and environmental management. In certain cases conventions and agreements have influenced policy, guidelines and regulations and must be complied with during the planning, construction and operation of the Project. Many of these conventions support the use of environmental studies as key tools for achieving pollution control, sustainable environmental development, and preservation of habitats of global significance. Some of the more pertinent of these are presented in the table below and briefly described subsequently.

Table 1.2: International Conventions Relating To Industry and Environment

Date of Ratification by Nigeria	Name of Convention	Objective of convention
1994	United Nations (UN) Convention on Biological Diversity *(1992)*	• Conservation of biological diversity, • The sustainable use of its components, and • The fair and equitable sharing of benefits arising out of the utilization
1994	Framework Convention on Climate Change *(1992)*	• Stabilisation of greenhouse gas concentrations in the atmosphere at safe level
1991	United Nations Educations, Scientific and Cultural Organisation (UNESCO) World Heritage Convention *(1972)*	• Sets aside areas of cultural and natural heritage for protection • Defines the areas as those with outstanding universal value from the aesthetic, scientific and conservation points of view.
1988	Convention on the Conservation of Migratory Species of Wild Animals *(1979)*	• Promotion of measures for the conservation (including habitat conservation especially for endangered species listed in Bonn) and management of migratory species.
1987	Montreal Protocol on Substances that Deplete the Ozone Layer	• To protect the ozone layer through enhanced international cooperation by taking precautionary measures to control equitably total global emissions of substances that deplete it.
1968	African Convention on Conservation of Nature and Natural Resources *(1968)*	• Adopt the measures necessary to ensure conservation, utilization and development of soil, water, flora and faunal resources in accordance with scientific principles and with due regard to the best interests of the people.

1.7.4 International Best Practice Guidelines and Standards

The following international requirements and standards have been considered within the ESIA process and are described below:

- Equator principles (EP)
- World Bank's environmental and social safeguard policies.
- IFC Performance Standards on Environmental and Social Sustainability
- United Nations Guiding Principles on the Human Environment
- The Rio Declaration on Environment and Development
- World Bank Group General Environmental, Health and Safety Guidelines (EHS)

Equator Principles 2013

Large infrastructure and industrial Projects can have adverse impacts on people and on the environment. As financiers and advisors, we work in partnership with our clients to identify, assess and manage environmental and social risks and impacts in a structured way, on an ongoing basis. Such collaboration promotes sustainable environmental and social performance and can lead to improved financial, environmental and social outcomes.

The Equator Principles Financial Institutions (EPFIs) adopted the Equator Principles in order to ensure that the Projects they finance and advise on are developed in a manner that is socially responsible and reflects sound environmental management practices. They recognise the importance of climate change, biodiversity, and human rights, and believe negative impacts on project-affected ecosystems, communities, and the climate should be avoided where possible. If these impacts are unavoidable they should be minimised, mitigated, and/or offset.

The Equator Principles are aimed to ensure that prior to agreeing to provide financing, (a) a project has been subject to an appropriate level of environmental and social assessment in accordance with the requirements of the IFC Performance Standards (2006) and (b) that the project will implement appropriate measures for the management of environmental, social and health issues during construction, operation and decommissioning phases. By adopting the Equator Principles, financial institutions undertake to review carefully proposals for which their customers request project financing. They commit not to provide loans to projects where the borrower will not, or is unable to, comply with the requirements of the IFC Performance Standards. Equator principles are tabulated below.

Table 1.3: Equator Principles

Principle 1	Categorisation of projects
Principle 2	The borrower has to conduct an Environmental and Social Impact Assessment (ESIA)
Principle 3	Applicable Social and Environmental Standards
Principle 4	Action Plan and Management System
Principle 5	Consultation and Disclosure
Principle 6	Grievance Mechanism
Principle 7	Independent Review
Principle 8	Covenants
Principle 9	Independent Monitoring and Reporting
Principle 10	Reporting and transparency

The Equator Principles set out the process for assessing a project in four key phases: Impacts are assessed on their degree of potential impact and are categorised as either A (High), B (Medium) or C (Low).

- **Category A**- Projects with potential significant adverse social or environmental impacts that are diverse, irreversible or unprecedented;
- **Category B-** Projects with potential limited adverse social and environmental impacts that are few in number, generally site-specific, largely reversible and readily addressed through mitigation measures; and
- **Category C**- Projects with minimal or no social or environmental impacts.

The Equator Principles are intended to serve as a common baseline and framework. EPFIs are committed to implementing the Equator Principles in their internal environmental and social policies, procedures and standards for financing Projects. Project Finance or Project-Related Corporate Loans shall not be provided to Projects where the client will not, or is unable to, comply with the Equator Principles. As Bridge Loans and Project Finance Advisory Services are provided earlier in the Project timeline, it is requested that the client explicitly communicates their intention to comply with the Equator Principles.

World Bank's Environmental and Social Safeguard Policies

The World Bank's environmental and social safeguard policies are a cornerstone of its support for programmes aimed at sustainable poverty reduction. The objective of these policies is to prevent and mitigate undue harm to people and their environment in the development process. These policies provide guidelines for lenders (including banks) and borrower staff in the identification, preparation, and implementation of programmes and projects. Safeguard policies have often provided a platform for the participation of stakeholders in the project design, and have been an important instrument for building a sense of project "ownership" among local populations. There are a total of ten environmental, social and legal Safeguard Policies of the World Bank, of which the seven most relevant are listed in **Table 1.4** below.

Table 1.4: World Bank Safeguard Policies and Guidelines

World Bank OP 4.01 for Environmental Assessment
World Bank OP 4.04 for Natural Habitats
World Bank OD 4.10 for Indigenous People
World Bank OPN 4.11 for Physical Cultural Resources
World Bank EA Sourcebook Update No 4: Sectoral EA (October 1993)
World Bank EA Sourcebook Update No 25: EMPs (January 1999)

The following policies are likely to be triggered by the utility-scale PV-based solar power plant project activities:

OP 4.01 – Environmental Assessment
Environmental Assessment is used in the World Bank to identify, avoid and mitigate the potential negative environmental impacts associated with the Bank's lending and guarantee operations. In World Bank operations, the purpose of Environmental Assessment is to improve decision making in order to ensure that project options under consideration are sound and sustainable and that potentially affected people have been properly consulted.

OP 4.01 – Environmental Assessment contains guidance on the World Bank requirements on various aspects of the EIA process. These include guidance on the categorisation of projects during Project screening, provisions for sector investing and financial intermediaries, exemptions for emergency situations, requirements for institutional capacity and requirements for public consultation and disclosure. According to the World Bank OP 4.01, the proposed project is likely to be classified as a Category A project. Projects under this Category are likely to have significant adverse environmental impacts that are considered sensitive, diverse, or unprecedented and which may affect an area beyond the site or facilities. An EIA for a Category A project is required to identify and assess potential negative and positive environmental and social impacts, compare these with those of feasible alternatives (including the no project alternative), and recommend mitigation measures to reduce negative impacts and enhance benefits. The EIA process and this EIA report have been conducted and prepared in line with OP 4.01.

OP 4.12 – Physical Cultural Resources
The World Bank recognises physical cultural resources (PCR) as valuable scientific and historical assets and an integral part of a people's cultural identity and practices. Thus development projects that are likely to have an impact on PCR must work to avoid or mitigate adverse impacts. In the event that PCR are impacted by project activities the developer is required to adhere to Nigerian legislation and, World Bank or any other international obligations. The following steps, which are integrated into the ESIA process, will take account of the PCR in the area of interest:

- screening, developing a terms of reference (TOR),
- collecting baseline data,
- impact assessment and
- Formulating mitigating measures and a management plan.

If the Project is identified to have adverse impacts on PCR, the proponent must identify appropriate measures for avoiding or mitigating these impacts as part of the EIA. These measures may range from full site protection to selective mitigation, including salvage and documentation, in cases where a portion or all of the physical cultural resources may be lost. The proponent is also required to develop a PCR management plan. In addition, OP4.12 requires the proponent to engage with project-affected groups, concerned government authorities, and relevant non-governmental organisations to document the presence and significance of PCR, assess potential impacts, and explore avoidance and mitigation options. The findings of the physical cultural resources component of the EIA are disclosed as part of, and in the same manner as, the EIA report.

World Bank's Environmental and Social Safeguard Policies

The World Bank's environmental and social safeguard policies are a cornerstone of its support to sustainable poverty reduction. The key objective of these policies is to prevent and mitigate undue harm to people and their environment in the development process. These are achieved through:

- supporting the integration of environmental and social aspects of projects into the decision making process;
- providing mechanism for addressing environmental and social issues in program and project design, implementation and operation;
- identifying and managing impacts and risks;
- providing framework for consultation and disclosure; and
- supporting development effectiveness – increase results on the ground both short and long term.

The World Bank Safeguard policies are mechanisms for integration of environmental and social issues into decision-making. They:

- provide a set of specialised tools to support development processes;
- support participatory approaches and transparency; and
- apply to all investments financed by the World Bank.

There are eleven (11) safeguard policies and they are:

- Environmental Assessment;
- Natural Habitats;
- Forestry;
- Pest Management;
- Physical Cultural Resources;
- Indigenous Peoples;
- Involuntary Resettlement;
- Safety of Dams;
- International Waterways;
- Disputed Areas; and
- Disclosure Policy.

It is should be noted that though the land for the proposed utility scale PV-based solar power plant was acquired from private indigent individuals by Katsina State Government (KSG), the land was being used primarily for agricultural purposes (and not residential). Thus, involuntary resettlement is not required.

Amongst the safeguard policies, the relevant ones that have been reviewed with potential of being triggered in the course of NSF PV-based solar powered plant project are listed below and discussed further.

Triggered Environmental and Social Safeguard Policies
Environmental Assessment (OP) 4.01
Natural Habitats (OP) 4.04
Forestry (OP) 4.36
Indigenous Peoples (OP) 4.10
Disclosure Policy

Environmental Assessment (OP) 4.01

The objective of this policy is to ensure that Bank-financed projects are environmentally sound and sustainable, and that decision-making is improved through appropriate analysis of actions and of their likely environmental impacts. This policy is triggered if a project is likely to have potential (adverse) environmental risks and impacts on its area of influence. OP 4.01 covers impacts on the natural environment (air, water and land); human health and safety; physical cultural resources; and trans-boundary and global environment concerns.

In line with this policy, NSF has carried out a category A ESIA. The ESIA process seeks to address the following OP 4.01 objectives:

- Ensure that projects proposed for Bank financing such as this project is environmentally and socially sound and sustainable;
- Inform decision makers of the nature of environmental and social risks;
- Increase transparency and participation of decision makers and other stakeholders in the decision-making process.

This report documents the ESIA study carried out for the NSF 125MWp PV-based solar Power Plant. An ESIA has been conducted because the proposed project would likely have potential (adverse) environmental risks and impacts on its immediate environment as well as the area of influence.

Natural Habitats (OP) 4.04

This policy recognizes that the conservation of natural habitats is essential to safeguard their unique biodiversity and to maintain environmental services and products for human society and for long-term sustainable development. The Bank therefore supports the protection, management, and restoration of natural habitats in its project financing, as well as policy dialogue and economic and sector work. The Bank supports, and expects borrowers to apply, a precautionary approach to natural resource management to ensure opportunities for environmentally sustainable development.

Specifically, the policy prohibits Bank support for projects which would lead to the significant loss or degradation of any Critical Natural Habitats, whose definition includes those natural habitats which are either:

- Legally protected,
- Officially proposed for protection, or
- Un-protected but of known high conservation value.
-

This project impacts assessment postulates conversion/ loss of natural habitats but only limited to footprint of proposed plant. Potential impacts on habitat are identified, mitigation measures put in place shall be given critical consideration in the Environmental Social Management Plan (ESMP) to reduce the adverse effects of habitat loss.

Forestry (OP) 4.36
The objective of this policy is to assist borrowers to harness the potential of forests to reduce poverty in a sustainable manner, integrate forests effectively into sustainable economic development and protect the vital local and global environmental services and values of forests. Where forest restoration and plantation development are necessary to meet these objectives, the Bank assists borrowers with forest restoration activities that maintain or enhance biodiversity and ecosystem functionality. The Bank assists borrowers with the establishment of environmentally appropriate, socially beneficial and economically viable forest plantations to help meet growing demands for forest goods and services.

This policy is triggered whenever any Bank-financed investment project:

- Has the potential to have impact on the health and quality of forests or the rights and welfare of people and their level of dependence upon or interaction with forests; or
- Aims to bring about changes in the management, protection or utilization of natural forests or plantations.

The area within which the proposed NSF project will be sited shall require removal of some rainforest vegetation. However, vegetation removal shall be limited to areas required for construction only (i.e. 60% of total acquired land). Mitigation measures would be developed to ensure impact to forest area is controlled. Also to be considered would be creation of green zones within and around the facility.

Indigenous Peoples (OP) 4.10
The objective of this policy is to:

1. Ensure that indigenous members provide advice and input on the design of proposed projects that affect their lives and environment;
2. Promotes dialogue between governments, communities, NGOs and implementing agencies.
3. Ensure that adverse effects during the development process are avoided, or if not feasible, ensure that these are minimised, mitigated or compensated; and
4. Should continue during implementation.

In line with bullet point 3 above, the land acquired for the utility scale NSF PV-based solar power plant project belonged to indigenous people of Kankiya. It was used primarily for farming purposes (not residential).

The World Bank policy on indigenous peoples underscores the need for borrowers and bank staff to identify indigenous peoples, consult with them, ensure that they participate in, and benefit from bank-funded operations in a culturally appropriate way, and that adverse impacts on them are avoided, or where not feasible, minimised or mitigated.

Consultation with indigenous people in the study area has commenced and it’s ongoing to ensure that they are aware of the project and familiar with its prospects and aspects. Socio-economic engagement meeting was carried out for the host community (Kankiya), evidences are shown in chapter four, section 4.11.5.

Disclosure
A number of public forums have so far been organised by NSF to disclose proposed project to stakeholders. This is to ensure active participation of stakeholders and as a feedback mechanism. Activities concerned with the project, impacts associated, benefits of the project as well as proposed mitigation for the project formed the basis of such forums. Public forum organised include:

- 21 days draft ESIA report public display at centers in Kankiya, and Katsina (both in Katsina State) as well centers in Abuja (the Capital of Nigeria); and
- Stakeholders and expert review workshop in Kankiya, Katsina State, Nigeria.

Stakeholder that participated include: regulators (FMEnv and DSMENV), representatives of Minister of Environment, Commissioner of Environment, Katsina State, Kankiya LGA Chairman, host community (Kankiya), and Power Holding
Company of Nigeria (PHCN), Kankiya. Details of public disclosure for the ESIA are presented in **Chapter four** of this report.

IFC Performance Standards on Environmental and Social Sustainability
These standards took effect from January 2012. IFC's Sustainability Framework articulates the Corporation's strategic commitment to sustainable development, and is an integral part of IFC's approach to risk management. The Sustainability Framework comprises IFC's Policy and Performance Standards on Environmental and Social Sustainability, and IFC's Access to Information Policy.

The Performance Standards are directed towards clients, providing guidance on how to identify risks and impacts, and are designed to help avoid, mitigate, and manage risks and impacts as a way of doing business in a sustainable way, including stakeholder engagement and disclosure obligations of the client in relation to project-level activities. Together, the eight Performance Standards establish standards that the client is to meet throughout the life of an investment by IFC. These standards comprise:

Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts;
This standard establishes the importance of (i) integrated assessment to identify the environmental and social impacts, risks, and opportunities of projects; (ii) effective community engagement through disclosure of project-related information and consultation with local communities on matters that directly affect them; and (iii) the client's management of environmental and social performance throughout the life of the project.

This standard applies to all projects that have environmental and social risks and impacts. Depending on project circumstances, other Performance Standards may apply as well. The Performance Standards should be read together and cross-referenced as needed. The requirements section of each Performance Standard applies to all activities financed under the project, unless otherwise noted in the specific limitations described in each paragraph. Clients are encouraged to apply the ESMS developed under Performance Standard 1 to all their project activities, regardless of financing source. A number of cross-cutting topics such as climate change, gender, human rights, and water, are addressed across multiple Performance Standards.

Performance Standards 2 through 8 describe potential environmental and social risks and impacts that require particular attention. Where environmental or social risks and impacts are identified, the client is required to manage them through its Environmental and Social Management System (ESMS) consistent with Performance Standard 1.

Performance Standard 2: Labor and Working Conditions;
This standard recognizes that the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental1 rights of workers. For any business, the workforce is a valuable asset, and a sound worker-management relationship is a key ingredient in the sustainability of a company. Failure to establish and foster

a sound worker-management relationship can undermine worker commitment and retention, and can jeopardize a project. Conversely, through a constructive worker-management relationship, and by treating the workers fairly and providing them with safe and healthy working conditions, NOVA Power may create tangible benefits, such as enhancement of the efficiency and productivity of its operations when due.

The requirements set out in this Performance Standard have been in part guided by a number of international conventions and instruments, including those of the International Labour Organisation (ILO) and the United Nations (UN). The objectives of this performance standard are:

- To promote the fair treatment, non-discrimination, and equal opportunity of workers.
- To establish, maintain, and improve the worker-management relationship.
- To promote compliance with national employment and labor laws.
- To protect workers, including vulnerable categories of workers such as children, migrant workers, workers engaged by third parties, and workers in the client’s supply chain.
- To promote safe and healthy working conditions, and the health of workers.
- To avoid the use of forced labor.

The scope of application of this Performance Standard depends on the type of employment relationship between the client and the worker. It applies to workers directly engaged by the client (direct workers), workers engaged through third parties to perform work related to core business processes of the project for a substantial duration (contracted workers), as well as workers engaged by the client’s primary suppliers (supply chain workers).

Performance Standard 3: Resource Efficiency and Pollution Prevention;
This standard recognizes that increased economic activity and urbanization often generate increased levels of pollution to air, water, and land, and consume finite resources in a manner that may threaten people and the environment at the local, regional, and global levels.1 There is also a growing global consensus that the current and projected atmospheric concentration of greenhouse gases (GHG) threatens the public health and welfare of current and future generations. At the same time, more efficient and effective resource use and pollution prevention2 and GHG emission avoidance and mitigation technologies and practices have become more accessible and achievable in virtually all parts of the world. These are often implemented through continuous improvement methodologies similar to those used to enhance quality or productivity, which are generally well known to most industrial, agricultural, and service sector companies.

This Performance Standard outlines a project-level approach to resource efficiency and pollution prevention and control in line with internationally disseminated technologies and practices. In addition, this Performance Standard promotes the ability of private sector companies to adopt such technologies and practices as far as their use is feasible in the context of a project that relies on commercially available skills and resources. The objectives of this standard are:

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

The applicability of this Performance Standard is established during the environmental and social risks and impacts identification process. The implementation of the actions necessary to meet the requirements of this Performance Standard is managed through the client’s Environmental and Social Management System, the elements of which are outlined in Performance Standard 1.

During the project life-cycle, the client will consider ambient conditions and apply technically and financially feasible resource efficiency and pollution prevention principles and techniques that are best suited to avoid, or where avoidance is not possible, minimize adverse impacts on human health and the environment.3. The principles and techniques applied during the project life-cycle will be.

Performance Standard 4: Community Health, Safety, and Security;
Performance Standard 4 recognizes that project activities, equipment, and infrastructure can increase community exposure to risks and impacts. In addition, communities that are already subjected to impacts from climate change may also experience an acceleration and/or intensification of impacts due to project activities. While acknowledging the public authorities' role in promoting the health, safety, and security of the public, this Performance Standard addresses the client's responsibility to avoid or minimize the risks and impacts to community health, safety, and security that may arise from project related-activities, with particular attention to vulnerable groups.

In conflict and post-conflict areas, the level of risks and impacts described in this Performance Standard may be greater. The risks that a project could exacerbate an already sensitive local situation and stress scarce local resources should not be overlooked as it may lead to further conflict. The objectives are:

- To anticipate and avoid adverse impacts on the health and safety of the Affected Community during the project life from both routine and non-routine circumstances.
- To ensure that the safeguarding of personnel and property is carried out in accordance with relevant human rights principles and in a manner that avoids or minimizes risks to the Affected Communities.

The applicability of this Performance Standard is established during the environmental and social risks and impacts identification process. The implementation of the actions necessary to meet the requirements of this Performance Standard is managed through the client's Environmental and Social Management System, the elements of which are outlined in Performance Standard 1.

This Performance Standard addresses potential risks and impacts to the Affected Communities from project activities. Occupational health and safety requirements for workers are included in Performance Standard, and environmental standards to avoid or minimize impacts on human health and the environment due to pollution are included in Performance Standard.

The requirements are that the client will evaluate the risks and impacts to the health and safety of the Affected Communities during the project life-cycle and will establish preventive and control measures consistent with good international industry practice (GIIP), such as in the World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines) or other internationally recognized sources. The client will identify risks and impacts and propose mitigation measures that are commensurate with their nature and magnitude. These measures will favor the avoidance of risks and impacts over minimization.

Performance Standard 5: Land Acquisition and Involuntary Resettlement 31
This performance standard recognizes that project-related land acquisition and restrictions on land use can have adverse impacts on communities and persons that use this land. Involuntary resettlement refers both to physical displacement (relocation or loss of shelter) and to economic displacement (loss of assets or access to assets that leads to loss of income sources or other means of livelihood) as a result of project-related land acquisition and/or restrictions on land use. Resettlement is considered involuntary when affected persons or communities do not have the right to refuse land acquisition or restrictions on land use that result in physical or economic

displacement. This occurs in cases of (i) lawful expropriation or temporary or permanent restrictions on land use and (ii) negotiated settlements in which the buyer can resort to expropriation or impose legal restrictions on land use if negotiations with the seller fail.

Unless properly managed, involuntary resettlement may result in long-term hardship and impoverishment for the Affected Communities and persons, as well as environmental damage and adverse socio-economic impacts in areas to which they have been displaced. For these reasons, involuntary resettlement should be avoided. However, where involuntary resettlement is unavoidable, it should be minimized and appropriate measures to mitigate adverse impacts on displaced persons and host communities should be carefully planned and implemented. The government often plays a central role in the land acquisition and resettlement process, including the determination of compensation, and is therefore an important third party in many situations. Experience demonstrates that the direct involvement of the client in resettlement activities can result in more cost-effective, efficient, and timely implementation of those activities, as well as in the introduction of innovative approaches to improving the livelihoods of those affected by resettlement.

To help avoid expropriation and eliminate the need to use governmental authority to enforce relocation, clients are encouraged to use negotiated settlements meeting the requirements of this Performance Standard, even if they have the legal means to acquire land without the seller's consent. The objectives are:

- To avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs.
- To avoid forced eviction.
- To anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use by (i) providing compensation for loss of assets at replacement cost4 and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected.
- To improve, or restore, the livelihoods and standards of living of displaced persons.
- To improve living conditions among physically displaced persons through the provision of adequate housing with security of tenure at resettlement sites.

The applicability of this Performance Standard is established during the environmental and social risks and impacts identification process. The implementation of the actions necessary to meet the requirements of this Performance Standard is managed through the client's Environmental and Social Management System, the elements of which are outlined in Performance Standard 1.

This Performance Standard applies to physical and/or economic displacement resulting from the following types of land-related transactions:

- Land rights or land use rights acquired through expropriation or other compulsory procedures in accordance with the legal system of the host country;
- Land rights or land use rights acquired through negotiated settlements with property owners or those with legal rights to the land if failure to reach settlement would have resulted in expropriation or other compulsory procedures;
- Project situations where involuntary restrictions on land use and access to natural resources cause a community or groups within a community to lose access to resource usage where they have traditional or recognizable usage rights;
- Certain project situations requiring evictions of people occupying land without formal, traditional, or recognizable usage rights; or

- Restriction on access to land or use of other resources including communal property and natural resources such as marine and aquatic resources, timber and non-timber forest products, freshwater, medicinal plants, hunting and gathering grounds and grazing and cropping areas.

This Performance Standard does not apply to resettlement resulting from voluntary land transactions (i.e., market transactions in which the seller is not obliged to sell and the buyer cannot resort to expropriation or other compulsory procedures sanctioned by the legal system of the host country if negotiations fail). It also does not apply to impacts on livelihoods where the project is not changing the land use of the affected groups or communities.

Where project impacts on land, assets, or access to assets become significantly adverse at any stage of the project, the client should consider applying requirements of this Performance Standard, even where no land acquisition or land use restriction is involved. In the case of this project, evaluation of the land, economic trees, cash crops and structures has been done but the compensation is yet to be paid for the land.

Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
Performance Standard 6 recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development. The requirements set out in this Performance Standard have been guided by the Convention on Biological Diversity, which defines biodiversity as “the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and of ecosystems.”

Ecosystem services are the benefits that people, including businesses, derive from ecosystems. Ecosystem services are organized into four types: (i) provisioning services, which are the products people obtain from ecosystems; (ii) regulating services, which are the benefits people obtain from the regulation of ecosystem processes; (iii) cultural services, which are the nonmaterial benefits people obtain from ecosystems; and (iv) supporting services, which are the natural processes that maintain the other services.1.

Ecosystem services valued by humans are often underpinned by biodiversity. Impacts on biodiversity can therefore often adversely affect the delivery of ecosystem services. This Performance Standard addresses how clients can sustainably manage and mitigate impacts on biodiversity and ecosystem services throughout the project’s lifecycle.
- To protect and conserve biodiversity.
- To maintain the benefits from ecosystem services.
- To promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.

The applicability of this Performance Standard is established during the environmental and social risks and impacts identification process. The implementation of the actions necessary to meet the requirements of this Performance Standard is managed through the client’s Environmental and Social Management System (ESMS), the elements of which are outlined in Performance Standard 1.

Based on the risks and impacts identification process, the requirements of this Performance Standard are applied to projects (i) located in modified, natural, and critical habitats; (ii) that potentially impact on or are dependent on ecosystem services over which the client has direct management control or significant influence; or (iii) that include the production of living natural resources (e.g., agriculture, animal husbandry, fisheries, forestry).

The risks and impacts identification process as set out in Performance Standard 1 should consider direct and indirect project-related impacts on biodiversity and ecosystem services and identify any significant residual impacts. This process will consider relevant threats to biodiversity and ecosystem services, especially focusing on habitat loss, degradation and fragmentation, invasive alien species, overexploitation, hydrological changes, nutrient loading, and pollution. It will also take into account the differing values attached to biodiversity and ecosystem services by Affected Communities and, where appropriate, other stakeholders. Where paragraphs 13–19 are applicable, the client should consider project-related impacts across the potentially affected landscape or seascape.

As a matter of priority, the client should seek to avoid impacts on biodiversity and ecosystem services. When avoidance of impacts is not possible, measures to minimize impacts and restore biodiversity and ecosystem services should be implemented. Given the complexity in predicting project impacts on biodiversity and ecosystem services over the long term, the client should adopt a practice of adaptive management in which the implementation of mitigation and management measures are responsive to changing conditions and the results of monitoring throughout the project's lifecycle.

Where paragraphs 13 – 15 are applicable, the client will retain competent professionals to assist in conducting the risks and impacts identification process. Where paragraphs 16–19 are applicable, the client should retain external experts with appropriate regional experience to assist in the development of a mitigation hierarchy that complies with this Performance Standard and to verify the implementation of those measures.

Performance Standard 7: Indigenous Peoples:
This standard recognizes that Indigenous Peoples, as social groups with identities that are distinct from mainstream groups in national societies, are often among the most marginalized and vulnerable segments of the population. In many cases, their economic, social, and legal status limits their capacity to defend their rights to, and interests in, lands and natural and cultural resources, and may restrict their ability to participate in and benefit from development. Indigenous Peoples are particularly vulnerable if their lands and resources are transformed, encroached upon, or significantly degraded. Their languages, cultures, religions, spiritual beliefs, and institutions may also come under threat. As a consequence, Indigenous Peoples may be more vulnerable to the adverse impacts associated with project development than non-indigenous communities. This vulnerability may include loss of identity, culture, and natural resource-based livelihoods, as well as exposure to impoverishment and diseases.

Private sector projects can create opportunities for Indigenous Peoples to participate in, and benefit from project-related activities that may help them fulfill their aspiration for economic and social development. Furthermore, Indigenous Peoples may play a role in sustainable development by promoting and managing activities and enterprises as partners in development. Government often plays a central role in the management of Indigenous Peoples' issues, and clients should collaborate with the responsible authorities in managing the risks and impacts of their activities.1. The objectives are:

- To ensure that the development process fosters full respect for the human rights, dignity, aspirations, culture, and natural resource-based livelihoods of Indigenous Peoples.
- To anticipate and avoid adverse impacts of projects on communities of Indigenous Peoples, or when avoidance is not possible, to minimize and/or compensate for such impacts.
- To promote sustainable development benefits and opportunities for Indigenous Peoples in a culturally appropriate manner.

- To establish and maintain an ongoing relationship based on Informed Consultation and Participation (ICP) with the Indigenous Peoples affected by a project throughout the project's life-cycle.
- To ensure the Free, Prior, and Informed Consent (FPIC) of the Affected Communities of Indigenous Peoples when the circumstances described in this Performance Standard are present.
- To respect and preserve the culture, knowledge, and practices of Indigenous Peoples.

The applicability of this Performance Standard is established during the environmental and social risks and impacts identification process. The implementation of the actions necessary to meet the requirements of this Performance Standard is managed through the client's Environmental and Social Management System, the elements of which are outlined in Performance Standard 1.

There is no universally accepted definition of "Indigenous Peoples." Indigenous Peoples may be referred to in different countries by such terms as "Indigenous ethnic minorities," "aboriginals," "hill tribes," "minority nationalities," "scheduled tribes," "first nations," or "tribal groups."

In this Performance Standard, the term "Indigenous Peoples" is used in a generic sense to refer to a distinct social and cultural group possessing the following characteristics in varying degrees:

- Self-identification as members of a distinct indigenous cultural group and recognition of this identity by others;
- Collective attachment to geographically distinct habitats or ancestral territories in the project area and to the natural resources in these habitats and territories;
- Customary cultural, economic, social, or political institutions that are separate from those of the mainstream society or culture; or
- A distinct language or dialect, often different from the official language or languages of the country or region in which they reside.

This Performance Standard applies to communities or groups of Indigenous Peoples who maintain a collective attachment, i.e., whose identity as a group or community is linked, to distinct habitats or ancestral territories and the natural resources therein. It may also apply to communities or groups that have lost collective attachment to distinct habitats or ancestral territories in the project area, occurring within the concerned group members' lifetime, because of forced severance, conflict, government resettlement programs, dispossession of their lands, natural disasters, or incorporation of such territories into an urban area.

The client may be required to seek inputs from competent professionals to ascertain whether a particular group is considered as Indigenous Peoples for the purpose of this Performance Standard.

Performance Standard 8: *Cultural Heritage.*

This standard recognizes the importance of cultural heritage for current and future generations. Consistent with the Convention Concerning the Protection of the World Cultural and Natural Heritage, this Performance Standard aims to ensure that clients protect cultural heritage in the course of their project activities. In addition, the requirements of this Performance Standard on a project's use of cultural heritage are based in part on standards set by the Convention on Biological Diversity. The objectives are:

- To protect cultural heritage from the adverse impacts of project activities and support its preservation.
- To promote the equitable sharing of benefits from the use of cultural heritage.

The applicability of this Performance Standard is established during the environmental and social risks and impacts identification process. The implementation of the actions necessary to meet the requirements of this Performance Standard is managed through the client's Environmental and Social Management System (ESMS), the elements of which are outlined in Performance Standard 1. During the project life-cycle, the client will consider potential project impacts to cultural heritage and will apply the provisions of this Performance Standard.
For the purposes of this Performance Standard, cultural heritage refers to (i) tangible forms of cultural heritage, such as tangible moveable or immovable objects, property, sites, structures, or groups of structures, having archaeological (prehistoric), paleontological, historical, cultural, artistic, and religious values; (ii) unique natural features or tangible objects that embody cultural values, such as sacred groves, rocks, lakes, and waterfalls; and (iii) certain instances of intangible forms of culture that are proposed to be used for commercial purposes, such as cultural knowledge, innovations, and practices of communities embodying traditional lifestyles.

Requirements with respect to tangible forms of cultural heritage are contained in paragraphs 6–16. For requirements with respect to specific instances of intangible forms of cultural heritage described in paragraph 3 (iii) see paragraph 16.

The requirements of this Performance Standard apply to cultural heritage regardless of whether or not it has been legally protected or previously disturbed. The requirements of this Performance Standard do not apply to cultural heritage of Indigenous Peoples; Performance Standard 7 describes those requirements.

IFC World Bank Group Environmental, Health and Safety (EHS) Guidelines
The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards.

The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, based on environmental assessments and/or environmental audits as appropriate, with an appropriate timetable for achieving them. Applicable EHS guidelines to the NSF Power Plant project are presented as follows.

IFC -EHS Guideline on Water Conservation
Water conservation programs should be implemented commensurate with the magnitude and cost of water use. These programs should promote the continuous reduction in water consumption and achieve savings in the water pumping, treatment and disposal costs. Water conservation measures may include water monitoring/management techniques; reuse, sanitary water conservation techniques, and other techniques.

IFC -EHS Guideline on Occupational Health and Safety
Employers and supervisors are obliged to implement all reasonable precautions to protect the health and safety of workers. This guideline provides guidance and examples of reasonable precautions to implement in managing principal risks to occupational health and safety. Although the focus is on the operational phase of projects, much of the guidance also applies to construction and decommissioning activities. Companies should hire contractors that have the technical capability to manage the occupational health and safety issues of their employees, extending the application of the hazard management activities through formal procurement agreements

Others are:

- IFC -Air Emissions and Ambient Air Quality Guidelines;
- IFC -Noise Management Guideline
- IFC -Construction and Decommission Guideline;
- IFC- Hazardous Materials Management Guideline;
- IFC -Waste Management Guideline; and
- IFC -Wastewater and Ambient Water Quality Management Guideline.

United Nations Guiding Principles on the Human Environment

The United Nations (UN), concerned about negative environmental trends since its formation, published two major concept documents: Guiding Principles on the Human Environment, 1972 and the Rio Declaration on Environment and Development.

Ten of these Guiding Principles were defined as formal declarations that express the basis on which an environmental policy can be built and which provide a foundation for action. The principles relevant to the proposed project are summarised as follows.

<u>Principle Two</u>

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

<u>Principle Four</u>

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

<u>Principle Six</u>

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

The Rio Declaration on Environment and Development

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

<u>Principle Ten</u>

Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes.

States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

Principle Thirteen
States shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.

Principle Seventeen
Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

World Heritage Convention
The World Heritage Convention (1978) seeks to set aside areas of cultural and natural heritage, the latter defined as areas with outstanding universal value from the aesthetic, scientific and conservation points of view.

Other Relevant International Conventions
Other conventions, (classified according to their applicability to waste management, marine and biodiversity protections), relevant to the proposed project and to which Nigeria is signatory, but for which enabling legislation may not be in place in all cases, include:

Biodiversity
- Environment of the West and Central African Regions, 1981;
- Convention on the Protection of the World Cultural and Natural Heritage, 1972;
- United Nations Framework Convention on Climate Change (Kyoto Protocol), 1997;
- Montreal Protocol on Substances that Deplete the Ozone Layer, 1987;
- Convention on International Trade in Endangered Species (CITES), 1973;
- Bonn Convention on the Conservation of Migratory Species of Wild Animals, 1979;
- United Nations Convention on Biological Diversity (CBD) adopted at the Earth Summit in Rio de Janeiro, 1992;
- The Copenhagen Accord reached by Heads of State, Heads of Government, Ministers and other heads of delegation at the United Nations Climate Change Conference 2009 in Copenhagen, Denmark.

1.8 EIA Approval Process in Nigeria
The Federal Ministry of Environment (FMEnv) is statutorily responsible for the processing and approval of ESIA reports. The EIA Act stipulates that no major project shall be undertaken without prior consideration, at early stages, of their environmental effects. Appropriate mitigation measures for potential significant impacts shall be stated before the commencement of the project. The steps leading to formal approval for EIA projects are usually as follows:

- Project Conceptualisation;
- ESIA Registration and ToR Submission;
- Site Verification Visit;
- ESIA Scoping;
- Conduct baseline and environmental impact studies;
- Proponent's informs host communities about the extent and processes of the project;

- Proponent submits required copies of the ESIA report to FMEnv for assessment;
- FMEnv publicly displays the ESIA report in designated areas to enable any interested members of the public to read and comment upon;
- FMEnv places advertisement in some National Dailies to inform the public about the display of ESIA report;
- FMEnv appoints an independent review panel, comprising academicians and professionals to review the EIA report;
- FMEnv distribute the ESIA report to the review panel members;
- FMEnv convenes a public hearing including site visit after the display of the ESIA reports, backed by state wide radio announcement;
- Proponent gives a presentation to the public panel at the review session giving details about the project and its environmental management, followed by a questions and answers session;
- The review panel members, and representatives present their comments on the presentation and the ESIA report;
- Proponent responds to all comments and takes note of the public and panel member's observations for incorporation in to the final ESIA report;
- Upon fulfillment of the environmental requirements, recommendation for provisional approval will be made by the review panel members; and
- FMEnv will communicate the granting of a provisional approval to proponent and requests the incorporation of the panel's comments into the final ESIA report before a final approval of the ESIA report. After that the permit is granted.

The steps mentioned above are presented in the diagram (**Figure 1.5**) overleaf.

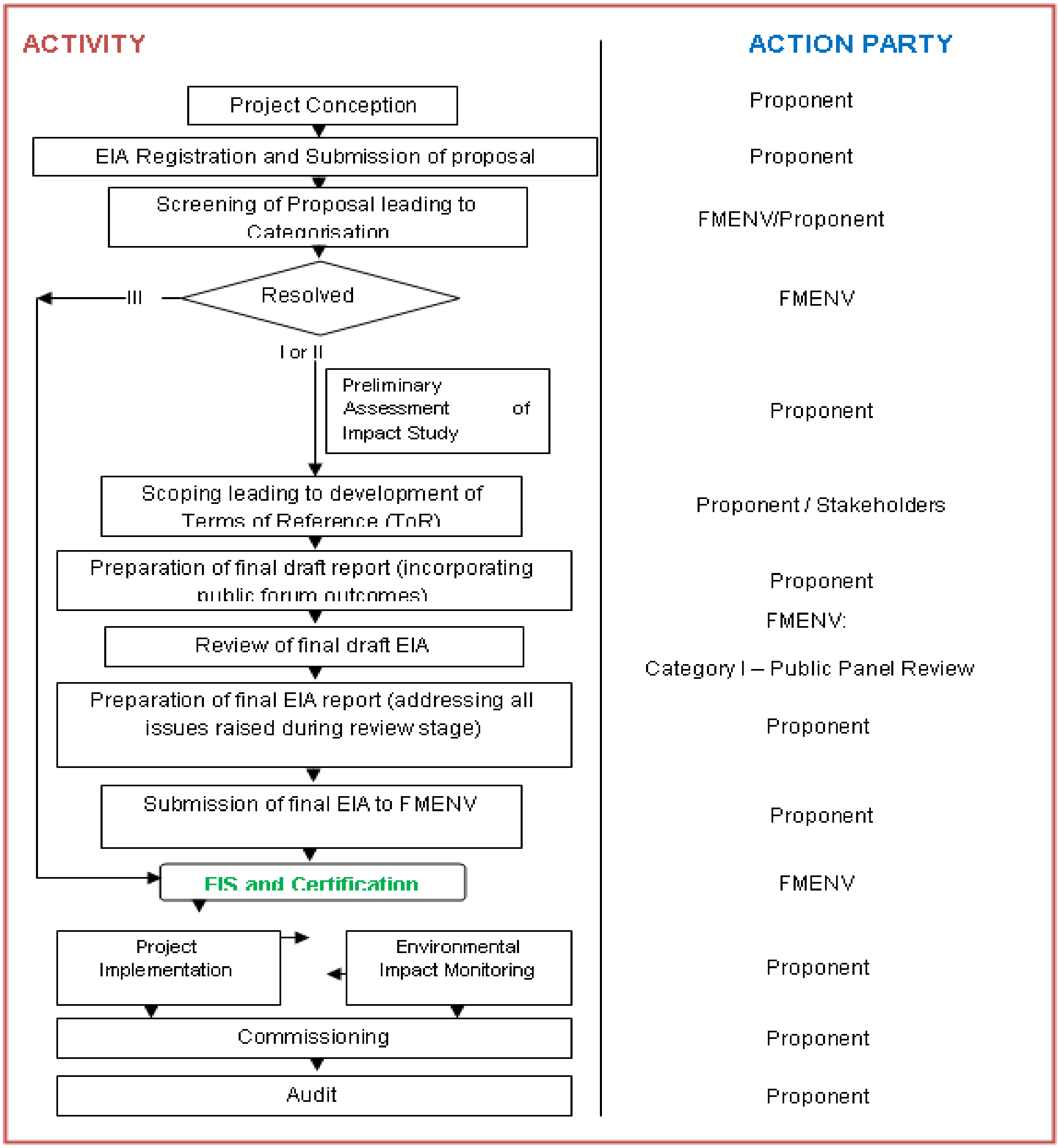

Figure 1.5: FMEnv EIA Process

1.9 Structure of Report

The ESIA report is presented in eight chapters as follows:

- **Chapter one:** is an introduction of the proposed project with background information on the proponent, project key design, project location, objectives, work scope, methodology and a review of the legal and administrative framework/ policies applicable to the project;
- **Chapter two:** discusses the project justification, benefits, sustainability, project options considered as well as site selection criteria;
- **Chapter three:** presents the project description which includes technical details of the proposed power plant project, waste streams and project timeline;
- **Chapter four:** describes the existing environmental condition (geographical and ecological) of the study areas as well as socio-economic and health conditions;
- **Chapter five:** identifies and evaluates the impacts from the project, which includes significant impacts;
- **Chapter six:** contains mitigation measures proffered for identified impacts;
- **Chapter seven:** presents the Environmental Social Management Plan (ESMP) to be adopted throughout the project life cycle;
- **Chapter eight** is the report conclusion. List of references and appendices are also included.

Other sections of the report are; table of content, list of ESIA preparers, list of abbreviations and acronyms, acknowledgment and executive summary.

CHAPTER TWO

PROJECT JUSTIFICATION

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PROJECT JUSTIFICATION

2.1 Background Information

Nigeria at large has need for electric power to drive its economy and sustain growth in the current decade and beyond. The Katsina State government liaising with the Federal Government having considered the abundance of sunlight most part of the year decided to take advantage of generating electricity through cleaner, cheaper and more environmentally sustainable source which is the sun to satisfy its energy needs. In order to improve the power Infrastructure, the government of Nigeria brought on board private participation in the power sector (build, own and operate). In-view of this, one of the players of this development is Nova Solar 5 Farms Limited which is requesting for license to build and operate a 125MWp Photovoltaic Solar Power farm at Kankiya, Katsina State. The proposed utility scale Power Plant project is expected to generate and channel the electric power generated to the national grid. The estimated value of the project is 220 million United States Dollars.

The power conversion source is photovoltaic modules that convert light directly to electricity. However, this differs from, and should not be confused with concentrated solar power, the other large-scale solar generation technology, which uses heat to drive a variety of conventional generator systems.

There exists a gap between demand and supply of electric power in Nigeria. Nigeria's population is put at between 150 and170 million people (NPC, 2006). 65% of this number lies between the ages of 18 and 45 years. Energy consumption is 1,259 TWH per Year, while electricity consumption is put at 18.1TWH. Peak electricity generation capacity 4,600 MW (compare with South Africa which has a population of 43 million, and has a peak generation capacity of 40, 00 MW). About 40% (68 million Nigerians have access to electricity).

The total installed capacity of the currently generating plants is 8644 MW but the installed available capacity was 5,500mw as at February, 2015. Electricity generation in Nigeria is characterised by excess capacity and inadequate supply. As at November 2014, only 7, 392 MW out of the total installed capacity of 8644 MW was connected to the national grid (**Figure 2.1**).

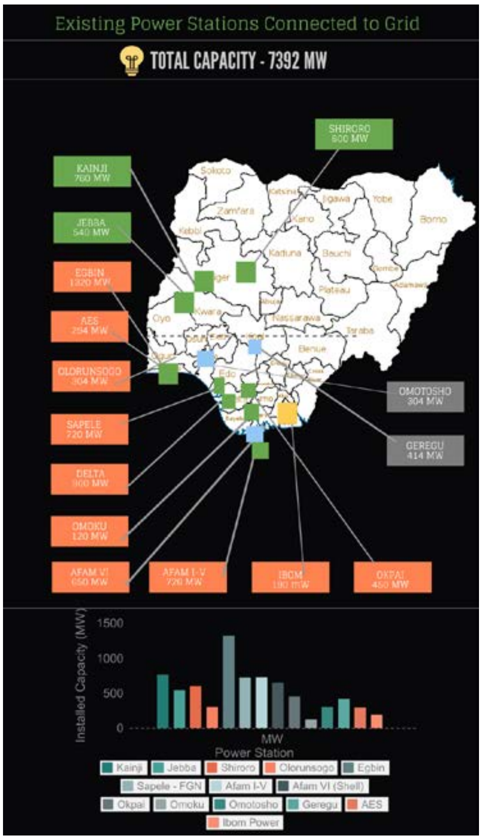


Figure 2.1: Existing Power Stations Connected to the National Grid

Seven of the generating stations are over 20 years old and the average daily power generation is below 2700 MW, which is far below the peak load forecast of 8900 MW for the currently existing infrastructure. As a result, the nation experiences massive load shedding.

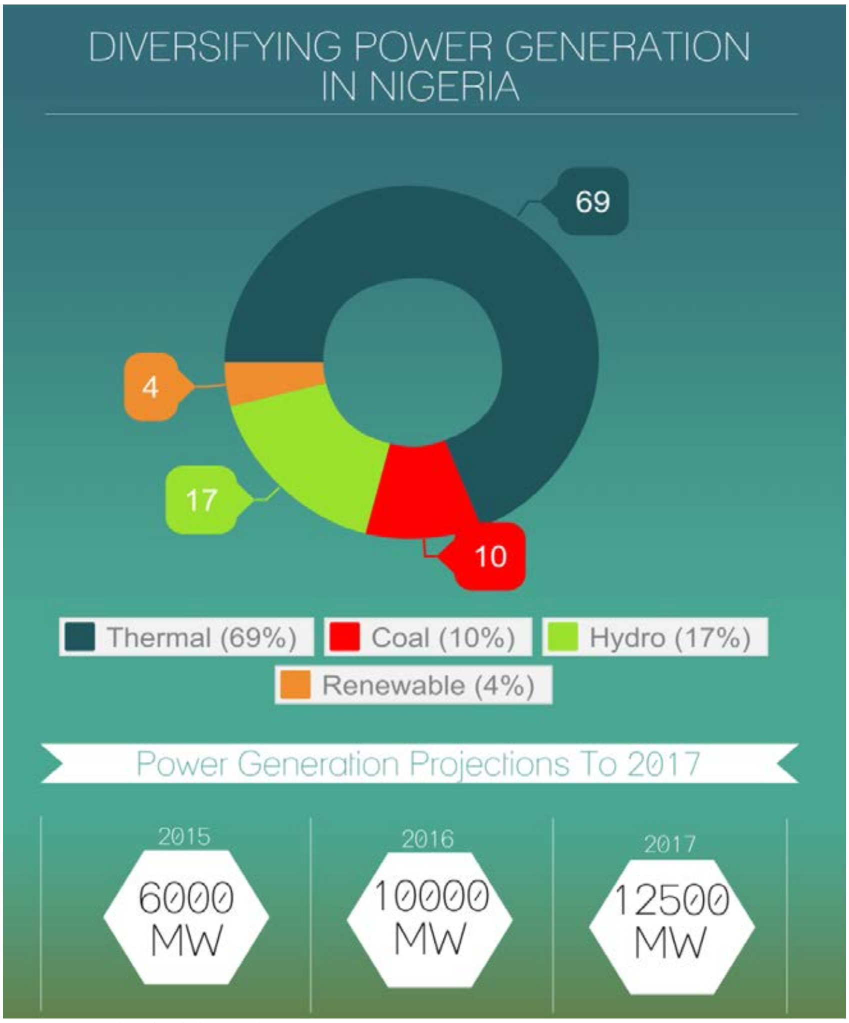
It is estimated that 26,561 MW will be required in the next 9 years to meet demand as envisioned in the Vision 20:20 targets (Presidential Task Force on Power 2010). This forecast has resulted in the need to diversify power sources thereby considering available alternatives. The current power generation statistics are presented in **Table 2.1**

Table 2.1: Power Generation Statistics as at Wednesday, 2nd September 2015

Peak Generation: 4,520.1MEGAWATTS (MW)	Peak Demand Forecast: 12,800 MEGAWATTS (MW)
Energy Generation: 4,154.27 MEGAWATTS HOUR/HOUR (MWH/H)	Energy Sent Out 4,026.49 MEGAWATTS HOUR/HOUR (MWH/H)
Highest Peak Generated: 4,810.7 MW on August 25, 2015	

Source: http://www.power.gov.ng/

Thermal, hydro, coal and renewable energy sources of power generation to increase power to about 12500 MW by 2017 are being considered (**Figure 2.3**).



Source: Federal Ministry of Power, 2014

Figure 2.2: Diversifying Nigeria Power Sources

In line with meeting the renewable energy source quota of the above, Nova Solar Power (NSP) has recently been requested by a consortium of Nigerian and International partners to be the project developer for the implementation of a Solar Photovoltaic (PV) Program in Nigeria as part of the 4% renewable energy quota projection between 2015 to 2017.

This solar program is based on the implementation of PV power plants with a minimum unitary installed capacity of 30 MW across several states in Nigeria. Katsina State has been selected to be the leading state in the implementation of this program.

2.2 Need for the Project

The proposed Kankia 125MW power station is a large-scale photovoltaic system designed for the supply of merchant power into the Nigerian electricity grid. It is differentiated from most building-mounted and other decentralized solar power applications because it will supply power at the utility level, rather than to a local user or users.

A key need of the overall solar power implementation program is to contribute as a form of renewable energy source to the projected 4% alternative power generation source between 2015 and 2017 in Nigeria. This is needed to meet the power target of 12500 MW by 2017. The Katsina 125 MW PV solar power plant is a leading project needed to achieve this.

In addition, according to Becans Business Environment Report on Katsina State (African Institute for Applied Economics in collaboration with National Planning Commission and Central Bank of Nigeria, 2007) the public power supply to the State from Power Holding Company of Nigeria (PHCN) was 21,530.87kilowatts in 2006. Averagely, electric power supply by PHCN per 24-hour day was 2 to 7 hours. The monthly/annual per capita electricity supply was 0.008 kilowatts (8 Watts). The State's per capita electricity supply is very low. This implies that there is significant need for improved electricity generation and supply Nigeria as a whole.

Furthermore, the success of the Katsina state government initiatives (policies, programmes, and investments) intended to better the socio-economic conditions of the people would not be fully realised in the absence of guaranteed and efficient power supply.

2.3 Benefit of the Project

Aside key needs of the projects as presented above, other benefits include:

- At the national level, construction of the power plant will result in an increase in grid based power generation capacity. At the local level, it directly contributes to development of Kankiya area and Katsina state as a whole (through the employment opportunities it will directly create and through multiplier effects that will flow from the increased availability of power within the region;
- The selection of world-class expertise enlisted for the project will bring a wealth of skills and technology not only to the project but the wider solar energy sector within Nigeria;
- Increased revenue/derivations to local and state governments as well as other mandated agencies/commissions.
- Decrease environmental emissions associated with private power generators and other thermal fossil fuel based power plants, thereby encouraging renewable energy form as better option to sustainable power sector development.

2.4 Envisaged Sustainability

Economic and Commercial Sustainability

The proposed power plant is expected to improve electric power availability at affordable price to industrial and domestic users in the State. The project is envisaged to be economically and commercially sustainable throughout its designed life span. This is because of:

- availability of constant sunlight at the site of the proposed Independent Power Plant;
- the close proximity of the proposed power plant to existing PHCN power evacuation infrastructure (sub-station) in the host community (Kankiya) area assures overall project cost (in terms generated power evacuation system, etc);
- project site is accessible by good road network for delivery of bulky plant parts for initial installation and maintenance; and

- the revenue that would accrue from power distribution, which would serve for payment of staff and procurement of maintenance facilities.

As previously indicated, there is a high demand for supply of power in Nigeria in order to support national economic growth. In addition to the employment and investment opportunities such projects will bring, the proposed utility scale PV-based solar power project will contribute to wealth generation and industrial growth in the region and assist in meeting the national electricity demand. The Project is expected to add a significant number of employment opportunities to the local labour market. It is envisioned that at the peak of construction up to 500 workers will be employed by the Project. Around 70 percent of the workers will be hired from the local communities. The EPC contractor will be responsible for the selection and management of all sub-contractors. NOVA solar 5 Farms Limited will however, reserve the right to review all suppliers of major equipment and materials (specified in the bidder's proposal or subsequently identified during the design phase) and to reject any suppliers where they do not meet desired quality standards or performance. More specifically, NOVA solar 5 Farms Limited will seek to monitor and guide the sub-contracting practices of the EPC contractor.

Technical Sustainability

Nova Solar Power Limited, the proponent of the proposed 125MWp photovoltaic solar power plant plans to carry out the development activities using best available technology (BAT). The technology to be applied would be European Standard that has been tested in countries with similar weather conditions including parts of the United States of America.

Nova Power is led by a team of experts in the energy business and power engineering. The company benefits from a lean, knowledge-driven entrepreneurial company culture. Additionally we benefit from the commercial network of our partners that are key players in the African power sector in order to disseminate our offer to all targeted countries. Nova Power is led by a highly experienced team located in Morocco, France, the United States, Germany and Nigeria, with project development, business, engineering, financial and legal competencies. Our dedicated experts provide both feasibility and profitability studies of power plant projects as well as timely, helpful and efficient support during the different stages of their development.

As a result of a wide range of experience in the energy marketplace, Nova Power is capable of setting up networks with industrial partners, Development Finance Institutions, investors in the African energy market as well as consultants. Our partners provide technical capabilities and finance for the development and implementation of the projects. The NOVA Group has also set up framework agreements with well-known EPC/O&M companies. The Figure hereunder presents a non-exhaustive list of Nova Power partners

Figure 2.3: A non-exhaustive list of Nova Power's partners

NOVA Group manages the entire solar project process, from concept to construction, and through the 25 years of operations, to ensure security to the investor and the buyer. NOVA Group:

- Conducts feasibility studies
- Develops the projects
- Secures local partners and service providers
- Secures rights, licenses and consents
- Secures financial commitments for debt and equity
- Arranges and supervise construction (EPC) and O&M contractors
- Establishes and manage the project's company
- Re-invests a portion of the developer's fee into 5-20% of the project's shares

Environmental Sustainability

The proposed 125MWp photovoltaic Solar Farm is a green power project. The technology is:

- eco-effective or eco-efficient , and involving greening in the form of renaturation measures
- Climate friendly: no CO_2 or other greenhouse gas emissions

Construction of the 125MWp photovoltaic Solar Farm shall be executed in line with the best environmentally acceptable techniques/methods to ensure minimal negative impacts on the environment. The Federal Ministry of Environment guidelines and standards for EIA as well as and other International standards shall guide the project. The incorporation of the findings and recommendations of this EIA at the various stages of the project activity, and adherence to the EMP will ensure environmental sustainability. Furthermore, the fact that the project source is renewable energy makes the project environmentally sustainable.

The solar power plant project will be environmentally sustainable because of the inherent environmental advantages of the mitigation measures that would be designed into the project as documented in this ESIA. The monitoring and management programmes to be implemented as recommended in the ESMP will help ensure environmental sustainability of the project.

Social Sustainability
An effective stakeholder consultation process has been implemented throughout the ESIA process to assist in ensuring that all stakeholders have had the opportunity to provide input into the project planning process. This has also assisted in laying a sound foundation for building relationships with stakeholders for the ongoing engagement that will continue throughout the lifecycle of the Project. NOVA Solar 5 Farms is committed to ensuring that a fair portion of the revenues earned by the 125MWp utility scale PV-based solar power plant is spent on programmes that will benefit the local communities. These programmes are likely to comprise projects aimed at improving the health and education of the inhabitants of these communities. The specific form and extent of these programmes will ultimately be guided by the company's Corporate Social Responsibility Policy (which will have input from all stakeholders including the Company's employees) and by the profitability and liquidity of the Company. However, NOVA Solar 5 Farms plans to train the people on how to create value and jobs from the electricity that will be reliably available in that region. NSF is also open to constitute a committee representing the population to host community and execute projects in coordination with the Special Purpose Vehicle and the Local and State Governments.

2.5 Project Options

Crystalline Silicone (C-Si) Photovoltaic grid connected technology system

Photovoltaic offers consumers the ability to generate electricity in a clean, quiet and reliable way. Photovoltaic systems are comprised of photovoltaic cells, devices that convert light energy directly into electricity. Because the source of light is usually the sun, they are often called solar cells. The word photovoltaic comes from "photo" meaning light, and "voltaic" which refers to producing electricity. Therefore, the photovoltaic process is "producing electricity directly from sunlight." Photovoltaics are often referred to as PV.

A grid-connected PV system will require a utility interactive DC to AC inverter. This device will convert the direct current (DC) electricity produced by the PV array into alternating current (AC) electricity typically required for loads such as radios, televisions and refrigerators. Utility interactive inverters also have built-in safety features required by photovoltaic is the field of technology and research related to the devices which directly convert sunlight into electricity. The solar cell is the elementary building block of the photovoltaic technology. Solar cells are made of semiconductor materials, such as silicon. One of the properties of semiconductors that makes them most useful is that their conductivity may easily be modified by introducing impurities into their crystal lattice.

Nova Solar 5 Farms proposed solar projects is a Crystalline Silicone (C-Si) technology based grid connected centralized PV system that connects the generated electricity to the grid through a transmission line of about 0,5 km length that will transmit the electricity from the proposed solar plant to TCN 132 KV Kano/Katsina transmission line which is crossing the proposed solar project plant.

2.5.1 Project Site Alternatives

A core option considered in the location of this project is site suitability. For proximity to an evacuation point, a 132kv or 330kv line was essential from an engineering and economics standpoint. Several locations within Katsina State were visited including the State Capital Katsina, Musawa, Daura and Dutsenma for this purpose.

Selecting the suitable site was a crucial part of developing a viable solar PV project. In selecting the Kankiya site, the aim was to maximise output and minimise cost. The main constraints that were assessed include:

Solar Resource
A high average annual Global Horizontal Irradiation (GHI) is the most basic consideration for developing a solar PV project. The higher the resource, the greater the energy yield per kWp installed.

Area
The area required per kWp of installed power varies with the technology chosen. The distance between rows of modules (the pitch) required to avoid significant inter-row shading varies with the site latitude.

Climate
In addition to a good solar resource, the local climate should not suffer from extremes of weather that will increase the risk of damage or downtime.

Topography
The chosen site is flat, as is required ideally.

Geotechnical
A geotechnical survey of the site has been carried out. The purpose was to assess the ground conditions in order to take the correct design approach, and to ensure that the mounting structures will have adequate foundations.

Access
The chosen site is just beside Kankiya – Katsina A9 highway. This is intended to allow access for trucks to deliver plant and construction materials.

Grid Connection
A grid connection of sufficient capacity is required to enable the export of power. The viability of grid connection depends on three main factors: capacity, availability and proximity.

Land Use
Solar PV power plants will ideally be built on low value land. Since the land was not already owned by NOVA Solar 5 Farms Limited, the cost of purchase was considered.

Module Soiling
If the modules are soiled by particulates, then the efficiency of the solar plant could be significantly reduced.

Water Availability
Clean, low mineral content water is preferred for cleaning modules.

Financial Incentives
Financial incentives (such as feed-in tariffs or tax breaks) in Katsina State, Nigeria have a strong bearing on the financial viability of this proposed project.

The reasons why the site in Kankiya has been selected among all the others considered is that the site location is devoid of constraints that could have hampered the project realization. The main criteria applied for land to be used for photovoltaic utility scale project are:

- Flat or near flat topography,
- Open land (no constructions, sparse vegetable cover),
- Stable geology (e.g. compact soil, avoid fractured rock terrains and shallow soil depth),
- Terrain exposure to erosion (e.g. rain, wind, terrain displacements, etc.) should be low or nonexistent,
- Absence of significant nearby shading sources, such as mountains or high-buildings,
- Preferably, the land should be State Government owned, or be subject to a simplified acquisition process.
- Located in the vicinity of the High Voltage Grid

Those criteria were submitted to Katsina State Government who came with the proposed land that was accepted by the developer. other options meeting all those criteria were sought but none was found.

2.5.2 Project Development Alternatives

Option 1: Do Nothing

Do nothing option implies that the proposed 125MWp Photovoltaic Solar Farm development project should not be implemented. This means that the Nova Solar Power objective of addition of electricity power to the national grid would not be met and the overall 2017 target of achieving 12,500MV electricity generation in Nigeria would be jeopardised. Also, job creation and skill acquisition as a result of executing this project would not be possible. Adopting this option would entail continually enduring the frequent outages, excessive low voltages and slowed economic development. This option was not adopted.

The proposed alternatives as outlined below were considered on the basis of engineering judgment, environmental concerns, adaptability, cost-effectiveness and ease of operation and maintenance of the system through its design life. Project alternatives were evaluated as part of the conceptual design process and alternatives that provide cost-effectiveness, environmental friendliness/management were preferred. Considerations for various aspects of the project include; power generation technology, power execution process and site selection alternatives.

Power Source Alternatives

Option 2: Wind Power

Wind power is the conversion of wind energy into a useful form of energy, such as electricity, using wind turbines. The wind power plants use the wind to push against the turbine blades, spinning the copper wires inside the generator to create an electric current.

The worldwide use of wind energy is growing rapidly, with several countries having achieved relatively high levels of wind power penetration by 2008, such as 19% of stationary electricity production in Denmark' 13% in Portugal and Spain, and 7% in Germany and the Republic of Ireland. In 2008, wind machines in the United States generated a total of 52 billion kilowatt-hours', about 1.3% of total U.S. electricity generation. The world's largest wind farm, the Horse Hollow Wind Energy Center in Texas, has 421 wind turbines that generate enough electricity to power 220,000 homes per year. As of May 2009, eighty countries around the world are using wind power on a commercial basis. Between 2000 and 2010, world wind electric generating capacity increased from 17,000 megawatts to nearly 200,000 megawatts, with global wind capacity at 194.4 GW in 2010 (World Wind Energy Association, 2010).

It is a renewable source of energy but it is non-dispatchable, i.e., for economic operation, all of the available output must be taken when it is available. The environmental and health benefits of wind power include: widespread, inexhaustible cheap resource that could be developed; low emissions (reduces smog and eliminates a major source of acid rain and total emissions of carbon dioxide - a greenhouse gas); and cleaner and healthier air, especially for people with respiratory disabilities. The drawback to the application of wind power which has made this option not to be preferred in for installation by the Government of Katsina State are:

- The tall towers and blades (up to 90m long) are cumbersome and delicate to transport;
- The entire plant units are generally difficult and expensive to install, operate and maintain; and
- Their height makes them obtrusively visible across large areas, disrupting the appearance of the landscape and its aesthetic appeal.
- Dependent on meteorological conditions.

Option 3: Nuclear Power Plant

Nuclear generators use nuclear fission to turn water into steam. This drives steam turbine, and spins a generator to produce electricity that is then evacuated through the grid. The energy yield is very high and with very low carbon foot print (with respect to green house gas emission and climate change). The nuclear power technology is well developed with track record of producing electricity with few safety incidents. It is also suitable for power production in areas with poor natural and renewable resources. The option was not adopted because of concerns associated with nuclear plant safety, nuclear weapons proliferation (uranium enrichment process can also produce higher concentrations of U^{235} suitable for nuclear weapons), and nuclear waste. It produces large amounts of highly radioactive nuclear waste that must be stored / isolated from the biosphere for very long time. Insurance cost and overall cost of high nuclear power stations are very high, including high risk of during accidents.

Option 4: Coal Power Plant
Coal power plant burns coal to generate steam which turns turbine engine to generate electricity which is then distributed through the grid. This is a viable option considering vast coal deposit in Nigeria and the technology of coal power plant is well developed. Energy supply from coal power plant is independent of weather conditions. It also has secondary advantage of providing jobs and revenue for existing industries and communities (coal mining and coal transport). However, this option was not adopted of its environmental footprints (particulates etc.). The carbon foot print is large with environmental concerns (particulate and gaseous pollutants emissions and contribution to global climate change through green house gas emissions). Coal mining is often very destructive to the landscape and to coal miners.

Option 5: Hydroelectric Plant
Hydroelectric Plant use gravitational force of falling (or flowing) water to spin the turbine blades which generates electricity. It is the most widely used form of renewable energy. Once a hydroelectric complex is constructed, the project produces no direct waste, and has a considerably lower output level of the greenhouse gases than fossil fuel powered energy plants. Approximately 20% of the world's electricity (and about 88% of electricity from renewable sources) come from hydroelectric plants (Renewable Global Status Report 2006 Update, REN21 published 2007). The hydroelectric plants also tend to have longer economic lives than fuel-fired power plants. On the other hand, hydroelectric dam failures create large scale environmental and socio-economic destruction. Often, good design and construction are not an adequate guarantee of dam safety. Dams for hydroelectric plants lead to siltation which damages both the aquatic ecosystem and reduces life span of the plant, thus this option was not adopted.

2.5.3 Power Plant Fuel Alternatives

Option 6: Bio-fuel
This involves the use of organic materials (plant and animals) as source of fuel. The technology is not popular in Nigeria. It was therefore not strongly considered.

Option 7: Natural Gas Power Plant
This option involves the use of natural gas as source of fuel. This is a viable option that would ensure a stable power generation for the state and its environs considering the availability of natural gas in Nigeria. This was not the preferred option because of the non-existing gas supply infrastructure in and around the state, and fact that this option contributes to atmospheric pollution.

However there were five different technology sub options under the natural gas powered thermal power plant these are:

- Natural gas-fired combined cycle system
- Natural gas-fired simple-cycle.
- Natural gas-fired conventional furnace/boiler steam turbine-generator.
- Natural gas-fired conventional combined-cycle.
- Natural gas-fired dual fuel diesel generator sets.

Combined Cycle System

The efficiency of natural gas-fired combined cycle system of around 330MW is typically around 50 percent, resulting in lower air emissions per kilowatt hour (kWh) than simple cycle gas turbine systems or conventional boiler-steam systems. In addition, natural gas-fired turbines in a state-of-the-art combined-cycle unit emit less NO_X, CO, VOC, SO_X, and PM_{10}. This option has higher efficiency, low air pollutant emissions, and low generation costs. However, the fact that this option contributes to atmospheric pollution makes it not a desirable option.

Simple Cycle System

Simple-cycle gas turbines have a low capital cost, have efficiency approaching 35 percent, and are fast-starting. Air quality impacts are higher with this technology than with combined-cycle technology because the high exhaust gas temperatures make it more difficult to control NO_X and also, more fuel must be burnt to produce the equivalent amount of power as compared to a natural gas-fired conventional combined cycle facility. As a result of the relatively low efficiency and high emissions rate, this technology was eliminated from consideration.

Conventional Furnace/ Boiler Steam Turbine Generator

Natural gas-fired conventional furnace/boiler steam turbine generators are less efficient (35 percent) than combined-cycle technology (50 percent) and emit more air pollutants per kWh generated. As a result of this, the option was not adopted.

Dual Fuel Diesel Generator Sets

The natural gas-fired dual fuel diesel generator sets technology has larger size, and more complex equipment. The capital costs and time to construct it is also greater. In addition, the cost of generation is comparatively high. Based on lower plant efficiency, higher emissions per kWh generated, higher capital costs, and increased labour costs to operate and maintain the facility, this technology was eliminated from consideration.

Natural gas-fired dual fuel diesel generator sets can achieve efficiencies up to 45%. The duel fuel engines sizes are restricted to 15MW per engine. Due to the large number of engines (nearly 22 units for 330MW generation), very high maintenance costs, this technology was eliminated from consideration.

2.5.4 Solar Power Plant Alternatives

It involves harnessing sunlight for generation of electricity. There are two main types, namely solar thermal and photovoltaic panels. Photovoltaic has been described earlier.

Option 8: Solar Thermal Source

The solar thermal method involves parabolically shaped mirrors arranged to concentrate sunlight on long steel pipes filled with circulating oil, heating it at 750°F. The heated oil pass through giant radiators (heat exchanger) that extract the heat and boil water into steam. The steam then turns turbine and dynamo thereby producing electricity that can be evacuated through the grid. The photovoltaic panels (made of semiconductors such as silicon) on the other hand convert sunlight directly into electricity. Solar power plants requires large acres of land (greater land-take) and long transmission lines to bring the power to where it is needed but is more efficient than the photovoltaic panels. However, both solar energy sources fade when it is cloudy and disappear at night. The average daily sunshine hours in Katsina are about 12 hours. The solar power plant was not considered for implementation because the technology is still being developed worldwide. At present, solar power costs several times more than natural gas or coal - which is why it still supplies only a small fraction of the world's energy need (National Geographic, 2009). For this reason this option was not considered.

Concentrated Solar Power (CSP)
CSP technology generates electricity by focusing the component of solar irradiance that travels directly from the sun. The diffuse component of solar irradiance which is scattered from the ground and the sky cannot be focused and therefore cannot be used by CSP technology. For this reason, a CSP plant must be located in an area where clear skies are common, as any cloud cover, haze, fog or smog would significantly reduce the levels of direct irradiance reaching the plant. To focus the direct irradiance, CSP technologies should face the sun at all times. They do this by using sun tracking technology. Financial viability of projects depends upon the resource, technology and project costs, and the extent of government-driven financial support. Current costs of the technology and constraints on financial support indicate that only projects that are located in the areas with the highest direct normal irradiation are likely to be viable in the near future with annual average direct normal irradiation values of greater than 2.2 MWh/m^2/year or 6.0 kWh/m^2/day. For these reasons, this option was not considered.

Option 9: PV-Based Solar Power Alternatives
There are four primary applications for PV power systems. One of them is the choice of NOVA Solar 5 Farms Limited. This is Grid-connected centralized PV **–** Providing centralized power generation for the supply of bulk power into the grid. The other three alternatives considered are:

- **Off-grid domestic –** Providing electricity to households and villages that are not connected to the utility electricity network (the "grid"). This option was not chosen because it is not of utility scale.
- **Off-grid non-domestic –** Providing electricity for a wide range of applications such as telecommunication, water pumping and navigational aids. This option was not chosen because it is not grid-connected.

- **Grid-connected distributed PV –** Providing electricity to a specific grid-connected customer. This option was not chosen because it is target at only specific customers.

2.6 Power Evacuation Considerations
The power to be generated would be evacuated through the Transmission Company of Nigeria (TCN) substation in Kankiya, Katsina State. The interconnection is required to transmit electricity from the proposed power plant via the nearest existing substation in Kankiya community. The substation has been assessed to determine its suitability for the evacuation of generated power, taking into consideration the present configuration of the substation and possible future configuration.

CHAPTER THREE

PROJECT DESCRIPTION

CHAPTER THREE

PROJECT DESCRIPTION

3.1 General

This chapter describes in details, the proposed NOVA Solar 5 Farms Plant project facilities to be installed and operated. The proposed project will be located at Kankiya, in Kankiya Local Government Area of Katsina State. The proposed project activities will generally involve land acquisition, site clearing, construction works, installation, operation and maintenance phases. This chapter also discusses the project design codes and standards, design specifications, project schedule/ timeline, anticipated waste streams and maintenance, operations and decommissioning process.

3.2 Project Overview

The proposed 125MWp Utility Scale Solar PV based power plant project is required to boost the country's overall electricity capacity and improve the living standards of its citizen.

The proposed solar power project is a photovoltaic solar farm installation that will use Aluminum Poles of about 3m long in height of which about 1.4m will be buried beneath the ground surface. The design of the panel is 70 cm by 150 cm. The proposed project is expected to generate 125MW of electricity. The project would be executed on 200 hectares of land.

The 125MWp PV based solar power plant development would be implemented in phases, namely:

- Pre engineering (design and site preparation) phase;
- Procurement under EPC (Engineering, Procurement and Construction) contract;
- Construction and installation phase;
- Operation phase; and
- Decommissioning phase.

The descriptions presented below are based on typical PV based solar power plant operations. Consequently, certain details of the project described below may be subject to adjustment and changes, either due to engineering designs or as a result of the EIA findings and review processes.

3.2.1 Site Selection

There are currently no regulations regarding the locating of large, stand-alone PV based solar power plant in Nigeria. Government legislation and regulations are recommended that will enshrine sufficient minimum setbacks and siting requirements to ensure future projects are appropriately sited in Nigeria, and fit with present and future neighbours. A clear policy on buffer zones for PV based solar power plants, and a proper siting requirements process, will:

- Provide certainty to communities and power plant developers;
- Address the legitimate safety and health concerns of residents;
- Level the playfield for power developers; and
- Ensure consistency with policies and requirements for other types of sensitive developments.

There are recommendations on siting for stand-alone PV based solar power plants. In addition to buffer zones (setbacks), the following aspects will be included in policies for Nigeria:

- Size of Site;

- Location;
- Safety;
- Municipal zoning and land use policies;
- Existing air/water quality of host community.

Selecting the suitable site was a crucial part of developing the 125MWp utility scale PV-based solar power plant. As stated in chapter two, in selecting the Kankiya site, the aim was to maximize output and minimise cost. The main constraints that were assessed in the selection process include:

Solar Resource

A high average annual Global Horizontal Irradiation (GHI) is the most basic consideration for developing a solar PV project. The higher the resource, the greater the energy yield per kWp installed. When assessing the GHI at the considered sites, care was taken to minimise any shading that would reduce the irradiation actually received by the modules. Shading could be due to mountains or buildings on the far horizon, or mutual shading between rows of modules, or shading near the location due to trees, buildings or overhead cabling.

Avoiding shading is critical as even small areas of shade may significantly impair the output of a module or string of modules. The loss in output could be more than predicted by simply assessing the proportion of the modules that are shaded. When assessing shading, it is considered that the path the sun takes through the sky changes with the seasons. An obstacle that provides significant shading at mid-day in December may not provide any shading at all at mid-day in June. The shading for this project was assessed using the full sun-path diagram for the location.

Area

The area required per kWp of installed power varies with the technology chosen. The distance between rows of modules (the pitch) required to avoid significant inter-row shading varies with the site latitude. The chosen site in Kankiya has sufficient area to allow the required power to be installed without having to reduce the pitch to levels that cause unacceptable yield loss. Depending on the site location (latitude) and the type of PV module selected (efficiency), a well-designed PV power plant with a capacity of 1 MWp developed is estimated to require between one and two hectares (10,000 to 20,000 m2) of land. A plant using lower efficiency Cadmium Telluride (CdTe) thin film modules may require approximately 40 to 50% more space than a plant using poly-crystalline modules.

Climate

In addition to a good solar resource, the local climate should not suffer from extremes of weather that will increase the risk of damage or downtime. Weather events that were considered in making the choice of site include:

- **Flooding –** This may increase the risk of erosion of support structure and foundations, depending on geo-technical conditions.
- **High wind speeds –** The risk of a high wind event exceeding the plant specifications was assessed. Locations with a high risk of damaging wind speeds were avoided. Fixed systems do not shut down at high wind speeds, but tracking systems must shut down in safe mode when speeds of 16-20 m/s are exceeded.
- **Temperature –** The efficiency of a PV power plant reduces with increasing temperature. It was established that if the chosen site is a high temperature site, mitigating measures should be included in the design and technology selection. For instance, it would be better to choose modules with a low temperature coefficient for power.

Topography
The chosen site is flat, as is required ideally. Such topography makes installation simpler, and reduces the cost of technical modifications required to adjust for undulations in the ground. With additional cost and complexity of installation, mounting structures can be designed for most locations. The cost of land was weighed against the cost of designing a mounting structure and installation time.

Geotechnical
A geotechnical survey of the site has been carried out. The purpose was to assess the ground conditions in order to take the correct design approach, and to ensure that the mounting structures will have adequate foundations. The level of the geotechnical survey carried out was informed by the foundation design envisaged.

In line with best practice, trial pits were made at regular intervals and at a depth appropriate for the foundation design. The trial pits typically assessed:

- The groundwater level.
- The resistivity of the soil.
- The load-bearing properties of the soil.
- The presence of rocks or other obstructions.
- The soil pH and chemical constituents in order to assess the degree of corrosion protection required and the properties of any cement to be used. The geotechnical study also included an assessment of the risk of seismic activity and the susceptibility to erosion and flooding.

Access
The chosen site is just beside Kankiya – Katsina A9 highway. This is intended to allow access for trucks to deliver plant and construction materials. This access road is constructed with a gravel chip finish. The choice of site was made knowing that the closer the site is to a main access road, the lower the cost of adding this infrastructure. Safe packaging of the modules and their susceptibility to damage in transport was also carefully considered. The selected site is in a secure location where there is little risk of damage from either people or wildlife. It is located where security and maintenance personnel can respond quickly to any issue. NOVA Solar 5 Farms Limited shall ensure that this requirement is stipulated in the maintenance contract.

Grid Connection
A grid connection of sufficient capacity is required to enable the export of power. The viability of grid connection depends on three main factors: capacity, availability and proximity. These factors were considered thoroughly at an early stage of the project in order to ensure the cost does not become prohibitive if the site is later found to be in an unfavorable area for grid connection.

***Capacity* –** The capacity for the grid to accept exported power from a solar plant depends on the existing network infrastructure and current use of the system. The rating of overhead lines, cables and transformers was an important factor during the assessment of the connection capacity available. It was considered that switchgear fault levels and protection settings may also be affected by the connection of a generation plant. It was considered that, if the available network does not have the existing capacity to allow connection, two options are available:
1). To reduce peak power export to the allowable limits of the network or, 2). To upgrade the network to allow the desired export capacity. Network upgrade requirements will be advised by the network operator (TCN). But some aspects of that upgrade can be carried out by contractors other than the network operator. Initial investigation into network connection point capacity was carried out by reviewing published data. However, discussion with the network operator will be required to fully establish the scope of work associated with any capacity upgrades.

Proximity – A major influence on the cost of connecting to the grid is the distance from the site to the grid connection point in Kankiya. The site is at a location where the cost of grid connection does not adversely affect project economics. Besides, a higher connection voltage will entail increased cost of electrical equipment such as switchgear and transformers, as well as a higher conductor specification. A higher voltage is also likely to increase the time taken to provide the connection resulting in a longer development period.

Availability – The grid availability describes the percentage of time that the network is able to export power from the solar PV plant. The annual energy yield from a plant may be significantly reduced if the grid has significant downtime. This may have adverse effects on the economics of the project.

Land Use

Solar PV power plants will ideally be built on low value land. Since the land was not already owned by NOVA Solar 5 Farms Limited, the cost of purchase was considered. NSF\KSG have purchased the land at replacement cost. Besides access to the site, provision of water, electricity supplies and the rights to upgrade access roads were also considered along with relevant land taxes. Since government permission is required to build a solar plant, the site was assessed in line with the local conditions imposed by the relevant regulatory bodies. Since the selected land is currently used for agricultural purposes, it has been re-classified for "industrial use". The future land use of the area was also taken into account. Since the plant will be in operation for at least 25 years, extraneous factors were considered to assess the likelihood of their impact on energy yield. For example, the dust associated with building projects could have significant impact on the energy yield of the plant. Locating the plant in an environmentally sensitive area was avoided in the site selection. Every tree on the project site and surrounding land may need to be felled and removed, with associated cost.

Module Soiling

If the modules are soiled by particulates, then the efficiency of the solar plant could be significantly reduced. Thus, local weather, environmental, human and wildlife factors were taken into consideration while determining the suitability of the selected site for the proposed solar PV plant. The criteria used for the assessment include:

- Dust particles from traffic, building activity, agricultural activity or dust storms.
- Module soiling from bird excreta. Areas close to nature reserves, bird breeding areas and lakes/dams were carefully assessed.

Soiling of modules may require an appropriate maintenance and cleaning plan at the selected site location.

Water Availability

Clean, low mineral content water is preferred for cleaning modules. A mains water supply, ground water, stored water or access to a mobile water tank may be required; the cost of the various options will have an impact on the project economics. The degree to which water availability is an issue will depend upon the expected level of module-soiling, the extent of natural cleaning due to rainfall and the required cleaning frequency.

Financial Incentives

Financial incentives (such as feed-in tariffs or tax breaks) in Katsina State, Nigeria will have a strong bearing on the financial viability of this proposed project. Such incentives could outweigh the costs associated with one or more of the site selection constraints.

3.3 Proposed Project Layout

The total land area for the proposed PV based solar power plant is 200 hectares. The site layout is influenced by the location of an existing Transmission Company of Nigeria (TCN) transmission station along adjoining road (Kankiya – Katsina A9 highway), the road access and the potential for future development of the site.

The layout is planned in a manner to achieve the following objectives:

- Minimise environmental impacts;
- Minimise health and safety risks for site personnel and general public;
- Coordinate site activities and make efficient use of on-site resources; and
- Manage potential impact on local economy.

See A3 attachment overleaf for site layout

3.4 Facilities Design Bases

The design intent of the solar power plant facilities is to develop environmentally sustainable facilities that satisfy best practice, applicable regulations, industry standards and codes. Thus, applicable engineering codes and standards for the proposed solar power plant are as presented below.

Applicable Codes and Standards

Nigerian Codes and Standards Organizations

FMEnv	Federal Ministry of Environment
NERC	Nigeria Electricity Regulatory Commission
NBC	Nigerian Building Code
NESREA	National Environmental Standards, Regulation and Enforcement Agency
NEMSA	Nigerian Electricity Management Services Agency
TCN	Transmission Company of Nigeria

International Standards and Codes

BS	British Standards
IEC	International Electro-technical Commission
IBC	International Building Code
WBS	World Bank Standards

US Standards and Codes

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
API	America Petroleum Institute
ASHRAE	American Society of Heating, Refrigeration And Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWPA	America Wood Preservers
AWS	American Welding Society
AWWA	American Water Works Association
CFR	Code of Federal Regulations
CMAA	Crane Manufacturers Association of America
HEI	Heat Exchange Institute
IEEE	Institute of Electrical and Electronic Engineers

US Standards and Codes cnt'd.

ISA	Institute Society of America
NACE	National Association of Corrosion Engineers
NEC	National Electrical Code
NEMA	National Electrical Manufacturer's Association
NFPA	National Fire Protection Association
NESC	National Electric Safety Code
OSHA	Occupational Safety and Health Administration
PCI	Precast Concrete Institute
SJI	Steel Joist Institute
SSPC	Steel Structures Painting Council
UBC	Uniform Building Code

3.5 PV Based Solar Power Plant Process

Photovoltaic (PV) is a method of converting solar energy into direct current electricity using semiconducting material (silicon) that exhibit the photovoltaic effect. It is the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, they result in electric current that can be used as electricity. A photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power. Power generation from solar PV is a clean sustainable energy technology which draws upon the planet's most plentiful and widely distributed renewable energy source – the sun. The direct conversion of sunlight to electricity occurs without any moving parts or environmental emissions during operation. This system is illustrated in **Figure 3.1.**

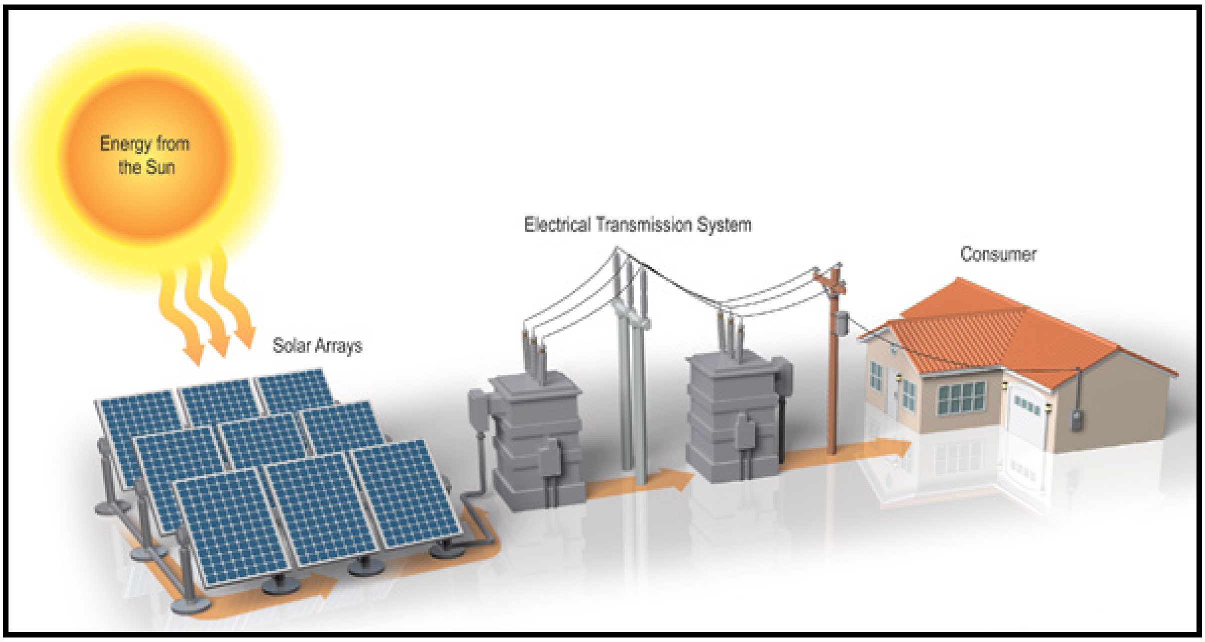


Figure 3.1: Illustrations of Photovoltaic Solar Plant System

As light hits the solar panels, the solar radiation is converted into direct current electricity (DC). The direct current flows from the panels and is converted into alternating current (AC) used by local electric utilities. Finally, the electricity travels through transformers, and the voltage is boosted for delivery onto the transmission lines so local electric utilities can distribute the electricity to homes and businesses.

The basic unit of a PV system is a solar cell. A solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light.

Solar cells are the building blocks of photovoltaic modules, otherwise known as solar panels. Solar cells are described as being photovoltaic irrespective of whether the source is sunlight or an artificial light. They are used as a photodetector (for example infrared detectors), detecting light or other electromagnetic radiation near the visible range, or measuring light intensity. The operation of a photovoltaic (PV) cell requires 3 basic attributes:

- The absorption of light, generating either electron-hole pairs or excitons. An exciton is a bound state of an electron and an electron hole which are attracted to each other by the electrostatic Coulomb force. It is an electrically neutral quasiparticle that exists in insulators, semiconductors and in some liquids. The exciton is regarded as an elementary excitation of condensed matter that can transport energy without transporting net electric charge.
- The separation of charge carriers of opposite types.
- The separate extraction of those carriers to an external circuit.

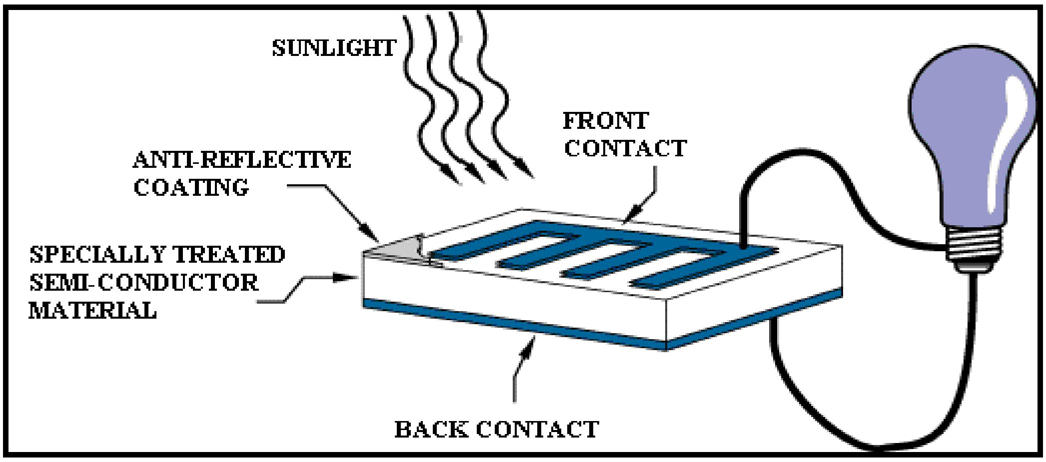


Figure 3.2: Operation of Basic Photovoltaic Cell

The diagram above illustrates the operation of a basic photovoltaic cell, also called a solar cell. Solar cells are made of the same kinds of semiconductor materials, such as silicon, used in the microelectronics industry. For solar cells, a thin semiconductor wafer is specially treated to form an electric field, positive on one side and negative on the other. When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current -- that is, electricity. This electricity can then be used to power a load, such as a light or a tool. A number of solar cells electrically connected to each other and mounted in a support structure or frame is called a photovoltaic module. Modules are designed to supply electricity at a certain voltage, such as a common 12 volts system. The current produced is directly dependent on how much light strikes the module.

Figure 3.3: Photovoltaic Cell

Figure 3.4: Solar Panel

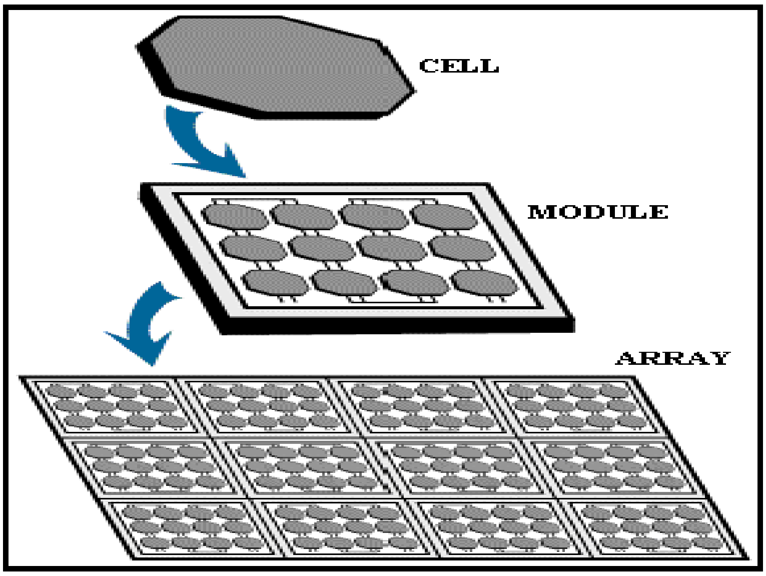
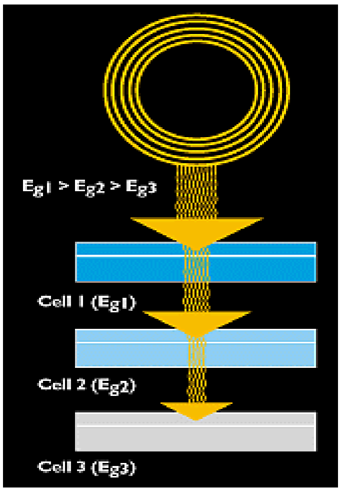


Figure 3.5: Solar Cell System

Multiple modules can be wired together to form an array. In general, the larger the area of a module or array, the more electricity that will be produced. Photovoltaic modules and arrays produce direct-current (dc) electricity. They can be connected in both series and parallel electrical arrangements to produce any required voltage and current combination.

Today's most common PV devices use a single junction, or interface, to create an electric field within a semiconductor such as a PV cell. In a single-junction PV cell, only photons whose energy is equal to or greater than the band gap of the cell material can free an electron for an electric circuit. In other words, the photovoltaic response of single-junction cells is limited to the portion of the sun's spectrum whose energy is above the band gap of the absorbing material, and lower-energy photons are not used. One way to get around this limitation is to use two (or more) different cells, with more than one band gap and more than one junction, to generate a voltage. These are referred to as "multijunction" cells (also called "cascade" or "tandem" cells). Multijunction devices can achieve a higher total conversion efficiency because they can convert more of the energy spectrum of light to electricity.

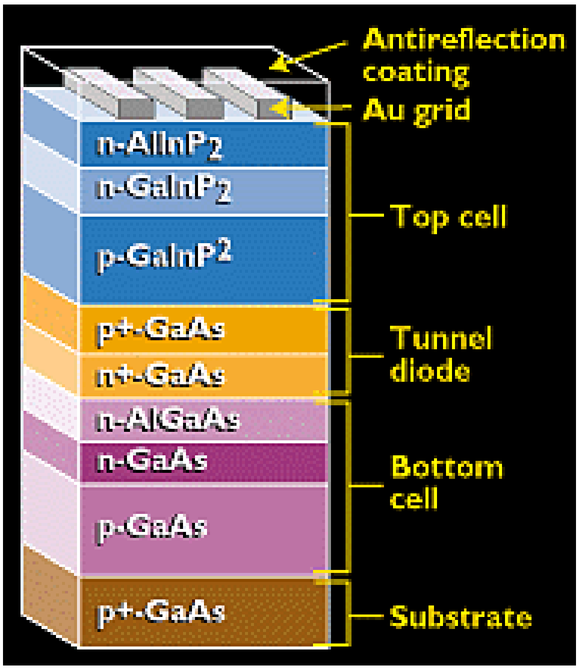


Source: http://www.spectrolab.com/p

Figure 3.6a: Multijunction Device

As shown below, a multijunction device is a stack of individual single-junction cells in descending order of band gap (Eg). The top cell captures the high-energy photons and passes the rest of the photons on to be absorbed by lower-band-gap cells.

Much of today's research in multijunction cells focuses on gallium arsenide as one (or all) of the component cells. Such cells have reached efficiencies of around 35% under concentrated sunlight. Other materials studied for multijunction devices have been amorphous silicon and copper indium diselenide.



Source: http://www.spectrolab.com/p

Figure 3.6b: Multijunction Device Architecture

A grid-connected PV system will require a utility interactive DC to AC inverter. This device will convert the direct current (DC) electricity produced by the PV array into alternating current (AC) electricity typically required for loads such as radios, televisions and refrigerators. Utility interactive inverters that have built-in safety features required by photovoltaic is the field of technology and research related to the devices which directly convert sunlight into electricity.

The solar cell is the elementary building block of the photovoltaic technology. Solar cells are made of semiconductor materials, such as silicon. One of the properties of semiconductors that makes them most useful is that their conductivity may easily be modified by introducing impurities into their crystal lattice. For instance, in the fabrication of a photovoltaic solar cell, silicon, which has four valence electrons, is treated to increase its conductivity. On one side of the cell, the impurities, which are phosphorus atoms with five valence electrons (n-donor), donate weakly bound valence electrons to the silicon material, creating excess negative charge carriers. On the other side, atoms of boron with three valence electrons (p-donor) create a greater affinity than silicon to attract electrons. Because the p-type silicon is in intimate contact with the n- type silicon a p-n junction is established and a diffusion of electrons occurs from the region of high electron concentration (the n-type side) into the region of low electron concentration (p-type side). When the electrons diffuse across the p-n junction, they recombine with holes on the p-type side. However, the diffusion of carriers does not occur indefinitely, because the imbalance of charge immediately on either sides of the junction originates an electric field. This electric field forms a diode that promotes current to flow in only one direction.

Ohmic metal-semiconductor contacts are made of both the n-type and p-type sides of the solar cell, and the electrodes are ready to be connected to an external load. When photons of light fall on the cell, they transfer their energy to the charge carriers. The electric field across the junction separates photo-generated positive charge carriers (holes) from their negative counterpart (electrons). In this way an electrical current is extracted once the circuit is closed on an external load.

There are several types of solar cells. However, more than 90 % of the solar cells currently made worldwide consist of wafer-based silicon cells. They are either cut from a single crystal rod or from a block composed of many crystals and are correspondingly called mono- crystalline or multi-crystalline silicon solar cells. Wafer-based silicon solar cells are approximately 200 µm thick. Another important family of solar cells is based on thin-films, which are approximately 1-2 µm thick and therefore require significantly less active, semiconducting material.

Thin-film solar cells can be manufactured at lower cost in large production quantities; hence their market share will likely increase in the future. However, they indicate lower efficiencies than wafer-based silicon solar cells, which mean that more exposure surface and material for the installation is required for a similar performance.

Grid connected systems (on-grid systems) are connected to the grid and inject the electricity into the grid. For this reason, the direct current produced by the solar modules is converted into a grid-compatible alternating current. However, solar power plants can also be operated without the grid and are then called autonomous systems (off-grid systems). More than 90 % of photovoltaic systems worldwide are currently implemented as grid-connected systems. The power conditioning unit also monitors the functioning of the system and the grid and switches off the system in case of faults.

As stated in chapter two, Nova Solar 5 Farms proposed solar projects is a Crystalline Silicone (C-Si) technology based grid connected system that connects the generated electricity to the grid through a transmission line of about 0,5 km length that will transmit the electricity from the proposed solar plant to TCN 132 KV Kano/Katsina transmission line which is crossing the proposed solar project plant.

3.6 Photovoltaic Plant Constituents

The proposed project is to utilize solar energy to generate electric power with a capacity of 125 MWp to be connected to the national grid in Katsina. The proposed photovoltaic plant consists of the following main components:

- Solar field: Main components of photovoltaic power plant or “solar field” consists of a large group of semiconductor technology based silicon solar cells arranged in solar PV panels or solar modules. Solar panels convert impinging sun rays (photons) to electrons. The electrons' flow generates direct current (DC) electricity which gets collected and channeled into an electronic device called "inverter" to invert the DC current into Alternating Current (AC); the form of electricity used to power homes, neighborhoods, factories, cities, etc.

- Racking: Structural components, which support the PV panels. These structures could be stationary (fixed) or movable through utilizing a "tracking system" to track sun movement during the day, throughout the entire year.
- Tracking: This is a mechanical system attached to the racking system to enable it to track sun movement. This could be a one axis tracking system (similar to the system used in this project) and it could also be a two axis tracking system, as another alternative.
- Other electric and/or electromechanical system components, such as cables, inverters, transformers, switchgear and controls are used to control and condition the power output of the solar field. An inverter is used to convert the electricity, which is produced as direct current in to alternating current for the purpose of grid connection. In order to connect a large solar facility to the national grid, numerous inverters will be arranged in several arrays to collect, and convert the produced power
- Connection to the grid: Routing energy generated from solar field to the national electricity grid.

3.6.1 Module Components Assembly

A typical solar module consists of several individual cells wired together and enclosed in protective material called encapsulant, commonly made of ethylene vinyl acetate. To provide structural integrity, the encapsulated cells are mounted on a substrate frequently made of polyvinyl fluoride. Both ethylene vinyl acetate and polyvinyl fluoride are widely considered to be environmentally preferable to other chlorinated plastic resins. A transparent cover, commonly glass, further protects these components from weather when in place for electrical generation. The entire module is held together in an aluminum frame. Most modules also feature an on board electrical junction box.

3.6.2 PV plant Infrastructure

The infrastructure of the PV plant component of the project comprises the followings:

- Energy source to provide the PV plant with the needed electrical power particularly during the construction phase, and lighting the proposed site;
- Water supply source; the proposed project will have a permanent water source from the public water supply system; the main use of the water in this project is for the construction and the cleaning of the solar panels in the operational phase, in addition to the use of water for the domestic purposes;

  The average quantity of water that will be needed for the plant in case of a wet cleaning system is around 12 M^3/day. NSF will build a 100 M^3 storage tank on site that will be fed either:
  - From the ground water if available
  - Public water through a permanent pipe if the distance does not exceed several kilometers or through a water tanker to be provided for such purposes.

  The studies performed on site show the availability of water al low depth. Further analyses are required to confirm if it can be used to clean modules. In case of dry cleaning, the average required quantity of water will not exceed 2 to 3 m^3 par day.
- Septic pool for containing the sewage water that is generated by the project operatories. This pool will be of about 50 cubic meter capacity, and will be evacuated by sewage tanks to approved waste treatment plant in the area such;
- Water distribution network to the facilities of the project;
- Sewage water network;
- Access Roads and Site Access within the site;
- Communication network;

- Warehouse of about 500 m^2;
- Site fencing with about 7,200m perimeter; and
- Within the site storage area there would be bund walls around transformers or any other oil containing equipment to ensure full containment in the event of any oil leakage.

3.7 The Connection Works Components

3.7.1 Transmission line Technology

The electric power transmission system is often referred to as a grid. Redundant paths and lines are provided so that power can be routed from any generation facility to any customer area through a variety of routes, based on the economics of the transmission path and the cost of power. The redundant paths and lines also allow power flow to be re-routed during planned maintenance and outages due to weather or accidents.

Power transmission occurs via a system of underground or/and above ground power lines and towers located between a power plant and a substation. Transmission systems are utilized to suspend high or medium voltage overhead power lines.

An overhead power line is an electric power transmission line suspended by towers or poles since most of the insulation is provided by air, overhead power lines are generally the lower cost method of transmission line for the large quantity of electric power. For the transmission line component of the proposed project, the proposed transmission line should be 132 Kv in compliance with Transmission Company of Nigeria (TCN) Specifications.

3.7.2 Plant Substation

The Plant substation will connect the plant step up transformers to the plant transmission lines.

3.7.3 Transmission Line Constituents

As mentioned earlier, the proposed project will involve development of a 0,5 km, 132kv transmission line between the Plant Substation and the existing 132 kV transmission line Kano/Katsina. To ensure the efficient functionality of the proposed transmission overhead line, all of the transmission line constituents will be installed using the best engineering practices. Following is a brief description of the transmission line constituents.

Support Structures

Structures for overhead lines take a variety of shapes depending on the type of line. For the proposed project, the overhead transmission line consists of about 3 poles along the line route that support the conductor that carry the electricity, a high voltage conductor diameter is used to maximize the carrying capacity. The poles are supposed to be spaced at 200 meter intervals. Insulators are used to isolate the poles from the conductors that carry the electricity.

Conductors

There are three conductors in the proposed transmission line, which are supported horizontally parallel to each other.

Insulator

Suspension and tension insulator sets of the cap and pin, pin or post type insulator, shackle insulators and stay insulator shall comply in galvanized respects with the requirements of the technical specification for insulator referenced. All insulators and insulator fitting shall be handled carefully during transportation, assembly and installation on the support structure to avoid chipping or damage and shall be cleaned when installed.

Foundations

The foundation design criteria shall be determined from the classification of the ground into which the structure is to be erected. In general the planting depth of the pole shall not be less than one sixth of the total length of the pole above the ground level, and shall not be less than 2.5 meters.

3.7.4 Substation Constituents

The components that will make up the Plant Substation are:

- Support Structures;
- Conductors/bus bars and cables;
- Switching equipment (breakers, line switches, earth switches)
- Measurement equipment (Current and voltage transformers)
- Insulators; and
- Foundations

3.8 Energy Yield Considerations and Prediction

An important step taken in assessing the feasibility of this project and attracting finance was to calculate the electrical energy expected from the proposed utility scale PV power plant. The energy yield prediction provided the basis for calculating project revenue. The aim of an energy yield analysis is to predict the average annual energy output for the lifetime of the proposed power plant. Typically, a 25 to 30 year lifetime is assumed.

The level of accuracy needed for the energy yield prediction depends on the stage of project development. For example, a preliminary indication of the energy yield was carried out using solar resource data and estimates of plant losses based on nominal values seen in existing projects. For a more accurate energy yield prediction, software was used to illustrate detailed plant specifications and three-dimensional modeling of the layout. Modeling also helped assess shading losses within time-step simulation.

To accurately estimate the energy produced from a PV power plant, information was needed on the solar resource and temperature conditions of the site in addition to the layout and technical specifications of the plant components. Sophisticated software was used to model the complex interplay of temperature, irradiance, shading and wind-induced cooling on the modules. While a number of software packages can predict the energy yield of a PV power plant at a basic level, financiers generally require an energy yield prediction carried out by a suitable expert. The procedure adopted for predicting the energy yield of a PV plant using time-step (hourly or sub-hourly) simulation software consist of the following steps:

1. Sourcing modeled or measured environmental data such as irradiance, wind speed and temperature from land-based meteorological stations and satellite imagery. This resulted in a time series of "typical" irradiation on a horizontal plane at the site location along with typical environmental conditions.
2. Calculating the irradiation incident on the tilted collector plane for a given time step.
3. Modeling the performance of the plant with respect to varying irradiance and temperature to calculate the energy yield prediction in each time step.
4. Applying losses using detailed knowledge of the inverters, PV module characteristics, the site layout, DC and AC wiring, module degradation, downtime and soiling characteristics.
5. Applying statistical analysis of resource data and assessing the uncertainty in input values to derive appropriate levels of uncertainty in the final energy yield prediction.

NSF sourced global horizontal irradiation data for the site location. Software will be used to simulate the complex interactions of temperature and irradiance impacting the energy yield. This software will take the plant specifications as input and modeled the output. Losses and gains will be calculated within the software. These losses/gains that will be considered are presented in the table below:

Table 3.1: Losses in a PV Power Plant

Loss	Description
Air pollution	The solar resource can be reduced significantly in some locations due to air pollution from industry and agriculture.
Shading	Due to mountains or buildings on the far horizon, mutual shading between rows of modules and near shading due to trees, buildings or overhead cabling.
Incident angle	The incidence angle loss accounts for radiation reflected from the front glass when the light striking it is not perpendicular. For tilted PV modules, these losses may be expected to be larger than the losses experienced with dual axis tracking systems, for example.
Low irradiance	The conversion efficiency of a PV module generally reduces at low light intensities. This causes a loss in the output of a module compared with the standard conditions at which the modules are tested (1,000W/m^2). This 'low irradiance loss' depends on the characteristics of the module and the intensity of the incident radiation.
Module temperature	The characteristics of a PV module are determined at standard temperature conditions of 25°C. For every degree rise in Celsius temperature above this standard, crystalline silicon modules reduce in efficiency, generally by around 0.5%. In high ambient temperatures under strong irradiance, module temperatures can rise appreciably. Wind can provide some cooling effect which can also be modeled.
Soiling	Losses due to soiling (dust and bird droppings) depend on the environmental conditions, rainfall frequency and on the cleaning strategy as defined in the Operation and maintenance (O&M) contract. This loss can be relatively large compared to other loss factors but is usually less than 4%, unless there is unusually high soiling. The soiling loss may be expected to be lower for modules at a high tilt angle as inclined modules will benefit more from the natural cleaning effect of rainwater.
Module Quality	Most PV modules do not match exactly the manufacturer’s nominal specifications. Modules are sold with a nominal peak power and a guarantee of actual power within a given tolerance range. The module quality loss quantifies the impact on the energy yield due to divergences in actual module characteristics from the specifications.
Module Mismatch	Losses due to “mismatch” are related to the fact that the modules in a string do not all present exactly the same current/voltage profiles; there is a statistical variation between them which gives rise to a power loss.
DC cable resistance	Electrical resistance in the cable between the modules and the input terminals of the inverter give rise to ohmic losses (I2R). This loss increases with temperature. If the cable is correctly sized, this loss should be less than 3% annually.
Inverter performance	Inverters convert from DC into AC with an efficiency that varies with inverter load.

Table 3.1: Losses in a PV Power Plant cnt'd.

Loss	Description
AC losses	This includes transformer performance and ohmic losses in the cable leading to the substation.
Downtime	Downtime is a period when the plant does not generate due to failure. The downtime periods will depend on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.
Grid availability and disruption	The ability of a PV power plant to export power is dependent on the availability of the distribution or transmission network. Typically, the owner of the PV power plant will not own the distribution network. He, therefore, relies on the distribution network operator to maintain service at high levels of availability. Unless detailed information is available, this loss is typically based on an assumption that the local grid will not be operational for a given number of hours/days in any one year, and that it will occur during periods of average production.
Degradation	The performance of a PV module decreases with time. If no independent testing has been conducted on the modules being used, then a generic degradation rate depending on the module technology may be assumed. Alternatively, a maximum degradation rate that conforms to the module performance warranty may be considered.
MPP Tracking	The inverters are constantly seeking the maximum power point (MPP) of the array by shifting inverter voltage to the MPP voltage. Different inverters do this with varying efficiency.
Curtailment of tracking	Yield loss due to high winds enforcing the stow mode of tracking systems.
Auxiliary power	Power may be required for electrical equipment within the plant. This may include security systems, tracking motors, monitoring equipment and lighting. It is usually recommended to meter this auxiliary power requirement separately.
Grid Compliance Loss	This parameter is included to draw attention to the risk of a PV power plant losing energy through complying with grid code requirements. These requirements vary on a country to country basis.

3.9 Plant Design and Technology Considerations

Designing a megawatt-scale PV power plant is a complex process that requires considerable technical experience and knowledge. There are many compromises that need to be made in order to achieve the optimum balance between performance and cost. This section highlights some of the key issues that will be considered when designing the proposed PV plant.

3.9.1 Technology Selection

Modules

It is relatively difficult to find comprehensive and independent module performance comparisons. Modules tested under a specific set of conditions of irradiance, temperature and voltage, with a specific inverter, may perform very differently under alternative conditions with a different inverter. This makes choosing a module a more difficult process than it may first appear. Many developers employ the services of an independent consultant for this reason. While choosing the module to adopt for this project, NSF will consider the following key points:

- The aim is to keep the levelised cost of electricity (LCOE) at a minimum. When choosing between high efficiency-high cost modules and low efficiency low cost modules, the cost and availability of land and plant components will have an impact.

High efficiency modules require significantly less land, cabling and support structures per MWp installed than low efficiency modules.

- When choosing between module technologies such as mono-crystalline silicon, multi crystalline silicon and thin film amorphous silicon, it will be noted that each technology has examples of high quality and low quality products from different manufacturers.
- Different technologies have a differing spectral response and so will be better suited for use in certain locations, depending on the local light conditions.
- Amorphous silicon modules generally perform better under shaded conditions than crystalline silicon modules. Many of them show a better response in low light levels.
- The nominal power of a module is given with a tolerance. Some modules may be rated with a ±5% tolerance while others are given with a ±3% tolerance. Some manufacturers routinely provide modules at the lower end of the tolerance, while others provide modules that achieve their nominal power or above (positive tolerance).
- When ordering a large number of modules, a sample of modules will be independently tested to establish the tolerance.
- The value of the temperature coefficient of power will be an important consideration for modules installed in hot climates.
- The degradation properties and long term stability of modules will be understood. The results of independent testing of modules can sometimes be found in scientific journals or papers from research institutes.
- The manufacturers' warranty period is useful for distinguishing between modules but care will be taken with the power warranty. Some manufacturers offer as guarantee of performance the percentage of the peak power for a given duration; others give it as a percentage of the minimum peak power (that is, the peak power minus the tolerance).
- Other parameters important for selection of modules include: cost ($/Wp), lifetime, and maximum system voltage.

Quality Benchmarks

Product Guarantee

Manufacturers are legally bound to provide a product guarantee ensuring that modules will be fully functional for a minimum of 2 years. Some companies guarantee a longer period, with 5-6 years being the usual duration.

Power Guarantee

In addition to the product guarantee, most manufacturers grant nominal power guarantees. These vary between manufacturers but a typical power guarantee stipulates that the modules will deliver 90% of the original nominal power after 10 years and 80% after 25 years. So far no module manufacturer has offered a power output guarantee beyond 25 years. The conditions listed in both the power guarantee and product guarantee are important, and vary between manufacturers.

Lifetime

Good quality modules with the appropriate IEC certification have a design life in excess of 25 years. Beyond 30 years, increased levels of degradation may be expected. The lifetime of crystalline modules has been proven in the field. Thin film technology lifetimes are currently unproven and rely on accelerated lifetime laboratory tests, but are expected to be in the order of 25-30 years also. The module data sheet format and the information that should be included have been standardized and are covered by EN 50380, which is the "data sheet and nameplate information for photovoltaic modules". An example of the information expected in a data sheet is provided in the table below.

Table 3.2: Comparison of Module Technical Specifications

Manufacturer	Xxxx
Module Model	Xxxx
Nominal power (P_{MPP})	210 Wp
Power tolerance	±3%
Voltage at PMAX (V_{MPP})	26.5V
Current at PMAX (I_{MPP})	7.93 A
Open circuit voltage (V_{OP})	33.2 V
Short circuit current (I_{SC})	8.54A
Maximum system voltage	1000 VDC
Module efficiency	14.33%
Operating temperature	-40°C to +85°C
Temperature coefficient of P_{MPP}	-0.41%/°C
Dimension	1480×990×50 mm
Module area	1.47 m2
Weight	18KG
Maximum load	5400 Pa
Product warranty	5 years
Performance guarantee	90%: after 10 years; 80%: after 25 years

Inverters Considerations

No single inverter concept is best for all situations. Thus, in practice, the local conditions and the system components were taken into account to tailor the system for the specific application. Different solar PV module technologies and layouts may suit different inverter types. So care was taken in the integration of modules and inverters to ensure optimum performance and lifetime. Among the major selection criteria for inverters, the financial incentive scheme and the DC-AC conversion efficiency are major inverter selection criteria, directly affecting the annual revenue of the solar PV plant.

Efficiency varies according to a number of factors. Among these, DC input voltage and percentage load are the two dominant factors. Several other factors informed inverter selection, including site temperature, product reliability, maintainability, serviceability and total cost of ownership. A thorough financial analysis was carried out determine the most cost-effective inverter option. Many of the inverter selection criteria listed in **Table 3.3** will be considered by NSF in the choice of inverter for this project.

Table 3.3: Inverter Selection Criteria

Incentive scheme	Banding of financial incentive mechanisms may have an influence on the choice of inverter. For example, feed-in tariff (FiT) schemes might be tiered for different plant sizes which may, in turn, influence the inverter size.
Project size	Size influences the inverter connection concept. Central inverters are commonly used in large solar PV plants.
Performance	High efficiency inverters should be sought. The additional yield usually more than compensates for the higher initial cost. The way the efficiency has been defined should be carefully considered. Consideration must also be given to the fact that efficiency changes with DC input voltage, percentage of load, and several other factors.
MPP range	A wide MPP range allows flexibility and facilitates design.
3-phase or single phase output	National electrical regulations might set limits on the maximum power difference between the phases in the case of an asymmetrical load. For example, this limit is 4.6 kVA in the German regulations.

Table 3.3: Inverter Selection Criteria cnt'd.

Module technology	The compatibility of thin-film modules with transformer-less inverters should be confirmed with manufacturers.
National and international regulations	A transformer inverter must be used if galvanic isolation is required between the DC and AC sides of the inverter.
Grid code	The grid code affects inverter sizing and technology. The national grid code might require the inverters to be capable of reactive power control. In that case, over-sizing inverters slightly could be required. The grid code also sets requirements on THD, which is the level of harmonic content allowed in the inverter's AC power output.
Product reliability	High inverter reliability ensures low downtime and maintenance and repair costs. If available, inverter mean time between failures (MTBF) figures and track record should be assessed.
Module supply	If modules of different specifications are to be used, then string or multi-string inverters are recommended, in order to minimise mismatch losses.
Maintainability and serviceability	Ease of access to qualified service and maintenance personnel, and availability of parts is an important dimension to consider during inverter selection. This may favour string inverters in certain locations.
System availability	If a fault arises with a string inverter, only a small proportion of the plant output is lost. Spare inverters could be kept locally and replaced by a suitably trained electrician. With central inverters, a large proportion of the plant output would be lost (for example, 100 kW) until a replacement is obtained.
Modularity	Ease of expanding the system capacity and flexibility of design should be considered when selecting inverters.
Shading conditions	For sites with different shading conditions or orientations, string inverters might be more suitable.
Installation location	Outdoor/indoor placement and site ambient conditions influence IP class and cooling requirements.
Monitoring/recording/telemetry	Plant monitoring, data logging, and remote control requirements define a set of criteria that must be taken into account when choosing an inverter.

The guarantee offered for inverters varies among manufacturers. A minimum guarantee of two years is typical, with optional extensions of up to twenty years or more. A 2009 survey of inverters showed that only one inverter manufacturer in the 100-500 kW range offers a guarantee longer than 20 years. While many manufacturers quote mean time between failures (MTBF) of 20 years or more, real world experience shows that inverters generally need to be replaced every five to ten years. Based on a 2006 study, investment in a new inverter is required three to five times over the life of a PV system. Inverter protection should include:

- Incorrect polarity protection for the DC cable.
- Over-voltage and overload protection.
- Islanding detection for grid connected systems (depends on grid code requirements).
- Insulation monitoring.

The inverter of choice is accompanied by the appropriate type test certificates, which are defined by the national and international standards applicable for the project and country (in this case, Nigeria). The inverter datasheet format and the information that should be included have been standardized for photovoltaic inverters. An example of the information expected in a datasheet is provided in **Table 3.4**.

Table 3.4: Inverter Specification

Model		XXX
Manufacturer		XXX
Type (e.g. string, central, etc)		String
DC	Maximum power	21.2 kW
	MPPT range	480…800 V
	Maximum voltage	1000 V
	Maximum current	41 A
AC	Rated power	19.2 kW
	Maximum power	19.2 kW
	Grid connection	3 AC 400 V + N, 50 – 60 Hz
	Maximum current	29A
	Cos**φ** (DPF)	1 (±0.9 on demand)
	THD	<2.5%
	Maximum efficiency	98.2%
	European efficiency	97.8%
	Internal consumption during night-time	
Transformer present		No
Cooling		Natural convection
Dimensions (WxHxD)		530 x 601 x 277 mm
Weight		41Kg
Working environment		-25…+55°C, up to 2000 m above sea level (ASL)
IP rating		IP 65 as per EN 60259
Warranty		3 years (basic); can be extended to 20 years
Standards compliance		EN 61000-6-4:2007, EN 61000-6-2:2005, DIN IEC 721-3-3, VDE 0126-1-1
Certificates		CE, UL, CSA

Mounting Structures Considerations

Mounting structures will typically be fabricated from steel or aluminum, although there are examples of systems based on wooden beams. The quality of mounting structure that will be chosen by NSF will:

- Have undergone extensive testing to ensure the designs meet or exceed the load conditions experienced at the site.
- Allow the desired tilt angle to be achieved within a few degrees.
- Allow field adjustments that may reduce installation time and compensate for inaccuracies in placement of foundations.
- Minimize tools and expertise required for installation.
- Adhere to the conditions described in the module manufacturer's installation manual.
- Allow for thermal expansion, using expansion joints where necessary in long sections, so that modules do not become unduly stressed.

Purchasing good quality structures from reputable manufacturers is generally a low-cost, low-risk option. Some manufacturers provide soil testing and qualification in order to certify designs for a specific project location.

Alternatively, custom-designed structures may be used to solve specific engineering challenges or to reduce costs. If this route is chosen, it is important to consider the additional liabilities and cost for validating structural integrity. This apart, systems should be designed to ease installation. In general, installation efficiencies can be achieved by using commercially available products.

The topographic conditions of the site and information gathered during the geotechnical survey will influence the choice of foundation type. This, in turn, will affect the choice of support system design as some are more suited to a particular foundation type.

Foundation options that will be considered by NSF for the ground-mounted PV systems include:

- **Concrete piers cast in-situ –** These are most suited to small systems and have good tolerance to uneven and sloping terrain. They do not have large economies of scale.
- **Pre-cast concrete ballasts –** This is a common choice for manufacturers having large economies of scale. It is suitable even at places where the ground is difficult to penetrate due to rocky outcrops or subsurface obstacles. This option has low tolerance to uneven or sloping terrain but requires no specialist skills for installation. Consideration must be given to the risk of soil movement or erosion.
- **Driven piles –** If a geotechnical survey proves suitable, a beam or pipe driven into the ground can result in low-cost, large scale installations that can be quickly implemented. Specialist skills and pile driving machinery are required; these may not always be available.
- **Earth screws –** Helical earth screws typically made of steel have good economics for large scale installations and are tolerant to uneven or sloping terrain. These require specialist skills and machinery to install.

The warranty supplied with support structures varies but may include a limited product warranty of 10 years and a limited finish warranty of five years or more. Warranties could include conditions that all parts are handled, installed, cleaned and maintained in the appropriate way, that the dimensioning is made according to the static loads and the environmental conditions are not unusual. The useful life of fixed support structures, though dependent on adequate maintenance and corrosion protection, could be expected to be beyond 25 years.

Tracker warranties vary between technologies and manufacturers but a 5-10 year guarantee on parts and workmanship may be typical. Tracking system life expectancy depends on appropriate maintenance. Key components of the actuation system such as bearings and motors may need to be serviced or replaced within the planned project life. Steel driven piles should be hot-dip galvanized to reduce corrosion. In highly corrosive soil, additional protection such as epoxy coating may be necessary in order to last the 25-35 year design life.

3.10 Layout and Shading Considerations

The general layout of the plant and the distance chosen between rows of mounting structures was selected according to the specific site conditions. The area available to develop the plant may be constrained by space and may have unfavorable geological or topographical features. The aim of the layout design is to minimise cost while achieving the maximum possible revenue from the plant. In general this will mean:

1. Designing row spacing to reduce inter-row shading and associated shading losses.
2. Designing the layout to minimise cable runs and associated electrical losses.
3. Creating access routes and sufficient space between rows to allow movement for maintenance purposes.
4. Choosing a tilt angle that optimizes the annual energy yield according to the latitude of the site and the annual distribution of solar resource.
5. Orientating the modules to face a direction that yields the maximum annual revenue from power production. In the northern hemisphere, this will usually be true south.

Computer simulation software will used to help design the plant layout. Such software includes algorithms which describe the celestial motion of the sun throughout the year for any location on earth, plotting its altitude and azimuth angle on a sun-path. This, along with information on the module row spacing, was used by NSF to do the following:

1. Calculate the degree of shading; and
2. Simulate the annual energy losses associated with various configurations of tilt angle, orientation and row spacing.

3.10.1 General Layout

Minimising cable runs and associated electrical losses may suggest positioning an LV/MV station centrally within the plant. If this option is chosen, then adequate space should be allocated to avoid the possibility of the station shading modules behind it. The NSF plant layout will allow adequate distance from the perimeter fence to prevent shading. It will also incorporate access routes for maintenance staff and vehicles at appropriate intervals.

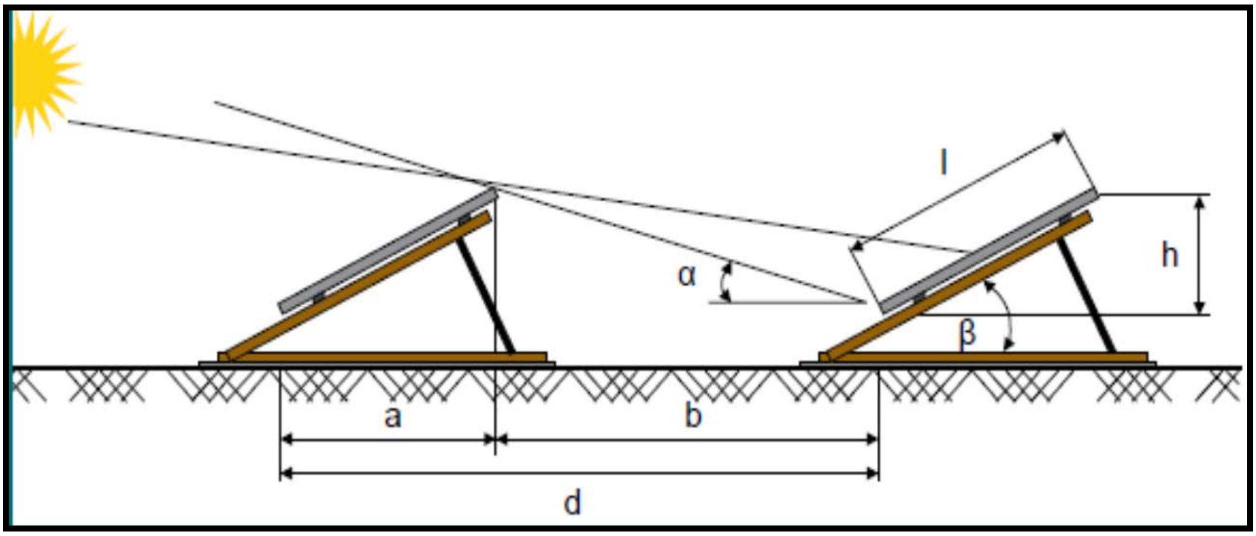
3.10.2 Tilt Angle

Every location will have an optimal tilt angle that maximizes the total annual irradiation (averaged over the whole year) on the plane of the collector. For fixed tilt grid connected power plants, the theoretical optimum tilt angle may be calculated from the latitude of the site. However, adjustments may need to be made to account for:

- **Soiling –** Higher tilt angles have lower soiling losses. The natural flow of rainwater cleans such modules more effectively.
- **Shading –** More highly tilted modules provide more shading on modules behind them. As shading impacts energy yield much more than may be expected simply by calculating the proportion of the module shaded, a good option (other than spacing the rows more widely apart) is to reduce the tilt angle. It is usually better to use a lesser tilt angle as a trade-off for loss in energy yield due to inter-row shading.
- **Seasonal irradiation distribution –** If a particular season dominates the annual distribution of solar resource (monsoon rains, for example), it may be beneficial to adjust the tilt angle to compensate for the loss. Simulation software is able to assess the benefit of this.

3.10.3 Inter-Row Spacing

The choice of row spacing is a compromise chosen to reduce inter-row shading while keeping the area of the PV plant within reasonable limits, reducing cable runs and keeping ohmic losses within acceptable limits. Inter-row shading can never be reduced to zero: at the beginning and end of the day the shadow lengths are extremely long. **Figure 3.7** illustrates the angles that must be considered in the design process.



Source: Schletter GmbH

Figure 3.7: Shading Angle Diagram

The shading limit angle α is the solar elevation angle beyond which there is no inter-row shading on the modules. If the elevation of the sun is lower than α then a proportion of the module will be shaded. Alongside, there will be an associated loss in energy yield. The shading limit angle may be reduced either by reducing the tilt angle β or increasing the row pitch d. Reducing the tilt angle below the optimal is sometimes a choice as this may give only a minimal reduction in annual yield. The ground cover ratio (GCR), given by l/d (see **Figure 3.7**), is a measure of the PV module area compared to the area of land required. For many locations a design rule of thumb is to space the modules in such a way that there is no shading at solar noon on the winter solstice (December 21st in the northern hemisphere). In general, if there is less than a 1% annual loss due to shading, then the row spacing may be deemed acceptable.

Detailed energy yield simulations will be carried out to assess losses due to shading, and to obtain an economic optimization that also takes into account the cost of land if required.

3.10.4 Orientation

In the northern hemisphere, the orientation that optimizes the total annual energy yield is true south. In the tropics, the effect of deviating from true south may not be especially significant. Some tariff structures encourage the production of energy during hours of peak demand. In such "time of day" rate structures, there may be financial (rather than energy yield) benefits of orientating an array that deviates significantly from being optimized to generate power in the afternoon. The effect of tilt angle and orientation on energy yield production will be modeled using simulation software.

3.11 Electrical Design Considerations

For most large solar PV plants, reducing the levelised cost of electricity is the most important design criteria. Every aspect of the electrical system (and of the project as a whole) will be scrutinized and optimized. The potential economic gains from such an analysis are much larger than the cost of carrying it out.

It is important to strike a balance between cost savings and quality. Engineering decisions should be 'careful' and 'informed' decisions. Otherwise, design made with a view to reduce costs in the present could lead to increased future costs and lost revenue due to high maintenance requirements and low performance. The design of this project will be judged on a case-by-case basis, as each site poses unique challenges and constraints. While general guidelines and best practices can be formulated, there are no "one-size-fits all" solutions. While the recommendations in the following sections are based on solar PV plants with centralized inverter architectures, many of the concepts discussed also apply to plants with string inverters.

The Nigerian and applicable international codes and regulations will be consulted and followed, to ensure that the installation is safe and compliant.

3.11.1 DC System

The DC system comprises the following:

- Array(s) of PV modules.
- DC cabling (module, string and main cable).
- DC connectors (plugs and sockets).
- Junction boxes/combiners.
- Disconnectors/switches.
- Protection devices.
- Earthing.

When sizing the DC component of the plant, the maximum voltage and current of the individual strings and PV array(s) were calculated using the maximum output of the individual modules. Simulation programs were used to help with sizing but their results were cross checked manually.

For mono-crystalline and multi-crystalline silicon modules, all DC components are rated as follows, to allow for thermal and voltage limits:

- Minimum Voltage Rating: $V_{OC(STC)}$ ×1.15
- Minimum Current Rating: $I_{SC(STC)}$ ×1.25

The multiplication factors used above (1.15 and 1.25) are location-specific and cover the maximum voltage and current values that can be expected under UK conditions of irradiance. While different multiplication factors may apply for Nigeria, national standards were consulted. For non-crystalline silicon modules, DC component ratings were calculated from manufacturer's data, taking into account the temperature and irradiance coefficients. In addition, certain modules have an initial settling-in period, during which the V_{OC} and I_{SC} output they produce is much higher than that given by standard multiplication factors. So, this effect was also taken into consideration. Whenever in doubt, the manufacturer will be consulted for advice.

PV Array Design

The design of a PV array depends on the inverter specifications and the chosen system architecture besides the specific context and conditions of use. Using many modules in series in high voltage arrays minimizes ohmic losses. However, safety requirements, inverter voltage limits and national regulations also will be considered.

- **Maximum number of modules in a string –** The maximum number of modules in a string is defined by the maximum DC input voltage of the inverter to which the string will be connected to ($V_{Max\ (Inv,\ DC)}$). Under no circumstances will this voltage be exceeded. Crossing the limit can decrease the inverter's operational lifetime or render the device inoperable. The highest module voltage that can occur in operation is the open-circuit voltage in the coldest daytime temperatures at the site location. Design rules of thumb for Europe use – 10°C as the minimum design temperature, but this may vary according standard in Nigeria. The maximum number of modules in a string (n_{Max}) may therefore be calculated using the formula:

$$V_{OC(Module)@Coldest\ Module\ Operating\ Temperature} \times N_{Max} < V_{Max(Inv,\ DC)}$$

- **Minimum number of modules in a string –** The minimum number of modules is governed by the requirement to keep the system voltage within the MPPT range of the inverter. If the string voltage drops below the minimum MPP inverter voltage, then the system will underperform. In the worst case, the inverter may shut down. The lowest expected module voltage occurs during the highest operating temperature conditions. Design rules of thumb for Europe use 70°C as the design benchmark, but this may vary according to site (Nigeria) conditions. The minimum number of modules in a string (n_{Min}) may therefore be calculated using the formula:

$$V_{MPP(Module)\ @Highest\ Module\ Operating\ Temperature} \times N_{Min} > V_{MPP(Inv\ Min)}$$

- **Voltage optimization –** As the inverter efficiency is dependent on the operating voltage, it is preferable to optimize the design by matching the array operating voltage and inverter optimum voltage as closely as possible. This will require voltage dependency graphs of inverter efficiency (see example in **Figure 3.8**). If such graphs are not provided by inverter manufacturers, they may be obtained from independent sources. Substantial increases in the plant yield can be achieved by successfully matching the operating voltages of the PV array with the inverter.

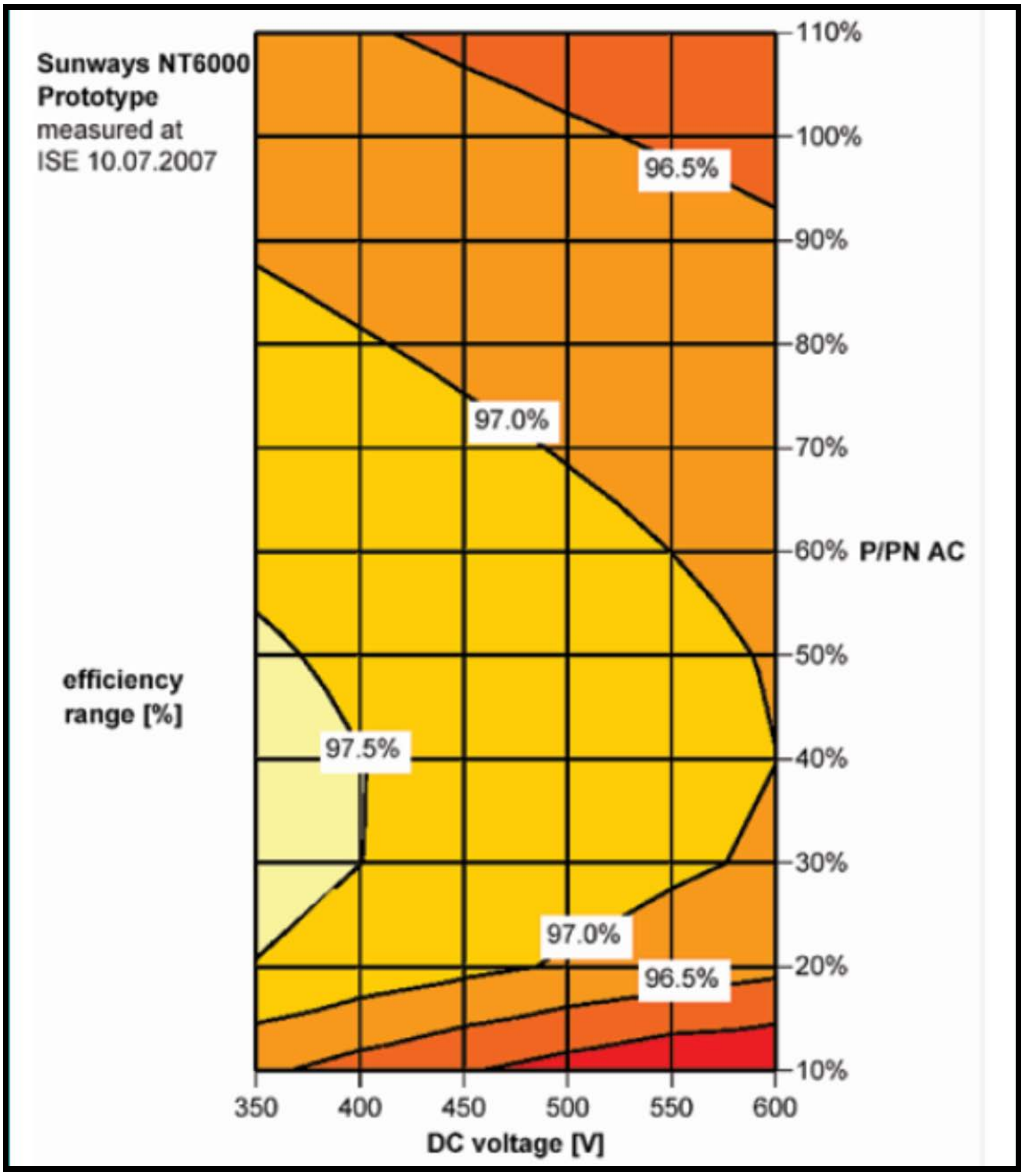


Figure 3.8: Voltage and Power Dependency Graph of Inverter Efficiency

- **Number of strings –** The maximum number of strings permitted in a PV array is a function of the maximum allowable PV array current and the maximum inverter current. This limit will not be exceeded as it leads to premature inverter ageing and yield loss.

Inverter Sizing

It is not possible to formulate an optimal inverter sizing strategy that applies in all cases. Project specifics such as the solar resource and module tilt angle play a very important role when choosing a design. While the rule of thumb has been to use an inverter-to-array power ratio less than unity, this is not always the best design approach. For example, this option might lead to a situation where the inverter manages to curtail power spikes not anticipated by irradiance profiles (based on one hour data). Or, it could fail to achieve grid code compliance in cases where reactive power injection to the grid is required. The optimal sizing is, therefore, dependent on the specifics of the plant design.

Guidance on inverter and PV array sizing can be obtained from the inverter manufacturers, who offer system sizing software. Such tools also provide an indication of the total number of inverters required. The following factors will be assessed when sizing the inverter for the NSF proposed project:

- The maximum VOC in the coldest daytime temperature must be less than the inverter maximum DC input voltage ($V_{Inv,\ DC\ Max}$).
- The inverter must be able to safely withstand the maximum array current.
- The minimum VOC in the hottest daytime temperature must be greater than the inverter DC turn-off voltage ($V_{Inv,\ DC\ Turn\text{-}Off}$).
- The maximum inverter DC current must be greater than the PV array(s) current.
- The inverter MPP range must include PV array MPP points at different temperatures.
- When installed, some thin film modules produce a voltage greater than the nominal voltage. This happens for a period of time until initial degradation has occurred, and must be taken into account to prevent the inverter from being damaged.
- Grid code requirements: for example, reactive power injection.
- The operating voltage should be optimized for maximum inverter efficiency.
- Site conditions of temperature and irradiation profiles.
- Economics and cost-effectiveness.

Inverters with reactive power control are recommended. Inverters can control reactive power by controlling the phase angle of the current injection. Moreover, aspects such as inverter ventilation, air-conditioning, lighting and cabinet heating must be considered. When optimizing the voltage, it should be borne in mind that the inverter efficiency is dependent on voltage. Specification sheets and voltage dependency graphs are required for efficient voltage-matching.

Cable Selection and Sizing

The selection and sizing of DC cables for solar PV plants will take into account national codes and regulations applicable to each country. Cables specifically designed for solar PV installations (“solar” cables) are readily available and will be used. In general, three criteria will be observed by NSF when sizing cables:

1. **The cable voltage rating.** The voltage limits of the cable—to which the PV string or array cable will be connected—must be taken into account. Calculations of the maximum VOC voltage of the modules, adjusted for the site minimum design temperature, are used for this calculation.
2. **The current carrying capacity of the cable.** The cable will be sized in accordance with the maximum current. De-rating will be done appropriately, taking into account the location of cable, the method of laying, number of cores and temperature. Care will be taken to size the cable for the worse case of reverse current in an array.
3. **The minimisation of cable losses.** The cable voltage drop and the associated power losses will be as low possible. Normally, the voltage drop must be less than 3%, but Nigerian regulations will be consulted for guidance. Cable losses of less than 1% are achievable.

In practice, the minimisation of voltage drop and associated losses will be the limiting factor in most cases.

Cable Management

DC cabling consists of module, string and main cables. Issues such as routing the main cables, and proper laying and trenching will be considered in the detailed design of the solar PV plant. Additionally, management of over-ground cables (for example, module cables) also needs attention. Importantly, these cables will be properly routed and secured to facilitate commissioning and troubleshooting. Proper management ensures that cables are properly protected from inclement weather and extraneous factors (for example, abrasion on the sharp edges of the support structures). A number of cable connection systems are available. These are:

- Screw terminals.
- Post terminals.
- Spring clamp terminals.
- Plug connectors.

Plug connectors have become the standard in grid connected solar PV plants, due to the benefits they offer in terms of installation ease and speed. These connectors are normally touch-proof (can be touched without risk of shock), and provide safety to module connections.

Module and String Cables

For module cables the following should apply:

Minimum Voltage Rating = $V_{OC(STC)} \times 1.15$
Minimum Current Rating = $I_{SC(STC)} \times 1.25$

The cables will be rated to the highest temperature they may experience (for instance, 80°C). Appropriate de-rating factors for temperature, installation method and cable configuration will also be applied. Single conductor, double insulation cables are preferable for module connections. Using such cables helps protect against short-circuits. When sizing string cables, the number of modules and the number of strings per array will be considered. The number of modules defines the voltage at which the cable will rated. The number of strings will be used to calculate the maximum reverse current that can flow through a string—especially, in case of a fault when there are no string-fuses. In an array comprising of N strings connected in parallel and M modules in each string, as shown in **Figure 3.9**, sizing of cables will be based on the following:

- Array with no string fuses (applies to arrays of three or fewer strings only).

  Voltage: $V_{OC\ (STC)} \times M \times 1.15$
  Current: $I_{(SC(STC))} \times (N - 1) \times 1.25$

- Array with string fuses.

  Voltage Rating = $V_{OC(STC)} \times M \times 1.15$
  Current Rating = $I_{SC(STC)} \times 1.25$

Usually, single conductor, halogen-free cables are preferred. If there is a high risk of lightning, cables will be screened. Opting for “solar” cables will be advisable, as they are designed to meet the relevant requirements.

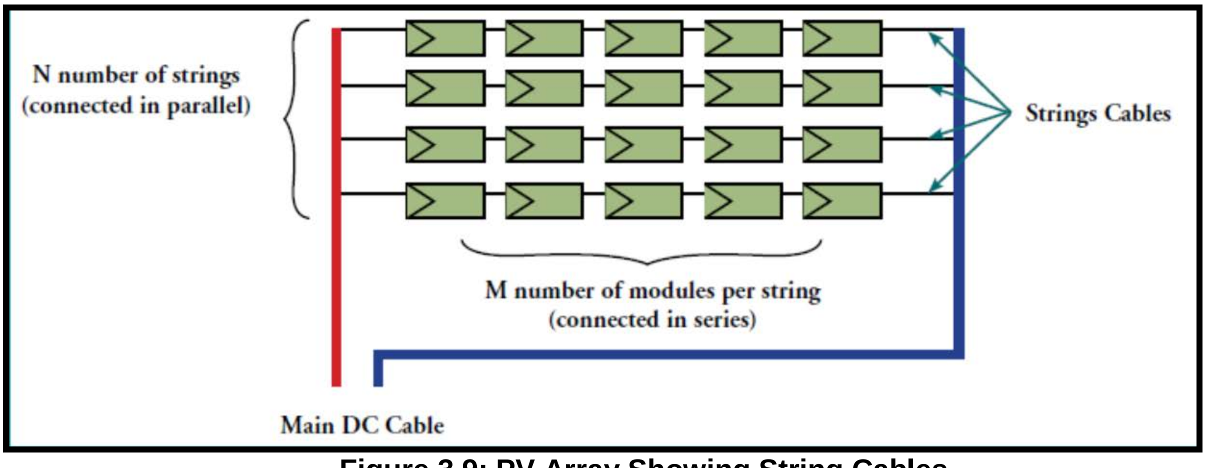


Figure 3.9: PV Array Showing String Cables

Main DC Cable
The formulae that guide the sizing of main DC cables running from the PV array to the inverter, for a system as shown in **Figure 3.10**, are given below:

Minimum Voltage Rating = $V_{OC\ (STC)} \times M \times 1.15$

Minimum Current Rating = $I_{SC\ (STC)} \times N \times 1.25$

In order to reduce losses, the overall voltage drop between the PV array and the inverter (at STC) will be minimised. A benchmark voltage drop of less than 3% will be considered suitable, and cables will be sized to reflect this benchmark. Over-sizing cables to achieve lower losses will be a worthwhile investment, since the allocated price for solar PV energy is usually much higher than the normal market price (due to incentive schemes such as FiTs). The increased costs for higher cross section cables are thus amortized much faster.

Junction Boxes
Junction boxes or combiners are needed at the point where the individual strings forming an array are marshaled and connected together in parallel before leaving for the inverter through the main DC cable. Junctions are usually made with screw terminals and must be of high quality to ensure lower losses and to prevent overheating. Junction boxes have protective and isolation equipment like string fuses and disconnects (also known as load break switches), and must be rated for outdoor placement using, for example, ingress protection (IP) 65. An explanation of the IP (International Protection Rating) bands is provided in **Table 3.5.** Depending on the solar PV plant architecture and size, multiple levels of junction boxes can be used.

Table 3.5: Definition of Ingress Protection (IP) Ratings

Example: IP65 1st digit 6 (Dust tight) 2nd digit 5 (Protected against water jets)			
1st digit	Protection from solid objects	2nd digit	Protection from moisture
0	Non-protected	0	Non-protected
1	Protection against solid objects greater than 50 mm	1	Protected against dripping water
2	Protection against solid objects greater than 12 mm	2	Protected against dripping water when tilted
3	Protection against solid objects greater than 2.5 mm	3	Protected against spraying water
4	Protection against solid objects greater than 1.0 mm	4	Protected against splashing water
5	Dust protected	5	Protected against water jets
6	Dust tight	6	Protected against heavy seas
		7	Protected against immersion
		8	Protected against submersion

Since the DC side of a PV system cannot be switched off and that the terminals remain live during the day. Therefore clear and visible warning signs will be provided to inform anyone operating on the junction box. Furthermore, all junction boxes will be properly labeled as per national regulations for safety. As a precaution, disconnects and string fuses will be provided. Disconnects permit the isolation of individual strings, while string fuses protect against faults, as discussed in **Section 3.11.1.10**. Disconnects shall be capable of breaking normal load and will be segregated on both the positive and negative string cables. To ensure protection against short-circuits, the following will be ensured:

- The junction box enclosure is fabricated from nonconductive material.
- The positive and negative bus bars are adequately separated and segregated.

- The enclosure layout will be such that short-circuits during installation and maintenance are extremely unlikely.

The system will be designed so that the main DC cable exiting the junction box can easily transition to a trench.

Connectors

Specialized plug and socket connections for PV applications have been developed, and are normally pre-installed to module cables to facilitate assembly. These plug connectors, which provide secure and touch-proof connections, are currently the preferred choice. Connectors will be correctly rated and used for DC applications. As a rule, the connector current and voltage ratings will be at least equal to those of the circuit they are installed on.

Connectors shall carry appropriate safety signs that warn against disconnection under load. Such an event can lead to arcing (producing a luminous discharge across a gap in an electrical circuit), and put personnel and equipment in danger. Any disconnection shall take place only after the circuit has been properly isolated. In order to avoid errors during installation, the design of DC connectors will be incompatible with AC connectors.

String Fuses

The main function of string fuses is to protect strings from over-currents. They must be designed for DC operation. Miniature fuses are normally used in PV applications. The Nigerian National codes and regulations will be consulted when selecting and sizing fuses. The following guidelines apply to string fuses:

- All arrays formed of four or more strings should be equipped with fuses. Alternatively, fuses should be used where fault conditions could lead to significant reverse currents.
- In most cases, string fuses can be omitted in arrays with three or fewer series connected strings. However, the string cables must be rated to withstand the highest reverse currents expected. The system

Designer will also consult the module manufacturer to ensure the module can withstand these reverse currents. Importantly, while it might not be necessary to fit fuses in systems consisting of two or three strings, it might still be beneficial to do so as this can facilitate testing and tracing of faults.

- Since faults can occur on both the positive and negative sides, fuses must be installed on all unearthed cables.
- To avoid nuisance tripping, the nominal current of the fuse should be at least 1.25 times greater than the nominal string current. Overheating of fuses can also cause nuisance tripping. For this reason, junction boxes should be kept in the shade.
- The string fuse must trip at less than twice the string short-circuit current at STC or at less than the string cable current carrying capability, whichever is the lower value.
- The trigger current of string fuses should be taken into account when sizing string cables. It should not be larger than the current at which the string cable is rated.
- The string fuse must be rated for operation at the string voltage using the formula:

$$\text{String Fuse Voltage Rating} = V_{OC(STC)} \times M \times 1.15$$

Miniature circuit breakers (MCBs) can also be used for over current protection, but they are less common than fuses due to their higher cost. Blocking diodes were commonly used in the past for circuit protection. However, string fuses are currently preferred as they serve the same function more efficiently.

DC Switching

DC switching is installed in the DC section of a solar PV plant to provide protection and isolation capabilities. DC switches/disconnects and DC circuit breakers are discussed below.

DC Switches/Disconnects – Judicious design practice calls for the installation of switching devices in PV array junction boxes. DC switches provide a means of manually electrically isolating entire PV arrays, which is required during installation and maintenance. DC switches must be:

- Double pole to isolate both the positive and negative PV array cables.
- Rated for DC operation.
- Capable of breaking under full load.
- Rated for the system voltage and maximum current expected.
- Equipped with proper safety signs.

DC Circuit Breaker – String fuses cannot be relied upon for disconnection of supply in case of fault conditions. This is due to the fact that PV modules are current-limiting devices, with a short-circuit current only a little higher than the nominal current. In other words, the fuse would not blow since the fault current would be less than the trigger current. For this reason, most PV codes and regulations recommend that main DC circuit breakers (CB) should be installed between the PV array fields and the grid connected inverters. Certain inverter models are equipped with DC CBs. As such, installation of additional circuit breakers may become redundant. However, national regulations must be consulted to confirm the standards.

Quality Benchmarks

Module cables must:

- Have a wide temperature range (-55 to 125°C).
- Be resistant to ultraviolet (UV) radiation and weather if laid outdoors without protection.
- Be single core and double insulated.
- Have mechanical resistance (animal proof, compression, tension and bending). Apart from these, the risk of earth faults and short circuits should be minimised. Consequently, cable runs should be kept as short as possible. The following cable options are preferable because they offer increased protection:
- Single conductor cable – insulated and sheathed. For example, properly rated HO7RNF cables.
- Single conductor cable in suitable conduit/trunking.
- Multi core Steel Wire Armoured (SWA) – only suitable for main DC cables and normally used where an underground or exposed run is required.

3.11.2 AC System

AC Cabling

Cabling for AC systems will be designed to provide a safe, economic means of transmitting power from the inverters to the transformers and beyond. Cables will be rated for the operating voltage. They will also have conductors and screens sized for operating currents and short circuit currents. The cable chosen will be specified correctly. The following will be considered when designing the cabling:

- The cable must be rated for the maximum expected voltage.
- The conductor should be able to pass the operating and short circuit currents safely.
- The conductor will be sized appropriately to ensure that losses produced by the cable are within acceptable limits, and that the most economic balance is maintained between capital cost and operational cost (losses).
- The conductors will be sized to avoid voltage drop outside statutory limits and equipment performance.

- Insulation will be adequate for the environment of installation.
- Either copper or aluminum conductors will be chosen.
- A suitable number of cores will be chosen (either single or multi-core).
- Earthing and bonding will be suitably designed for the project application.
- The installation method and mechanical protection of the cable will be suitably designed for the project.

Cables will comply with relevant IEC standards or national standards. Examples of these include:
- IEC 60502 for cables between 1 kV and 36 kV.
- IEC 60364 for LV cabling (BS 7671 in UK).
- IEC 60840 for cables rated for voltages above 30 kV and up to 150 kV.

AC Switchgear

Appropriately rated switchgear and protection systems will be provided throughout the electrical system to ensure disconnection, isolation, earthing and protection for the various components of the plant. On the output side of the inverters, provision of a switch disconnector will be recommended as a means to isolate the PV array. Other switchgear may be required, depending on the size and set up of the electrical infrastructure in the solar plant. Switchgear type will largely be dependent on the voltage of operation. Switchgear up to 33 kV is likely to be an internal metal clad cubicle type. Also, it will have gas – or air-insulated bus bars, and vacuum or SF6 breakers. For higher voltages, the preferred choice will most likely be air-insulated outdoor switchgear or, if space is an issue, gas-insulated indoor switchgear.

All switchgear will:
- Be in accordance with relevant IEC and national standards.
- Have the option to be secured by locks in off/ earth positions.
- Clearly show the ON and OFF positions with appropriate labels.
- Be rated for operational and short circuit currents.
- Be rated for the correct operational voltage.
- In the case of HV switchgear, have remote switching capability.
- Be provided with suitable earthing.

HV switching is a hazardous procedure, and safety measures to minimise risk will be adopted as good practice.

Sizing and Selecting Transformers

The purpose of transformers in a solar power plant is to provide suitable voltage levels for transmission across the site and for export to the grid. In general, the inverters supply power at LV. But for a commercial solar power plant, grid connection is typically made at upwards of 11 kV (HV levels). It will therefore be necessary to step up the voltage using a transformer between the inverter and the grid connection point. **Figure 3.11** shows a high level single line diagram showing typical voltages of operation for the AC system of a solar power plant.

Selection and specification – The selection of an appropriate transformer will consider several basic issues. These include the required size of the transformer, its position within the electrical system, and the physical location of installation. The size of the transformer, which will depend on the projected maximum power exported from the solar array, will be specified in MVA. Power would generally be expected to flow from the solar arrays to the grid. To prepare for the reverse case (a need to supply power back to the plant), this will be specified or an auxiliary transformer used. The position of the transformer in the electrical system will define the required voltage levels on the primary and secondary sides of the transformer. Tertiary supplies for substation auxiliary services and/or harmonic mitigation will also be considered. In addition, the physical location and the anticipated environmental conditions will need to be specified.

International and national standards will be specified as required. The requirements for power transformers are defined in IEC 60076. Other issues that will be consider when designing and specifying a transformer may also include:

- Tap setting requirements.
- Cooling medium.
- Earthing.
- Winding connections.
- Number of windings.
- Requirement for redundancy/spare transformer.
- Losses.
- Bushings for connection of cabling and overhead lines.
- Transformer trip and warning alarms.

Choosing a reputable manufacturer to carry out the detailed design and manufacture will ensure that the transformer provided is of the required standard. There are, of course, many other parameters and design considerations that could be specified.
Losses – Transformers can lose energy through magnetising current in the core, known as iron losses and copper losses in the windings. Minimising the losses in a transformer is a key requirement as this will increase the energy supplied to the grid and, as a result, enhance the revenue of the solar power plant.

Test Requirements – Transformers will be subject to a number of routine and type tests performed on each model manufactured; these tests are set out in IEC 60076. The manufacturer also may be requested to undertake special tests mentioned in IEC 60076.

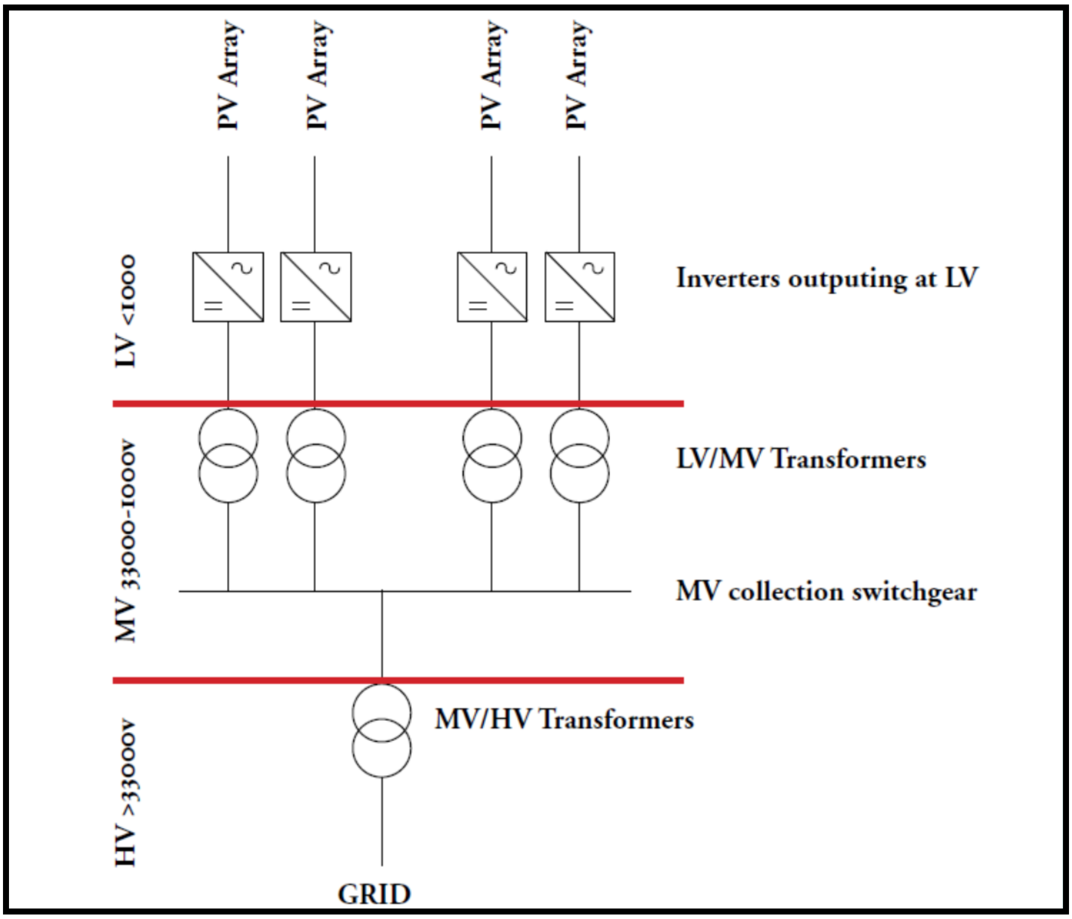


Figure 3.10: Typical Transformer Locations where Export to Grid is at HV

Delivery and Commission – Consideration will be given to the period of time required for manufacture and delivery of transformers. Most large transformers will be designed and built on order, and will therefore have a lengthy lead time, which can stretch to several years. The delivery of large transformers to the site can also be a problem. Large transformers can be broken down to some extent, but the tank containing the core and winding will always need to be moved in one piece. In the case of transformers around the 100 MVA size, the burden of transportation will still be significant and road delivery may require special measures such as police escort.

The positioning of the transformer in the power plant will also be decided at the planning stage. By doing this, a transformer can be easily and safely installed, maintained and—in the event of a failure—replaced. Liquid-filled transformers will be provided with a bund to catch any leakage. Oil-filled transformers, if sited indoors, are generally considered a special fire risk. As such, measures to reduce the risk to property and life will be considered.

Substation

The substation houses the primary and secondary electrical equipment for the central operation of the solar plant and connection to the local electricity grid. The substation can also provide an operational base for staff required for operation and maintenance as well as stores or other auxiliary functions associated with the solar plant. Equipment such as the LV/MV transformers, MV switchgear, SCADA (Supervisory Control and Data Acquisition) systems, protection and metering systems can be placed within the substation.

The layout of the substation will optimize the use of space while still complying with all relevant building codes and standards. A safe working space will be provided around the plant for the operation and maintenance staff. The substation may be wholly internal or may consist of internal and external components such as transformers, HV switchgear and backup generators. Separation between MV switch rooms, converter rooms, control rooms, store rooms and offices is a key requirement, besides providing safe access, lighting and welfare facilities. In plants where the substation is to be manned, care will be taken to provide facilities like a canteen and washrooms. Where HV systems are present, an earth mat may need to be provided to obtain safe step/touch potentials and earth system faults. Earth mats will be installed prior to setting the foundation. Lightning protection will be considered to alleviate the effect of lightning strikes on equipment and buildings.

A trench is often required as a means for easing the routing of power and data cables to the substation. Where necessary, the substation may accommodate the grid company's (TCN) equipment (which might be in a separate area of the building). Additional equipment may include:

Metering – Tariff metering will be required to measure the export of power. This will be provided at the substation or at the point of connection to the grid. Current transformers and voltage transformers provided in the switchgear will be connected to metering points by screened cable.

Data Monitoring/SCADA – SCADA systems provide control and status indication for the items included in the substation and across the solar plant. The key equipment may be situated in the substation in control and protection rooms. Air conditioning will be considered due to the heat generated by the electronic equipment in the modules.

Auxiliary equipment – The design of the substation will take into account the need for auxiliary systems required for a functioning substation/control room. All auxiliary equipment will be designed to relevant standards and may include:

- LV power supplies.

- Back-up power supplies.
- Uninterruptible power supply (UPS) batteries.
- Diesel generators.
- Auxiliary transformers and grid connections.
- Telephone and internet connections.
- Lighting.
- Heating Ventilation and Air Conditioning (HVAC).
- Water supplies.
- Drainage.
- Fire and intruder alarms.

Earthing and Surge Protection

The earthing of a solar PV plant influences a number of risk parameters, namely:

- The electric shock risk to people on site.
- The risk of fire during a fault.
- The transmission of surges induced by lightning.
- The severity of Electromagnetic Interface (EMI).

The earthing of a solar PV plant encompasses the following:

- Array frame earthing.
- System earthing (DC conductor earthing).
- Inverter earthing.
- Lightning and surge protection.

Earthing will be provided as a means to protect against electric shock, fire hazard and lightning. By connecting to the earth, charge accumulation in the system during an electrical storm is prevented. The entire PV plant and the electrical room will be protected from lightning. Protection systems are usually based on early streamer emission, lightning conductor air terminals. The air terminal will be capable of handling multiple strikes of lightning current and will be maintenance-free after installation. These air terminals will be connected to respective earthing stations. Subsequently an earthing grid will be formed, connecting all the earthing stations through the required galvanized iron tapes. The earthing arrangements on the site will vary, depending on a number of factors:

- National electricity requirements.
- Installation guidelines for module manufacturers.
- Mounting system requirements.
- Inverter requirements.
- Lightning risk.

While the system designer must decide the most appropriate earthing arrangement for the solar PV plant, NSF can follow the general guidelines given below:

- Ground rods will be placed close to junction boxes. Ground electrodes will be connected between the ground rod and the ground lug in the junction box.
- A continuous earth path will be maintained throughout the PV array.
- Cable runs will be kept as short as possible.
- Surge suppression devices can be installed at the inverter end of the DC cable and at the array junction boxes.
- Both sides of an inverter will be properly isolated before carrying out any work, and appropriate safety signs should be installed as a reminder.
- Many inverter models include internal surge arrestors. Besides, separate additional surge protection devices may be required. Importantly, national codes and regulations, and the specific characteristics of each project will be taken into account.

Quality Benchmarks

The AC cable will be supplied by a reputable manufacturer accredited to ISO 9001. The cable will have:

- Certification to current IEC and national standards such as IEC 60502 for cables between 1 kV and 36 kV, IEC 60364 for LV cabling and IEC 60840 for cables rated for voltages above 30 kV and up to 150 kV.
- Type testing completed to appropriate standards.
- A minimum warranty period of two years.
- A design life equivalent to the design life of the project.
- Ultraviolet (UV) radiation and weather resistance (if laid outdoors without protection).
- Mechanical resistance (for example, compression, tension, bending and resistance to animals).

AC switchgear will be supplied by a reputable manufacturer accredited to ISO 9001 and will have:

- Certification to current IEC and appropriate national standards such as IEC 62271 for HV switchgear and IEC 61439 for LV switchgear.
- Type testing to appropriate standards.
- A minimum warranty period of two years.
- An expected lifetime at least equivalent to the design life of the project.

Transformers will be supplied by reputable manufacturers accredited to ISO 9001. They will have:

- Certification to IEC and appropriate national standards such as IEC 60076 for the power transformer, IEC 60085 for electrical insulation and IEC 60214 for tap changers.
- Type testing to appropriate standards.
- A minimum warranty period of two years.
- An expected lifetime at least equivalent to the design life of the project.
- The efficiency will be at least 96%.

3.12 Infrastructure

The NSF proposed utility scale PV power plant requires infrastructure appropriate to the specifics of the design chosen. Location has been selected in a place where buildings will not cast unnecessary shading on the PV module. It may be possible to locate the project buildings on the northern edge of the plant to reduce shading, or to locate them centrally if appropriate buffer zones are allowed for. Depending on the size of the plant, infrastructure requirements may include:

- **Office –** A portable office and sanitary room with communication devices. This will be watertight and prevent entry to insects. It will be located to allow easy vehicular access.
- **LV/MV station –** Inverters may either be placed amongst the module support structures (if string inverters are chosen) in specially designed cabinets or in an inverter house along with the medium voltage transformers, switchgear and metering system. This “LV/MV station” may be equipped with an air conditioning system if it is required to keep the electrical devices within their design temperature envelopes.
- **MV/HV station –** An MV/HV station may be used to collect the AC power from the medium voltage transformers and interface to the power grid.
- **Communications –** The plant monitoring system and the security system will require a communications medium with remote access for visibility and control of the plant. There may also be a requirement from the grid network operator (TCN) for specific telephone landlines for the grid connection. Often, an Internet broadband (DSL) or satellite communications system is used for remote access. A GSM (Global

System for Mobile Communications) connection or standard telephone line with modems is an alternative though it has a lower data transfer rate.

3.12.1 Quality Benchmarks

Some benchmark features of the proposed PV plant infrastructure include:

- Water-tight reinforced concrete stations or prefabricated steel containers.
- Sufficient space to house the equipment and facilitate its operation and maintenance.
- Inclusion of:
  - Ventilation grilles, secure doors and concrete foundations that allow cable access.
  - Interior lighting and electrical sockets.
  - Either adequate forced ventilation or air-conditioning with control thermostats, depending on environmental conditions.

3.12.2 Site Security

The proposed PV power plant represents a large financial investment. The modules are not only valuable but also portable. Efforts will be made by NSF to reduce the risk of theft and tampering. Such efforts may include:

- Reducing the visibility of the power plant by planting shrubs or trees at appropriate locations. Care will be taken that these do not shade the plant.
- Installing a wire mesh fence with anti-climb protection. A fence will also be recommended for safety reasons and may be part of the grid code requirements for public safety. Measures will be taken to allow small animals to pass underneath the fence at regular intervals.
- Security cameras, lights and microwave sensors with GSM and TCP/IP transmission of alarms and faults to a security company will be an option.
- Anti-theft module mounting bolts may be used and synthetic resin can be applied once tightened. The bolts can then only be released after heating the resin up to 300°C.
- Anti-theft module fiber systems may be used. These systems work by looping a plastic fiber through all the modules in a string. If a module is removed, the plastic fiber is broken. This triggers an alarm.
- A permanent guarding station with security guard providing the level of security required in the insurance policy.
- An alarm system fitted to the power plant gate and the medium voltage station, metering station and to any portable cabins.

3.12.2.1 Quality Benchmarks

Some benchmark security features include:

- Fence at least two meters high.
- Metallic posts installed every 6m.
- Galvanized and plastic coated fencing.
- Video surveillance:
- Multiple night and day cameras at a set distance apart.
- Illumination systems (infrared) for cameras along the perimeter of the site.
- A minimum of 12 months recording time.

3.12.3 Monitoring and Forecasting

Monitoring Technology

If high performance, low downtime and rapid fault detection is required, automatic data acquisition and monitoring technology is essential. This allows the yield of the plant to be monitored and compared with calculations made from solar irradiation data. Monitoring and comparison also help raise warnings on a daily basis if there is a shortfall. Faults can be detected and rectified before they have an appreciable effect on production. Relying solely on manual checks of performance is not advisable. A high level of technical expertise is needed to detect certain partial faults at the string level. In fact, it can take many months for reduced yield figures to be identified. The lower yield may lead to appreciable revenue loss for a utility scale PV power plant.

The key to a reliable monitoring and fault detection methodology will be to have good knowledge of the solar irradiance, environmental conditions and plant power output simultaneously. This will allow faults to be distinguished from, for example, passing clouds or low resource days. There are three main methods for obtaining the solar irradiance and environmental conditions:

- **On-site weather stations –** To measure the plane of array irradiance, module temperature and preferably horizontal global irradiance, humidity and wind speed. This is the option of preference for many current utility scale PV power plants. It allows data to be collected and compared remotely with yield figures on a daily basis for immediate fault detection.
- **Meteorological data gathered from weather satellites –** Simulation and calculation algorithms measure the projected power plant output. This figure becomes the benchmark for comparing values received from the PV plant on a daily basis, and helps detect faults immediately. This method removes the need for an onsite weather station. A number of good commercial providers of packages use this technique in Europe. Rapid fault detection depends on data being made available from satellites and being analysed quickly.
- **Local weather stations –** This is the least desirable of the three options as data may not be available for several months. During that period, the plant may lose considerable revenue if faults in the plant go undetected. It is also possible that the local weather station does not accurately track the conditions at the site (especially if it is some kilometers distant). In case there are other PV power plants in the vicinity of the site—or one large plant is split into a number of components it is possible to compare production data and identify a fault with one plant. Internet-based solutions are available that function in this manner. The on-site weather station solution is currently the most common option. Data-loggers can be used to collect data from the weather station, inverters, meters and transformers. This information is transferred once a day to a server which carries out three key functions:
  - **Operations management –** The performance management (either onsite or remote) of the PV power plant enables the tracking of inverters or strings.
  - **Alarm management –** Flagging any element of the power plant that falls outside pre-determined performance bands. Failure or error messages can be automatically generated and sent to the power plant service team via fax, email or text message.
  - **Reporting –** The generation of yield reports detailing individual component performance, and benchmarking the reports against those of other components or locations. **Figure 3.11** illustrates the architecture of an internet portal based monitoring system.

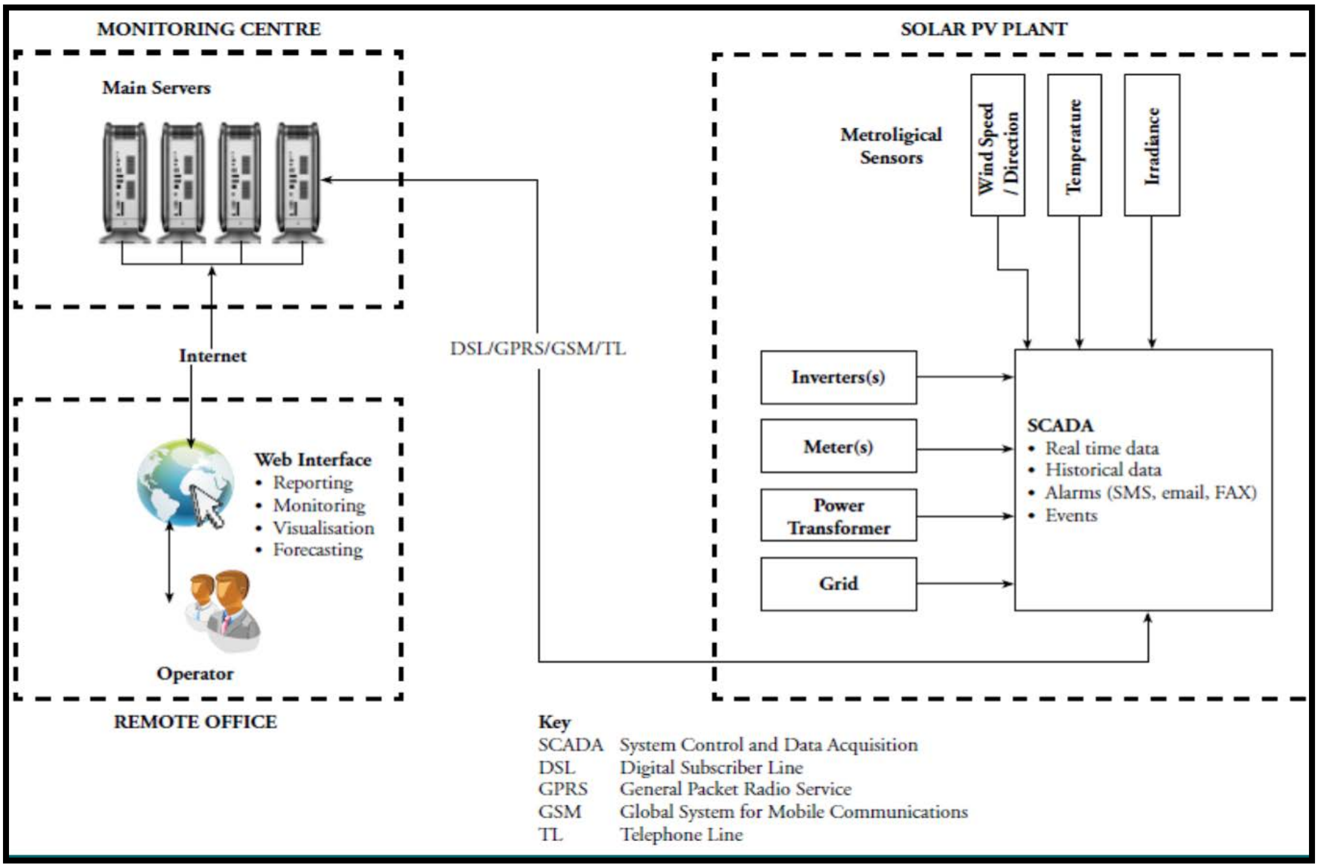


Figure 3.11: PV System Monitoring Schematic

Forecasting Technology

Dispatchable power plants such as the proposed one typically need to provide a forecast to the network operator. This helps to fix plant schedules and guarantee continuity of supply. Often, production forecasts (in half hourly time-steps) are required 24 hours in advance. This entails weather forecasts coupled with power forecasting algorithms—more so since PV power production is intermittent and random in nature. Such forecasting algorithms can use physical models, statistical approaches or a combination of both. At the least, the algorithms require the definition of:

- Power plant capacity.
- Module tilt and orientation.
- Module specifications.
- Latitude and longitude of the plant.
- Meteorological agency data, gathered from ground measurement stations and/or satellites.

The algorithms typically take three-hour national and/or regional forecasts and break them down to 30 minute local forecasts (temporal interpolation) before using algorithms to forecast power production. Comparison of historical production and actual weather can also allow learning algorithms to be employed. **Figure 3.12** shows the components of a forecasting system. Results of forecasting are typically posted on web portals. There are a variety of commercial forecasting products available in the market today. But availability may be limited to regions that have rapid access to meteorological agency's weather data.

Quality Benchmarks

Monitoring systems will be based on commercially available software/hardware which is supplied with user manuals and appropriate technical support. Depending on the size and type of the plant, minimum parameters to be measured include:

- Plane of array irradiance measured to accuracy within 5% and stability within 0.5% per year. The irradiation sensor will be of the same technology as the modules being measured or technology independent. Silicon sensor reference cells are not advisable for use in Performance Ratio calculations.
- Ambient temperature measured in a location representative of site conditions with accuracy better than ±1°C.
- Module temperature measured with accuracy better than ±1°C. This is done using a sensor thermally bonded to the back of the module in a location positioned at the centre of a cell.
- Array DC voltage measured to an accuracy of within 1%.
- Array DC current measured to an accuracy of within 1%.
- Inverter AC power measured as close as possible to the inverter output terminals with an accuracy of within 1%.
- Power to the utility grid.
- Power from the utility grid.
- Measurement of key parameters at one minute intervals.

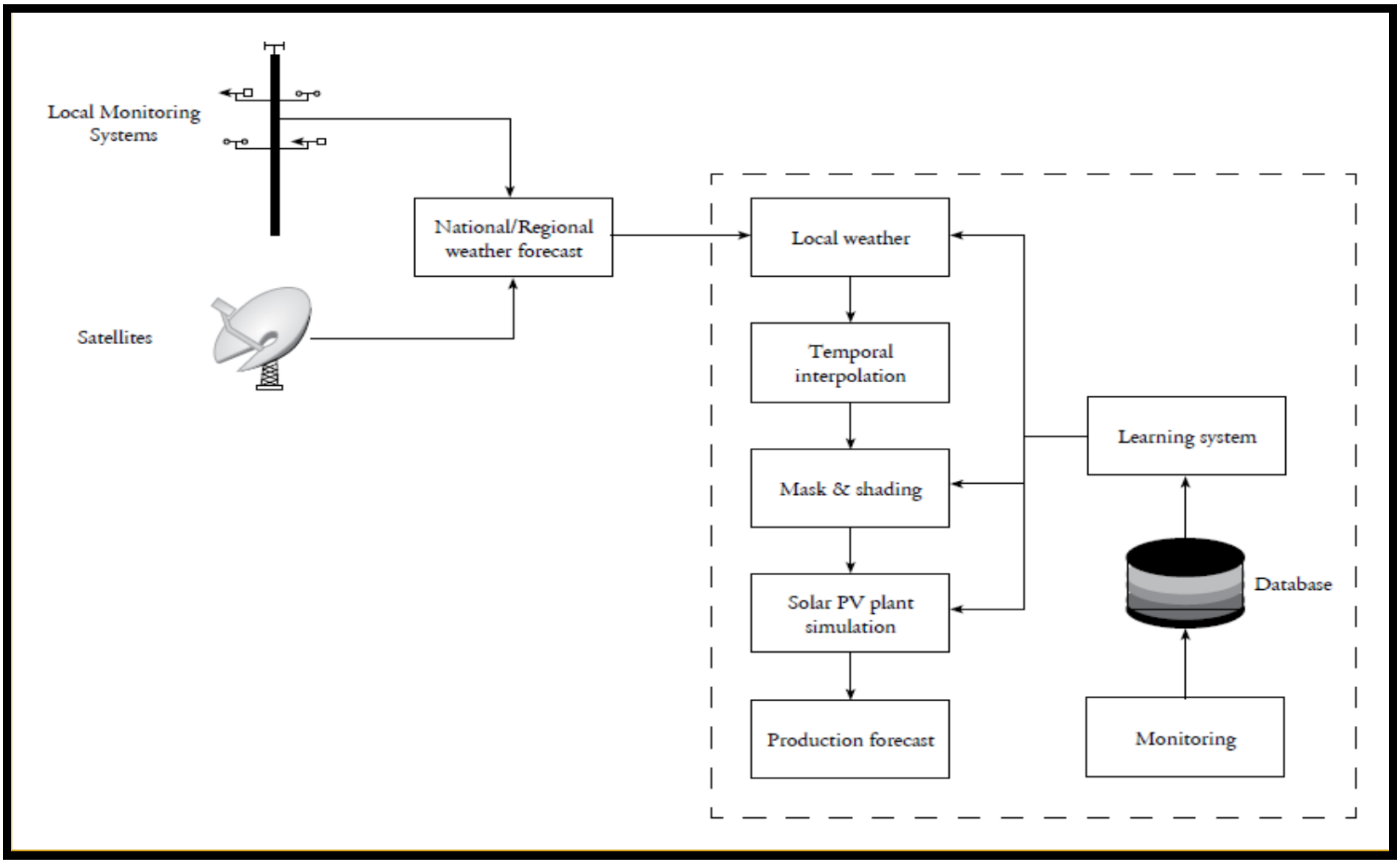


Figure 3.12: Components of a Forecasting System

3.12.4 Optimizing System Design

The performance of the proposed PV power plant may be optimized by a combination of several enabling factors: premium quality modules and inverters; a good system design with high quality and correctly installed components; and a good preventative maintenance and monitoring regime leading to low operational faults.

The aim is to minimise losses. Measures to achieve this are described in **Table 3.6**. Reducing the total loss increases the annual energy yield and hence the revenue, though in some cases it may increase the cost of the plant. Interestingly, efforts to reduce one type of loss may be antagonistic to efforts to reduce losses of a different type. It is the skill of the plant designer to make suitable compromises that result in a plant with a high performance at a reasonable cost. The ultimate aim of the designer is to create a plant that maximizes financial returns. In other words, it will usually mean minimising the levelised cost of electricity.

Table 3.6: Performance Optimization Strategies

Loss	Mitigating Measure to Optimize Performance
DC wiring resistance	• Use appropriately dimensioned cable. • Reduce the length of DC cabling.
Inverter performance	• Choose correctly sized, highly efficient inverters.
AC losses	• Use correctly dimensioned cable. • Reduce the length of AC cabling. • Use high efficiency transformers.
Downtime	• Use a robust monitoring system that can identify faults quickly. • Choose an O&M contractor with good repair response time. • Keep spares holdings.
Grid availability	• Install PV plant capacity in areas where the grid is strong and has the potential to absorb PV power.
Degradation	• Choose modules with a low degradation rate and a peak power guarantee.
MPP tracking	• Choose high efficiency inverters with good maximum power point tracking algorithm. • Avoid module mismatch.
Curtailment of tracking	• Ensure that tracking systems are suitable for the wind loads to which they will be subjected.

3.12.5 Design Documentation Requirements

There are a number of minimum requirements that will be included within design documentation. These include:

- Datasheets of modules, inverters, array mounting system and other system components.
- Wiring diagrams including, as a minimum, the information laid out in **Table 3.7**.
- Layout drawings showing the row spacing and location of site infrastructure

Mounting structure drawings with structural calculations reviewed and certified by a licensed engineer.

- A detailed resource assessment and energy yield prediction.
- A design report. It will include information on the site location, site characteristics, solar resource, a summary of the results of the geotechnical survey, design work and the energy yield prediction.

Table 3.7: Annotated Wiring Diagram Requirements

Section	Required details
Array	• Module type(s) • Total number of modules • Number of strings • Modules per string
PV String Information	• String cable specifications – size and type. • String over-current protective device specifications (where fitted) – type and voltage/ current ratings. • Blocking diode type (if relevant).
Array electrical details	• Array main cable specifications – size and type. • Array junction box locations (where applicable). • DC isolator type, location and rating (voltage/current). • Array over-current protective devices (where applicable) – type, location and rating (voltage/current).
Earthing and protection devices	• Details of all earth/bonding conductors – size and connection points. This includes details of array frame equi-potential bonding cable where fitted. • Details of any connections to an existing Lightning Protection System (LPS). • Details of any surge protection device installed (both on AC and DC lines) to include location, type and rating.
AC system	• AC isolator location, type and rating. • AC over current protective device location, type and rating. • Residual current device location, type and rating (where fitted). • Grid connection details and grid code requirements.
Data acquisition and Communication system.	• Details of the communication protocol. • Wiring requirements. • Sensors and data logging.

3.12.6 The Auxiliary Systems

The main auxiliary systems for the solar farm include the following:

- Administrative Buildings, Security/ Gate house
- Water supply Borehole
- Surface Drainage

Perimeter of the fencing will be 7 kilometers (please see the layout **Figure 3.1**). The toilets and washrooms will be located in the administrative building at the entry of the plant and in the High voltage substation for the substation people.

During the construction, mobile toilets and wash rooms will be installed in line with the requirements of the international and local standards in force. The location, and dimension of the administrative building, and the substation will be defined during the detailed engineering.

3.13 Evacuation of Power

The power evacuation would be at the appropriate level and the plant will be connected to the substation of TCN (Transmission Company of Nigeria) in Kankiya. Developing the electricity-generation assets will start with grid integration.

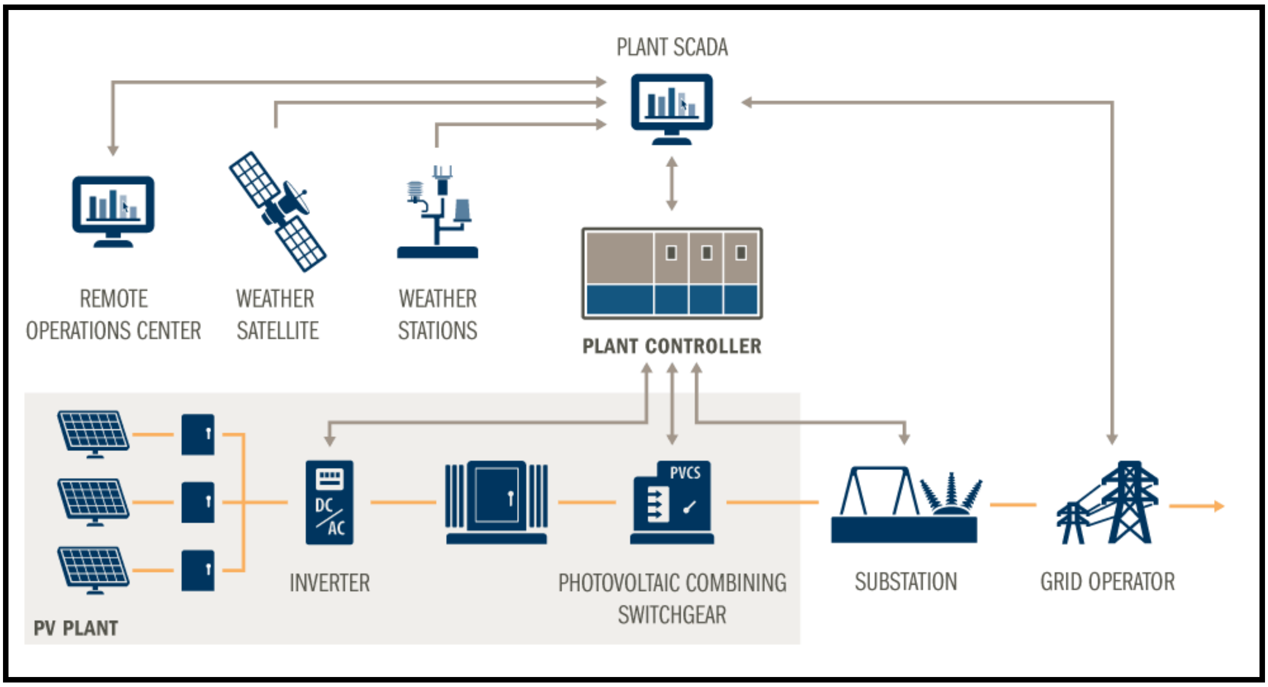


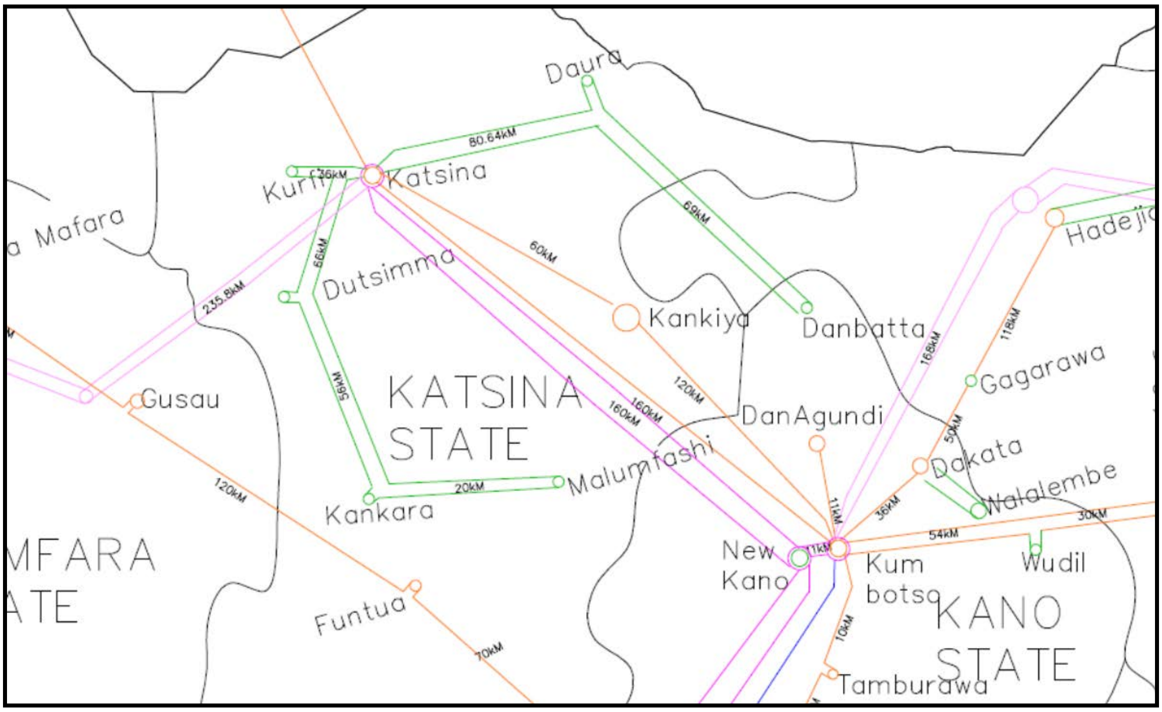
Figure 3.13: Power Evacuation Format

The PV based solar power plant will be equipped with advanced plant control features typical of large, conventional power plants that actively stabilize the electricity grid.

NOVA Solar 5 Farms Limited has performed a site visit on May 12th, 2014 to assess all the possibilities offered by the grid to connect the proposed PV Plant. The aim of the present note is to provide the details about each possibility. NOVA Solar 5 Farms Limited will perform a power evacuation and grid stability study considering the identified offtake options to define the maximum size of the proposed plant that can be evacuated through Transmission Company of Nigeria (TCN) infrastructures and allowing the maximum stability of the Grid.

Two 132 KV transmission lines are crossing the land proposed for the PV Plant to be developed by NOVA Solar 5 Farms Limited. The following offtake options will be studied:

1. Connection to the existing 132/33 KV substation in Kankiya through its extension and upgrade and the construction of a new transmission line between the PV plant and Kankiya 132/33KV substation.
2. Connection to the 132 KV transmission line Kankiya/Katsina through a new 132 KV substation to be built on the PV plant site.
3. Connection to the 132 KV transmission line Kano/Katsina through a new 132 KV substation to be built on the PV plant site.



Key

Grid lines

Figure 3.14: Grid Configuration

Connection to the 132/33KV Kankiya substation:

KANKIA 132/33 KV substation is located 3.5 km from the proposed PV plant at 12°33'3.8644N, 07°50'44.27''E and at 582.3 m from sea level. This substation's schematic diagram is as follows:

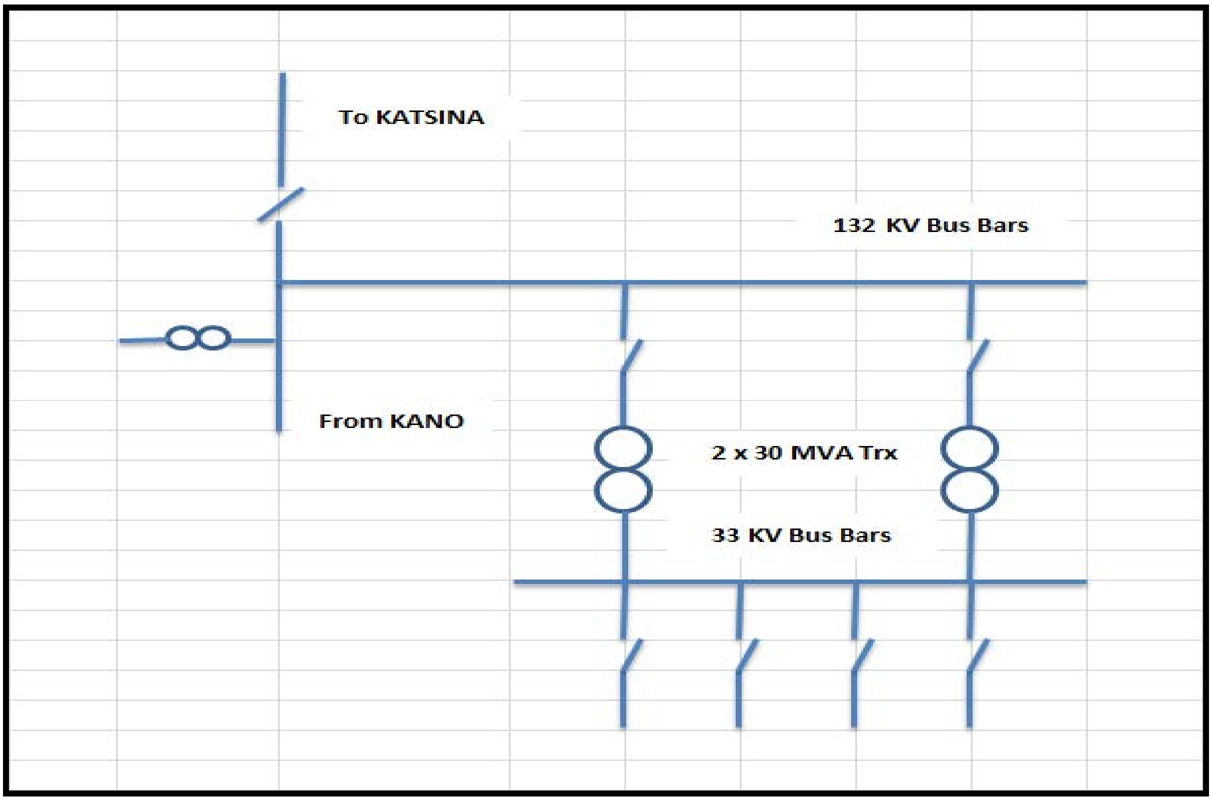


Figure 3.15: Configuration for Connection to Kankiya Substation

The connection of the proposed PV plant to the 132/33 KV Kankiya substation will require the following works:

- Construction of 4 to 5 kilometers of 132 KV transmission line.
- Modification of Transformer 2 feeder to allow the Kankiya substation's bus bars extension
- Extension of the substation's bus bars
- Construction of a new 132 KV feeder

The modification of the transformer to feeder and the extension of the bus bars will required many short to medium outages and consequently the de-energizing of the 132 and 33KV lines.

Connection to the Kano/Katsina 132 KV transmission line:

The connection of the proposed PV plant to the Kano/Katsina transmission line will require the following works:

- Construction of a new 132 KV substation with two outgoing feeders and one transformer incoming feeder.
- Connection to the existing 132 KV line crossing the site.

The Schematic diagram of the future substation will be as follows:

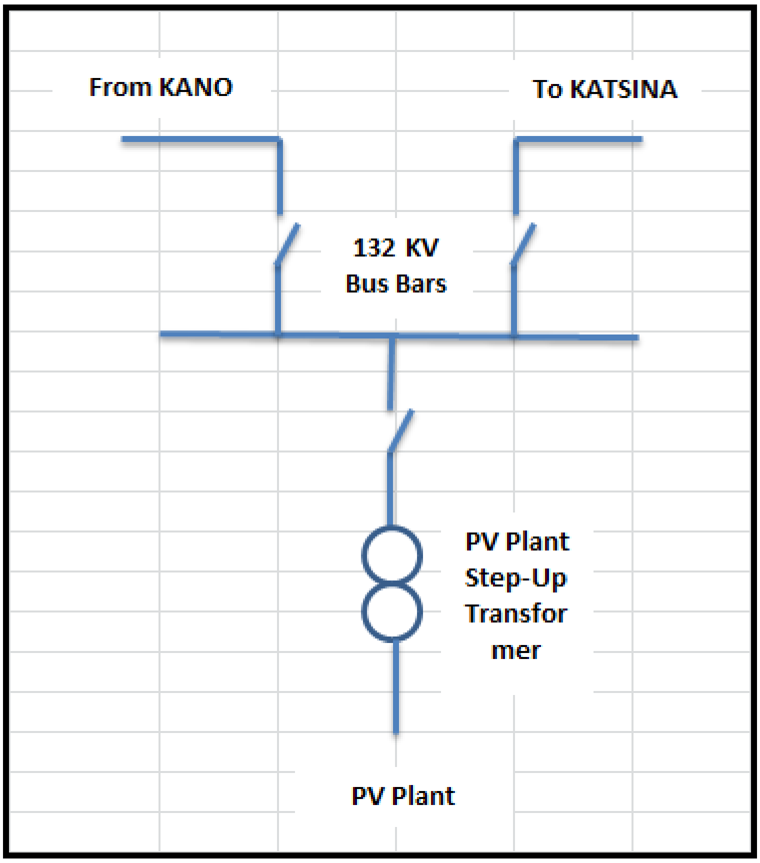


Figure 3.16: Configuration for Connection to Kano/Katsina Transmission Line

Cost Estimates

The connection of the proposed PV plant to the Kankiya/Katsina transmission line will require the same works as in Kano/Katsina as both transmission lines are crossing the site.

Connection to the 132/33KV KANKIA substation

	Item	Unit	Quantity	Unit Price (K€)	Total Price (K€)
1	Construction of 4 to 5 kilometers of 132 KV transmission line	u	5	200	750
2	Modification of Transformer 2 feeder to allow the KANKIA substation's bus bars extension	u	1	500	350
3	Extension of the substation's bus bars	u	1	250	250
4	Construction of a new 132 KV feeder	u	2	600	1200
	TOTAL				**2550**

Connection to the Kano/Katsina or Kankia/Katsina 132 KV transmission line:

	Item	Unit	Quantity	Unit Price (K€)	Total Price (K€)
1	Construction of a new 132 KV substation with two outgoing feeders and one transformer incoming feeder.	u	4	600	2400
2	Connection to the existing 132 KV line crossing the site.	u	1	200	200
	TOTAL				**2600**

The connection of the proposed PV plant to Kankiya substation will require many shut downs of the system to allow the execution of the works. It will also require more time for execution as all the works that need shut down should be prepared in advance in expectation of the opportunity to have the substation and the transmission line outage for execution. The works that can be executed without outage will need a special care as the installation is energized, and therefore more time for execution. This option will be envisaged.

The construction of a new substation seems to be the most viable solution from the technical and commercial points of view. Under the feasibility studies, RECA will perform the power evacuation and grid stability studies including the short circuit studies, and static and dynamic studies. The grid configuration after the connection of the projected PV plant will be as shown in the **Figure 3.17**.

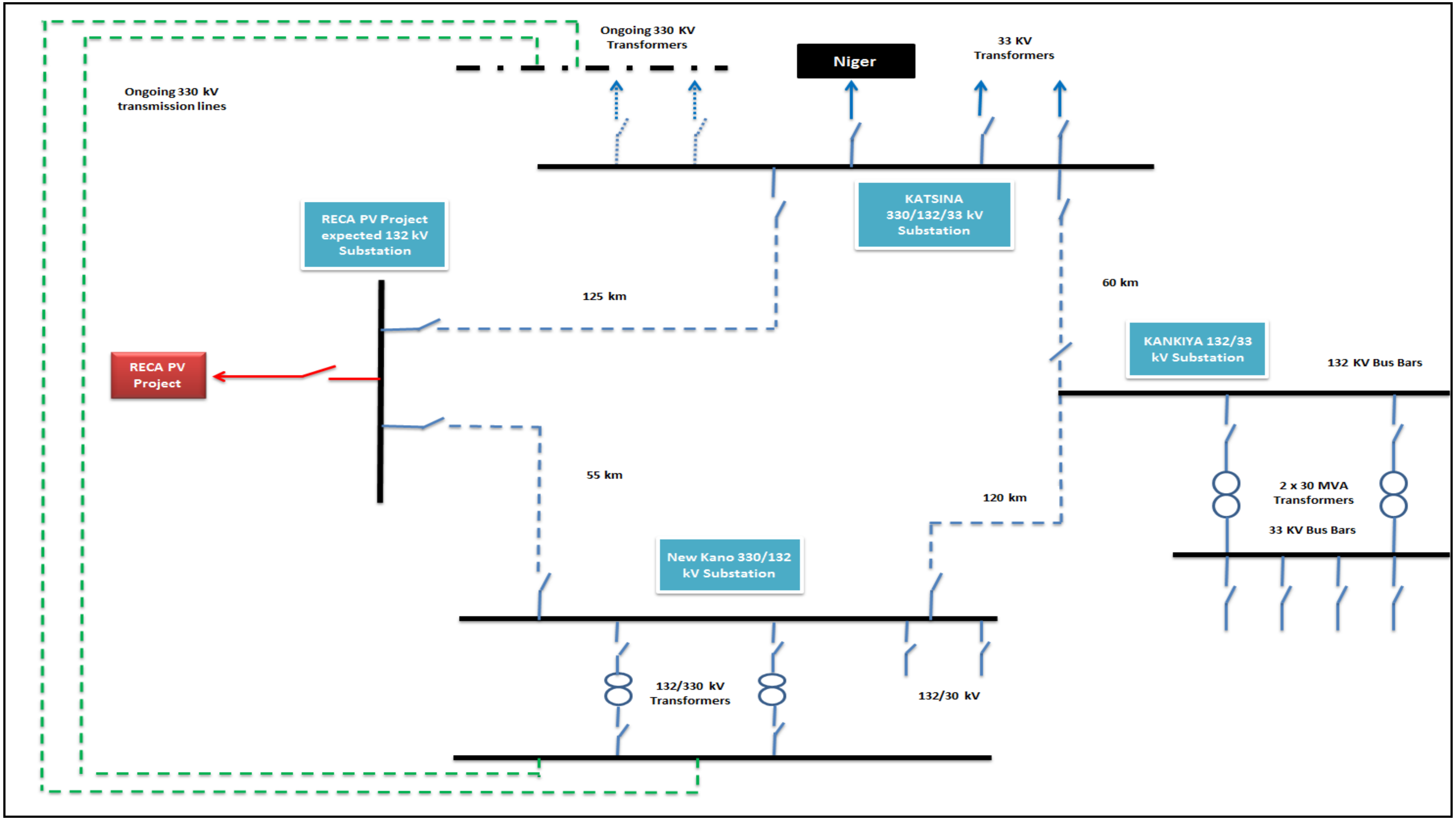


Figure 3.17: **Grid Configuration 2**

	
Outgoing feeder to KATSINA	View of the whole 132 KV substation
	
Transformers' feeders	33 KV bay

Figure 3.18: **Photos of Kankiya and Katsina Substations**

3.14 Performance Engineering Services

The Performance Engineering Services will offer access to unique engineering experience, innovative technologies, and solar photovoltaic (PV) expertise to maximize the plant output and reduce operational expenses. The proprietary ADvise™ Advanced Diagnostics will pinpoint suboptimal aspects of the plant performance and make specific, actionable recommendations to improve results.

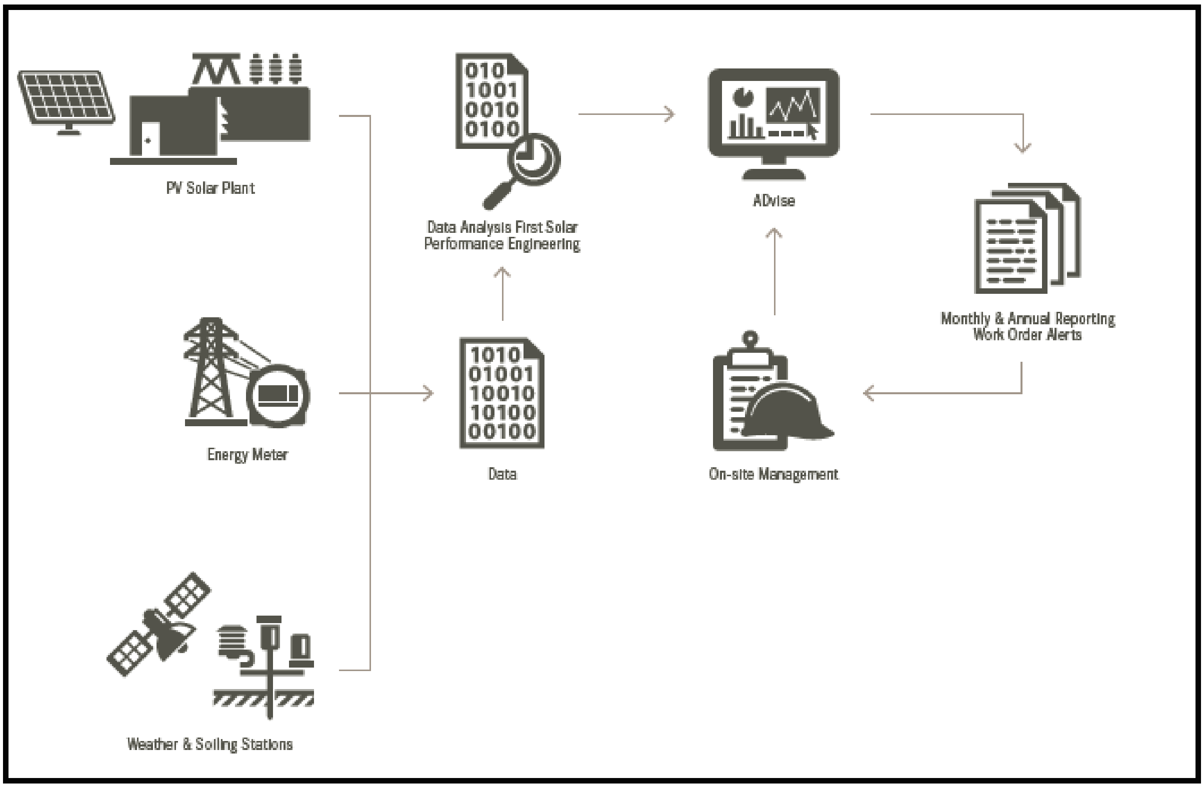


Figure 3.19: Performance Engineering Sequence

ADvise™ gives more than just energy monitoring service. ADvise™ gives expert diagnostic, analytic, and optimization solution that includes:

- Daily DC health analysis;
- Daily sensor validation analysis;
- Weekly performance engineering reviews;
- Plant health and instrumentation maintenance recommendations;
- Plant performance modeling and variance analysis;
- ADvise™ web portal; and
- Monthly in-depth performance analysis report.

3.15 Project Scheduling and Implementation

The project milestone schedule is presented in **Figure 3.21**. It is envisaged to synchronise the 125 MW in 24 months, reckoned from the date of financial closure of the project. This schedule is based on in-house estimates of equipment delivery and construction schedules. Trial operation of PV based solar power plant including submission of report upon successful completion, for duration of four (4) weeks. Necessary studies required for augmentation / strengthening of 125 kV network in the vicinity of the plant site and at the nearest TCN substation for power evacuation (in Kankiya) will be carried out, as required.

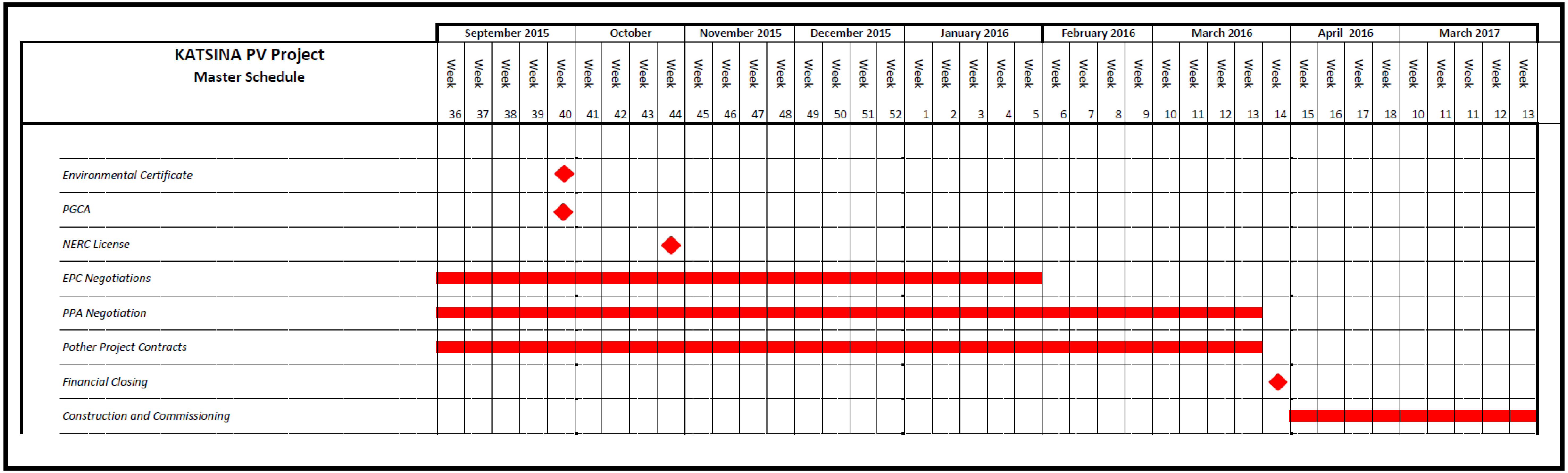


Figure 3.20: Project Execution Schedule.

3.16 Construction

The management of the construction phase of a solar PV project will be in accordance with general construction project management best practice. Therefore, the aim is to construct the project to the required level of quality, and within the time and cost limits. During construction, issues like environmental impact, and health and safety of the workforce (and other affected people) will also be carefully managed. The approach to construction project management for the proposed NSF solar PV plant will depend on many factors. Among these, one of the most important is the project contract strategy.

From a developer's perspective, construction project management for a full turnkey EPC contract will be significantly less onerous than that required for a multi-contract approach. However, a multi-contract approach will give NSF greater control over the final plant configuration. Regardless of the contract strategy selected, there are a number of key activities that will need to be carried out, either by the NSF or a contractor. These activities are described in the following sections.

3.16.1 Interface Management

Interface management is of central importance to the delivery of any complex engineering project, and solar PV projects are no exception. The main interfaces to be considered in this solar PV project are listed in **Table 3.8**. The interfaces may differ, depending on the contracting structure and specific requirements of this particular project. For a multi-contract strategy, the NSF will develop a robust plan for interface management. This plan will list all project interfaces, describe which organisations are involved, allocate responsibility for each interface to a particular individual, and explicitly state when the interface will be reviewed. In general, design and construction programmes will be developed to minimise interfaces wherever possible. Opting for a turnkey EPC contract strategy will, in effect, pass the onus for interface management from the NSF to the EPC contractor. But interface management will remain an important issue and one that requires ongoing supervision. To some extent interfaces between the project and its surroundings (for example grid connection) will remain the responsibility of the NSF.

If a turnkey EPC strategy is chosen, then a contractor with a suitable track record in the delivery of complex projects will be selected to minimise this risk. Information will also be sought from potential contractors on their understanding of the project interfaces and their proposed approach to managing them.

3.16.2 Programme and Scheduling

A realistic and comprehensive construction programme is a vital tool for the construction planning and management of a solar PV project. The programme will be sufficiently detailed to show:

- Tasks and durations.
- Restrictions placed on any task.
- Contingency of each task.
- Milestones and key dates.
- Interdependencies between tasks.
- Parties responsible for tasks.
- Project critical path.
- Actual progress against plan.

Table 3.8: Solar PV Project Interfaces

Item	Element	Organizations	Interface/comment
1	Consents	• All contractors • Landowner • Planning authority	Monitoring of compliance with all planning conditions and permits.
2	Civil Works	• Civil contractor • Mounting or tracking system supplier • Central inverter supplier • Electrical contractor • Grid connection contractor • Security contractor	Site clearance. Layout and requirements for foundations, cable trenches, ducts, roads and access tracks.
3	**Security**	• Civil contractor • Electrical contractor • Security contractor • Communications contractor	Layout of the security system, including power cabling and communications to the central monitoring system.
4	Module Mounting or Tracking System	• Mounting or Tracking system supplier • Civil contractor • Module supplier • Electrical contractor	Foundations for the mounting or tracking system, suitability for the module type and electrical connections, and security of the modules. Earthing and protection of the mounting or tracking system.
5	Inverter	• Civil contractor (for central inverters) • Mounting system supplier (for string • inverters) • Module supplier • Inverter supplier • Electrical contractor • Communications contractor	Foundations for larger central inverters, or suitability for the mounting system. Suitability of the module string design for the inverter. Interface with the communications for remote monitoring and input into the SCADA system.
6	AC/DC and Communications Cabling	• Electrical contractor • Civil contractor • Communications contractor • Security contractor	Liaison with regard to cable routes, sizes, weights, attachments and strain relief requirements.
7	Grid Interface	• Civil contractor • Electrical contractor • Inverter supplier • Network operator	Liaison with regard to required layout of building equipment and interface with onsite cabling installed by the site contractor. More interface outside the site boundary for the grid connection cable/line to the network operator's facilities.
8	Communications	• Electrical contractor • Security contractor • Communications contractor • Owner and Commercial operator	Interface between the security system, inverter system, central monitoring (SCADA), the monitoring company, and the owner or commercial operator of the PV plant.
9	Commissioning	• All contractors	Commissioning of all systems will have several interface issues particularly if problems are encountered.

All tasks and the expected timescale for completion will be detailed along with any restrictions to a particular task. For example, if permits or weather constraints stop construction during particular months. For the proposed solar PV project, it is likely that the programme will have different levels, incorporating different levels of detail around each of the following main work areas:

- Site access.
- Security.
- Foundation construction.
- Module assembly.
- Mounting frame construction.
- Substation construction.
- Electrical site works.
- Grid interconnection works.
- Commissioning and testing.

A high level programme will be produced to outline the timescales of each task, the ordering of the tasks and any key deadlines. This will be completed as part of the detailed design. The programme will then be built up to detail all the associated tasks and sub tasks, ensuring that they will be completed within the critical timescale. A thorough programme will keep aside time and resources for any contingency. It will also allocate allowance for weather risk or permit restrictions for each task.

Interdependencies between tasks will allow the programme to clearly define the ordering of tasks. A project scheduling package will then indicate the start date of dependent tasks as well highlighting the critical path. Critical path analysis is important to ensure that tasks that can affect the overall delivery date of the project are highlighted and prioritized. A comprehensive programme will also take into account resource availability. This will ensure that tasks are scheduled for when required staff or plant are available. Incorporating a procurement schedule that focuses on items with a long manufacturing lead time (such as transformers, central inverters and modules) will ensure that they are ordered and delivered to schedule. It will also highlight any issues with the timings between delivery and construction, and the need for storage onsite. To share this information and to save time and effort, it is strongly recommended that an “off-the-shelf” project scheduling package is used.

3.16.3 Milestones

Milestones are goals that are tied in with contractual obligations, incentives or penalties. Incorporating milestones in the programme helps the project team to focus on achieving these goals. In effect, construction shall be planned around certain milestones or fixed dates (for example, the grid connection date). If the contracted milestones are included in the programme, the impact of slippage on these dates will be apparent. Appropriate budgetary and resourcing decisions can then be made for those delays. The milestones can also indicate when payments are due to a contractor.

3.16.4 Planning and Task Sequencing

Appropriate sequencing of tasks is a vital part of the planning process. The tasks will be sequenced logically and efficiently. The overall sequence of works is generally: site access, site clearance, security, foundation construction, cable trenches and ducts, substation construction, mounting frame construction, electrical site works, communications, onsite grid works and then testing and commissioning. Each of these work areas will be broken down into a series of sub-tasks. Alongside, an assessment of the inputs required for each task (especially when interfaces are involved) will help develop a logical and efficient sequence. Consideration will also be given to any factors that could prevent or limit possible overlap of tasks. These factors could include:

- Access requirements.
- Resource availability (plant and manpower).
- Planning (or other regulatory) restrictions.
- Safety considerations.

3.16.5 Risk Management

The risks associated with the project will be identified, assessed and managed throughout the construction process. The hazards need to be incorporated in the planning and scheduling of the project. Each aspect of the project will be assessed for likelihood and impact of potential risks (**Chapter Six**). The next step would be to develop a suitable action plan to mitigate identified risks (**Chapter Seven**). If a particular risk could affect the delivery of the whole project, alternatives for contingency (in terms of time and budget) will be included.

3.16.6 Cost Management

The viability of the proposed solar project will be affected by the duration of the construction period. During construction, the project will be in debt owing to interest and finance charges, and lack of income to make payments. Therefore, a shorter construction period will be generally preferable. The period of construction also requires prudent cost management, which is tied in with the project schedule and the contracted payment structure.

The payment structure will depend upon the type of contract opted for, but is likely to involve milestone payments. The typical range of EPC payment schedules is detailed in **Table 3.9**. If a multi-contract strategy is chosen, then a similar structure for phased-out payments for each contract is advisable. This schedule shows that a high percentage of the payments are made once the goods have been delivered to site. It also allows enough money to be held back to ensure that the contractor completes the works. The tools used for construction cost management in a solar PV venture are the same as for any major engineering project. These can include:

***Earned value management* –** This is an approach based on monitoring the project plan, actual work completed and work-completed value to assess if a project is on track. Earned value management indicates how much of the budget (and available time) will have been spent, with regards to the amount of work done to date. This method necessitates advance calculation of both the baseline cost for a task and the resources required. If used correctly, this is a powerful tool for estimating and controlling project overspends as early as possible in the construction period.

***Completion certificates* –** Completion certificates will be issued once the entire (or a specific) part of the plant is physically complete. These certificates will be issued prior to any tests taking place and confirm that the contractor has installed the equipment correctly. They may only be for a specific part of the project (for example a string of modules). Payment for a particular item of work will not be made until the appropriate completion certificate has been issued.

Table 3.9: Typical EPC Payment Schedule

Payment	Payment Due Upon	% of Contract Price
1	Advance payment (commencement date)	10-20
2	Civil works completed	10-20
3	Delivery of components to site (probably on a pro-rata basis)	**40 - 60**
4	Modules mechanically complete	5-15
5	Modules electrically complete	5-15
6	Provisional completion and commercial operation	5-10
7	Solar PV plant taken over	5-10

***Snagging lists* –** Compiling “Snag Lists” as an ongoing exercise will be recommended. A prerequisite to the hand-over phase, this list is a process of monitoring and tracking any defects. These will be addressed and rectified to the satisfaction of the NSF. In some cases, the take-over will occur with some minor defects still outstanding. In such a scenario, the snagging list will detail these minor defects, which will then have to be addressed within a stipulated period.

***Take-Over certificates* –** Take-over certificates will be issued by the contractor for acceptance by the NSF. These will be issued once all tests have been completed and defects addressed. It is normal for the power purchaser to request a copy of the take-over certificate. To expedite the launch of the project, the developer may choose to take over a project with minor snags, subject to the contractor taking responsibility to complete them. While this conditionality is acceptable, progress in addressing defects will be monitored.

3.16.7 Contractor Warranties

The NSF will typically use the services of an EPC contractor to design and build the utility scale project. NSF will also require an operation and maintenance (O&M) contractor to operate and maintain the plant during its operational phase. The EPC contractor offers project planning services, and will provide the necessary engineering for project design. The contractor will typically be responsible for material selection and procurement of modules, inverters, and balance of plant components. Construction may be carried out by the EPC contractor or through partnerships with local installation and project development companies (in this case, the EPC contractor will provide on-site inspection). Warranties within the EPC contract may include a Defect Warranty, Module Capacity Warranty, Performance Ratio Warranty and Structure Warranty as described in **Table 3.10**.

Table 3.10: Warranty Types and Requirements

Warranty Type	Details
Defect warranty	The contractor warrants that the plant will be free from defects in materials and workmanship, and that the project will adhere to the qualities set out in a technical specifications document
Module capacity warranty	The contractor may guarantee that the total peak capacity of the project within a certain time period after completion is not less than a certain value, and may also certify that the degradation will not exceed a given value during the warranty period.
Performance ratio warranty	The contractor guarantees that the PR as measured during a PR test will not be less than a given value, and that the PR shall not reduce by more than a given percentage during the warranty period.
Structure warranty	The contractor warrants the structural integrity of elements of the works for a given period.

Warranty Duration

Warranties for EPC contracts are typically in the two to five year range. If the O&M contractor is also the EPC contractor, it can be easier to enforce these warranties. However, if they are separate companies, the exclusions to the warranties will be checked carefully. Also, the maintenance carried out by the O&M contractor will be in compliance with the EPC contractor’s requirements. The original manufacturer’s warranties on components such as inverters, support structures and modules will be passed from the EPC contractor to the plant owner at handover. Acceptance testing is often completed before the plant is handed over to NSF. Even in a multiple contract structure, the component warranties described in **Table 2.10** above would be applicable and will be incorporated. However, these warranties will be contract-specific, and need to be decided upon before tendering for the work. This is a judicious way to ensure that the guarantees provided are on a par with those expected by the developers.

3.16.8 Quality Management

Controlling construction quality is essential for the success of the project. The required level of quality will be defined clearly and in detail in the contract specifications. A quality plan is an overview document (generally in a tabular form), which details all works, deliveries and tests to be completed within the project. This allows work to be signed off by the contractor and enables the developer to confirm if the required quality procedures are being met. A quality plan will generally include the following information:

- Tasks (broken into sections if required).
- Contractor completing each task or accepting equipment.
- Acceptance criteria.
- Completion date.

- Details of any records to be kept (for example, photographs or test results).
- Signature or confirmation of contractor completing tasks or accepting delivery.
- Signature of person who is confirming tasks or tests on behalf of the developer.

Quality audits will be completed regularly. These will help developers verify if contractors are completing their works in line with their quality plans. Audits also highlight quality issues that need to be addressed at an early stage. Suitably experienced personnel should undertake these audits.

3.16.9 Environmental Management

The IFC Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of good international industry practice. With respect to environmental management, the guidelines cover the following areas:

- General Guidelines.
- Air Emissions and Ambient Air Quality.
- Energy Conservation.
- Wastewater and Ambient Water Quality.
- Water Conservation.
- Hazardous Materials Management.
- Waste Management.
- Noise Emissions.
- Contaminated Land.

These guidelines will be followed as a benchmark, along with any specific local guidelines and information from this ESIA. As for quality management, contractors will be urged to develop an environmental management plan (addressing the areas listed above), against which their performance can and will be monitored.

Expected Emissions

The anticipated emissions from the proposed PV based solar power plant have the capacity to cause environmental pollution if it is not managed or controlled adequately. The expected emissions during the construction phase are:

- Dust caused by earthworks using heavy equipment and trolley;
- Gases Emissions (fossil fuel charged equipment and Vehicles);
- Noise generated from the heavy equipment and machinery;
- Solid and Liquid wastes;

3.16.10 Health and Safety Management

The health and safety of the project work force and other affected people will be carefully overseen by the NSF. Apart from ethical considerations, the costs of not complying with health and safety legislation can represent a major risk to the project. Furthermore, a project with a sensitive approach to health and safety issues is more likely to obtain international financing. The IFC EHS guidelines cover two main areas of health and safety: occupational health and safety and community health and safety. The issues covered under these areas are listed below.

Occupational Health and Safety:

- General Facility Design and Operation.
- Communication and Training.
- Physical Hazards.
- Chemical Hazards.
- Biological Hazards.
- Personal Protective Equipment (PPE).
- Special Hazard Environments.
- Monitoring.

- Community Health and Safety:
- Water Quality and Availability.
- Structural Safety of Project Infrastructure.
- Life and Fire Safety (L&FS).
- Traffic Safety.
- Transport of Hazardous Materials.
- Disease Prevention.
- Emergency Preparedness and Response.

The IFC guidelines give guidance on how each of these aspects of H&S should be approached, outline minimum requirements for each aspect and list appropriate control measures that can be put in place to reduce risks. As a minimum standard, compliance with local H&S legislation should be rigorously enforced. Where local legal requirements are not as demanding as the IFC guidelines, the IFC guidelines will be followed.

3.16.11 Specific Solar PV Construction Issues

The following sections describe common pitfalls or mistakes that can occur during the construction phase of the proposed solar PV project. Most of these pitfalls will be avoided by appropriate design, monitoring, quality control and testing on site.

Civil

The civil works relating to the construction of the solar PV plant are relatively straightforward. However, there can be serious and expensive consequences if the foundations and road networks are not adequately designed for the site. The main risks lie with the ground conditions. Importantly, ground surveys lacking in meticulous detailing or proper interpretation could lead to risks such as unsuitable foundations.

Used land also poses a risk during the civil engineering works. Due to the nature of digging or pile driving for foundations, it is important to be aware of hazardous obstacles or substances below the surface.

Mechanical

The mechanical construction phase usually involves the installation and assembly of mounting structures on the site. Some simple mistakes can turn out to be costly, especially if these include:

- Incorrect use of torque wrenches.
- Cross bracing not applied.
- Incorrect orientation.

If a tracking system is being used for the mounting structure, other risks include:

- Lack of clearance for rotation of modules.
- Actuator being incorrectly installed (or as specified), resulting in the modules moving or vibrating instead of locking effectively in the desired position. These mistakes are likely to result in remedial work being required before hand-over and involve extra cost.

Electrical

Cables will be installed in line with the manufacturer's recommendations. Installation will be done with care as damage can occur when pulling the cable into position. The correct pulling tensions and bending radii will be adhered to by the installation contractor to prevent damage to the cable. Similarly, cables attached to the mounting structure require the correct protection, attachment and strain relief to make sure that they are not damaged.

Underground cables will be buried at a suitable depth (generally between 500mm and 1,000mm) with warning tape or tiles placed above and marking posts at suitable intervals on the surface. Cables may either be buried directly or in ducts. If cables are buried directly, they will be enveloped in a layer of sand or sifted soil will be included to avoid damage by backfill material. Comprehensive tests will be undertaken prior to energisation to verify that there has been no damage to the cables.

3.16.13 Grid Connection

The grid connection will generally be carried out by a third party over whom the NSF will have limited control. Close communication with the grid connection contractor is essential to ensure that the grid requirements are met. Delay in the completion of the grid connection will affect the energisation date, which will delay the start of commercial operation.

3.16.14 Logistical

Logistical issues can arise if designs or schedules have not been well-thought through. Issues that may arise include:

- Lack of adequate clearance between rows of modules for access.
- Constrained access due to inclement weather conditions.
- For larger tracking systems and central inverters, cranes may be required. Therefore, suitable access and maneuverability room within the site is essential (see **Figure 3.21**).

Figure 3.21: Spacing Between Module Rows

3.17 Construction Supervision

NSF and lenders of the project will be kept informed of developments during construction. Construction supervision may be carried out by in-house resources. Alternatively, a “technical advisor” or “owner’s engineer” may be commissioned to carry out the work on their behalf. The role of the technical advisor during the construction phase is to ensure contractor compliance with the relevant contracts, as well as to report on progress and budget. The construction supervision team would generally comprise of a site engineer supported by technical experts in an office. The main parts of the technical advisor’s role are: review of proposed designs, construction monitoring and witnessing of key tests. Design reviews will generally be carried out on:

- Design basis statements.
- Studies/investigations.
- Design specifications.
- Design of structures.
- Drawings (all revisions).

- Calculations.
- Execution plans.
- Risk assessments and method statements.
- Quality plans.
- Safety plans/reports.
- Material and equipment selection.
- O&M manuals.
- Test reports.

The objective of the design review will be to ensure that the contractor has designed the works in accordance with the contract agreements and relevant industry standards. It also aims to ascertain that the works will be suitably resourced and sequenced to deliver the project as specified. The design review could also cover specific areas such as grid compliance or geotechnical issues, depending upon the specific project requirements and experience of NSF. Key stages and tests for witnessing will include:

- Inspection of road construction.
- Inspection of foundations.
- Verification of cable routes.
- Inspection of cable tracks.
- Witnessing of delivery/off-load of solar modules, transformers, inverters and switchgear.
- Inspection of module, switchgear and inverter installation.
- Witnessing of site acceptance tests.
- Witnessing of completion tests.
- Monitoring and expediting defects.

Besides NSF's engineer, the lender's engineer has the additional role of signing off and issuing certificates that state the percentage of the project completed. These certificates are required by the lenders prior to releasing funds in accordance with the project payment milestones.

3.18 Commissioning

The commissioning process certifies that the NSF's requirements have been met, the power plant installation is complete and the power plant complies with grid and safety requirements. Successful completion of the commissioning process is often considered to be part of the provisional or final acceptance of the PV plant. Commissioning will follow the procedure described in IEC 62445 and prove three main criteria:

1. The power plant is structurally and electrically safe.
2. The power plant is sufficiently robust (structurally and electrically) to operate for the specified lifetime of a project.
4. The power plant operates as designed and its performance is as expected.

Critical elements of a PV power plant that will require commissioning include:

- Module strings.
- Inverters.
- Transformers.
- Switchgear.
- Lightning protection systems.
- Earthing protection systems.
- Electrical protection systems.
- Grid connection compliance protection and disconnection systems.
- Monitoring systems (including irradiation sensors).
- Support structure and tracking systems (where employed).

Inverter commissioning will follow the protocol described in the inverter installation manual. Tasks may include:

- Checking inverter cabling for conformity to schematic diagrams.

- Checking that cable connections are firm.
- Checking DC voltages for polarity and verifying that they are approximately the same for each string. Voltages must not exceed the maximum voltage of the inverter.
- Checking AC grid voltage. AC voltage measurements between the external conductors should be approximately the same as the nominal voltage of the inverter.
- Checking the internal AC power supply.
- Mounting the inverter paneling.
- Inserting fuses or insulation blades (if applicable).
- Switching on the voltage supply by turning on the grid monitoring circuit breaker (if applicable) and the external voltage supply circuit breaker. Status lights should not be showing a fault.
- Switching on the inverter and checking for power export to the grid (if the irradiation level is above the inverter threshold) and for any abnormal noise.

With the exception of the module strings, the commissioning of the remaining plant components follows standard procedures for power plant (the guide does not dwell further on the details). The following sections provide an overview of the pre-connection and post-connection acceptance testing and documentation requirements for the module strings.

3.18.1 General Recommendations

Commissioning will start immediately after installation has been completed or, where appropriate, sequentially as strings are connected. If the proposed power plant employs modules which require a settling-in period, for example, thin film amorphous silicon modules, performance testing will begin once the settling in period has been completed and the modules have degraded. Since irradiance has an impact on performance, tests will be carried out under stable sky conditions. The temperature of the cells within the modules will be recorded in addition to the irradiance and time. Ideally, commissioning will be carried out by an independent specialist third party selected by the owner. It will include both visual and electrical testing. In particular, visual testing will be carried out before any system is energised. The testing outlined in this section does not preclude local norms which will vary from country to country.

Test results will be recorded as part of a signed-off commissioning record. While an independent specialist would be expected to carry out these tests, NSF are aware of them and make sure that the required documentation is completed, submitted and recorded.

3.18.2 Pre-Connection Acceptance Testing

Prior to connecting the power plant to the grid, electrical continuity and conductivity will be checked by the electrical contractor. Once completed, pre-connection acceptance testing will be carried out on the DC side of the inverters. These tests according to IEC 62446 will include:

- Open Circuit Voltage Test.
- Short Circuit Current Test.

Open Circuit Voltage Test

This test checks whether all strings are properly connected (module and string polarity) and whether all modules are producing the voltage level as per the module data sheet. The test will be conducted for all strings. The open circuit voltage, Voc, will be recorded and compared with temperature adjusted theoretical values.

Short Circuit Current Test

This test verifies whether all strings are properly connected and the modules are producing the expected current. The test will be conducted for all strings. The short circuit current, Isc, will be recorded and compared with the temperature adjusted theoretical values.

3.18.3 Grid Connection

Grid connection will only be performed once all DC string testing has been completed. It is likely that the distribution or transmission system operator will wish to witness the connection of the grid and/or the protection relay. Such a preference will be agreed in advance as part of the connection agreement. The grid connection agreement often stipulates the level of parameters—such as electrical protection, disconnection and fault—to which the PV power plant is required to adhere. Usually, these conditions need to be met before commissioning the grid connection.

3.18.4 Post Connection Acceptance Testing

Once the power plant is connected to the grid, the inverters will be powered up according to the manufacturer's start-up sequence. Inverter internal meters and displays will be verified prior to use. Post grid connection will include:

- DC current test.
- Performance ratio test.

DC Current Test

This test verifies whether all strings are producing adequate and consistent operating current as per the module data sheets. The test should be conducted for all strings. The string current values per inverter will be checked against the average values of all strings connected to the same inverter and checked against acceptance criteria.

Performance Ratio Test

This test checks if the power plant is performing at or above the performance ratio agreed or warranted within the EPC contract. A standard testing period will be continuous testing for a minimum of ten consecutive days. Typically, a minimum irradiance will be defined and the performance ratio measured for the period in which that irradiance is exceeded. The electrical energy generated will be recorded at the metering point (or as agreed in the contract documentation) and compared with the guaranteed value provided by the EPC contractor. An adjustment can be made to account for the temperatures observed during the test. This is known as the adjusted performance ratio. The electrical energy generated is typically considered to be acceptable if it is within ± 3-5% of the value given by the agreed temperature adjusted performance ratio. If there are significant differences between the contractual and actual adjusted performance ratio, the EPC contractor will identify and rectify the discrepancy before repeating the performance ratio test.

Availability Test

An availability test will be performed in parallel with the performance ratio test as described above. This will confirm that an acceptable availability is being achieved according to guaranteed values. The test will typically be performed for a minimum of ten consecutive days under stable sky conditions. The availability of the system can be defined using the formula:

$$\text{Measured Average Availability} \quad 100\% * \frac{\text{(Power export time + Time in which power is not exported due to reasons beyond control)}}{\text{(Theoretical time for which power may be exported)}}$$

3.18.5 Provisional Acceptance

The completion of the commissioning tests outlined above often forms part of the acceptance tests for the PV power plant. In some instances, the performance ratio test will be repeated after a period of operation. In such a case, the completion of the commissioning tests marks the provisional acceptance of the PV power plant. The final acceptance takes place after a successful repeated performance ratio test. The period of operation between the two tests is dependent on the contract with the EPC contractor and the level of risk taken on the components of the PV power plant. For example, a PV power plant with a new technology, an untested module manufacturer or a new EPC contractor may carry a larger degree of technology risk. Therefore, repeating the performance ratio test after one or two year's operation helps identify degradation and teething problems.

3.18.6 Handover Documentation

The commissioning record will be handed over to the developer once commissioning is complete, having been signed by the authorized signatory to confirm that the work is satisfactory. Where appropriate, the O&M contractor will be informed of any system performance issues. The commissioning record is typically submitted along with other handover documentation, which will include:

- The O&M manual.
- Conformity and guarantee certificates.
- Warranty documentation.
- Performance guarantees.
- Monitoring compliance certificates.

3.19 Operation and Maintenance

Compared to most other power generating technologies, PV plants have low maintenance and servicing requirements. However, proper maintenance of the proposed PV plant is essential to optimize energy yield and maximize the life of the system. Maintenance can be broken down as follows:

- **Scheduled or preventative maintenance –** Planned in advance and aimed at preventing faults from occurring, as well as keeping the plant operating at its optimum level.
- **Unscheduled maintenance –** Carried out in response to failures. Suitably thorough scheduled maintenance should minimise the requirement for unscheduled maintenance although, inevitably, some failures still occur. A robust and well-planned approach to both scheduled and unscheduled maintenance is important.

3.19.1 Scheduled/Preventative Maintenance

The scheduling and frequency of preventative maintenance is dictated by a number of factors. These include the technology selected, environmental conditions of the site, warranty terms and seasonal variances. The scheduled maintenance is generally carried out at intervals planned in accordance with the manufacturers' recommendations, and as required by the equipment warranties. Scheduled maintenance should be conducted during non-peak production periods and, where possible, at night. Although scheduled maintenance will both maximize production and prolong the life of the plant, it does represent a cost to the project. Therefore, the aim will be to seek the optimum balance between cost of scheduled maintenance and increased yield throughout the life of the system. Specific scheduled maintenance tasks are covered in the following sections.

Module Cleaning

Module cleaning is a simple but important task. It can produce significant and immediate benefits in terms of energy yield. The frequency of module cleaning will depend on local site conditions (for example, prevalence of dust or rain) and the time of year. As the soiling of modules is site-specific, the duration between clean-ups is likely to vary between sites. However, it is generally recommended to clean the modules at least twice annually. When scheduling module cleaning, consideration will be given to the following:

- Environmental and human factors (for instance, autumn fall debris and soiling from local agricultural activities).
- Weather patterns: cleaning during rainy periods is less likely to be required.
- Site accessibility based upon weather predictions.
- Availability of water and cleaning materials.

If the system efficiency is found to be below the expected efficiency, then module cleaning will be scheduled as necessary. The optimum frequency of module cleaning can be determined by assessing the costs and benefits of conducting the procedure. The benefit of cleaning will be seen in an improved performance ratio due to the lower soiling loss—and resultant increase in revenue). A cost estimate to clean all the modules at the PV plant will be obtained from the cleaning contractor. If the cost to clean is less than the increased revenue then it is beneficial to clean the modules.

Module Connection Integrity

Checking module connection integrity is important for systems that do not have string level monitoring. This is more likely for central inverter systems for which no string monitoring at the junction/combiner boxes has been designed. In such cases, faults within each string of modules may be difficult to detect. Therefore, the connections between modules within each string will be checked periodically (this may include measuring the string current).

Junction or String Combiner Box

All junction boxes or string combiner boxes will be checked periodically for water ingress, dirt or dust accumulation and integrity of the connections within the boxes. Loose connections could affect the overall performance of the PV plant. Any accumulation of water, dirt or dust could cause corrosion or short circuit within the junction box. Where string level monitoring is not used, periodic checks on the integrity of the fuses in the junction boxes, combiner boxes and, in some cases, the module connection box will be conducted.

Hot Spots

Potential faults across the PV plant can often be detected through thermography. This technique helps identify weak and loose connections in junction boxes and inverter connections. It can also detect hot spots within inverter components and along strings of modules that are not performing as expected. Thermography will be conducted by a trained specialist using a thermographic camera.

Inverter Servicing

Generally, inverter faults are the most common cause of system downtime in PV power plants. Therefore, the scheduled maintenance of inverters will be treated as a centrally important part of the O&M strategy. The maintenance requirements of inverters vary with size, type and manufacturer. The specific requirements of any particular inverter will be confirmed by the manufacturer and used as the basis for planning the maintenance schedule.

The annual preventative maintenance for an inverter will, as a minimum, include:

- Visual inspections.
- Cleaning/replacing cooling fan filters.
- Removal of dust from electronic components.
- Tightening of any loose connections.
- Any additional analysis and diagnostics recommended by the manufacturer.

Structural Integrity

The module mounting assembly, cable conduits and any other structures built for the PV plant will be checked periodically for mechanical integrity and signs of corrosion. This will include an inspection of support structure foundations for evidence of erosion from water run-off.

Tracker Servicing

Similarly, tracking systems also require maintenance checks. These checks will be outlined in the manufacturers' documentation and defined within the warranty conditions. In general, the checks will include inspection for wear and tear on the moving parts, servicing of the motors or actuators, checks on the integrity of the control and power cables, servicing of the gearboxes and ensuring that the levels of lubricating fluids are suitable. The alignment and positioning of the tracking system will also be checked to ensure that it is functioning optimally. Sensors and controllers should be checked periodically for calibration and alignment.

Balance of Plant
The remaining systems within a PV power plant, including the monitoring and security systems, auxiliary power supplies, and communication systems will be checked and serviced regularly. Communications systems within the PV power plant and to the power plant should be checked for signal strength and connection.

Vegetation Control
Vegetation control and ground keeping are important scheduled tasks for solar PV power plant since there is a strong likelihood for vegetation (for example, long grass, trees or shrubs) to shade the modules. The ground keeping can also reduce the risk of soiling (from leaves, pollen or dust) on the modules. The vegetation on the project site shall be controlled by mechanical weeding and trimming with no use of chemicals.

3.19.2 Unscheduled Maintenance
Unscheduled maintenance is carried out in response to failures. As such, the key parameter when considering unscheduled maintenance is diagnosis, speed of response and repair time. Although the shortest possible response is preferable for increasing energy yield, this will be balanced against the likely increased contractual costs of shorter response times. The agreed response times will be clearly stated within the O&M contract and will depend on the site location— and whether it is manned. Depending on the type of fault, an indicative response time may be within 48 hours, with liquidated damages if this limit is exceeded. The majority of unscheduled maintenance issues are related to the inverters. This can be attributed to their complex internal electronics, which are under constant operation. Depending on the nature of the fault, it may be possible to rectify the failure remotely – this option is clearly preferable if possible.

Other common unscheduled maintenance requirements include:
- Tightening cable connections that have loosened.
- Replacing blown fuses.
- Repairing lightning damage.
- Repairing equipment damaged by intruders or during module cleaning.
- Rectifying SCADA faults.
- Repairing mounting structure faults.
- Rectifying tracking system faults.

The contractual aspects of unscheduled O&M are described in more detail below.

3.19.3 Spares
In order to facilitate a rapid response, a suitably stocked spares inventory is essential. The numbers of spares required will depend on the size of the plant and site-specific parameters. Adequate supplies of the following components will be ensured:
- Mounting structure pieces.
- Junction/combiner boxes.
- Fuses.
- DC and AC cabling components.
- Communications equipment.
- Modules (in case of module damage).
- Spare inverters (if string inverters are being used).
- Spare motors, actuators and sensors should also be kept where tracking systems are used.

It is important that spares stock levels are maintained. Therefore, when the O&M contractor uses some spares he should replenish the stocks as soon as possible. This arrangement will reduce the time gap between the identification of the fault and replacement of the nonoperational component. This can be of particular relevance for remote locations with poor accessibility and adverse weather conditions. Consultation with manufacturers to detail the spare parts inventory, based upon estimated component lifetimes and failure rates, is recommended.

3.19.4 Performance Monitoring, Evaluation and Optimization

To optimize system performance, there is a need to ensure that the plant components function efficiently throughout the lifetime of the plant. Continuous monitoring of PV systems is essential to maximize the availability and yield of the system. A SCADA system is able to monitor the real-time efficiency and continuously compare it with the theoretical efficiency to assess if the system is operating optimally. This information can be used by the O&M contractor to establish the general condition of the system and schedule urgent repair or maintenance activities such as cleaning.

3.19.5 Contracts

This section describes the key issues for consideration with regards to O&M contracts. It is common for the O&M of PV plants to be carried out by specialist O&M contractors. The contractor will be responsible for the operation and maintenance of the whole plant. This is likely to include:

- Modules and mounting frames or tracking system.
- Inverters.
- DC and AC cabling.
- String combiner or junction boxes.
- Site SCADA system, remote monitoring and communication systems.
- Site substation.
- Site fencing and security system.
- Auxiliary power supply.
- Site access routes and internal site roads.
- Site building and containers.
- Vegetation control.
- Maintenance of fire-fighting equipment or reservoirs.

Purpose

The purpose of an O&M contract is to optimize the performance of the plant within established cost parameters. To do this effectively, the contract must be suitably detailed and comprehensive. In particular, the O&M contract should clearly set out:

- Services to be carried out by and obligations on the contractor.
- Frequency of the services.
- Obligations on the owner.
- Standards, legislation and guidelines to which the contractor must comply.
- Payment structure.
- Warranties and operational targets.
- Terms and conditions.
- Legal aspects.
- Insurance requirements and responsibilities.

These issues are discussed in the following sections.

Contractor Services and Obligations

The O&M contract will list the services to be performed by the contractor. This list will be site-specific and include the following:

- Plant monitoring requirements.
- Scheduled maintenance requirements.
- Unscheduled maintenance requirements.

- Agreed targets (for example, response time or system availability).
- Reporting requirements (including performance, environmental, and health and safety reporting).

It will be stipulated that all maintenance tasks shall be performed by the contractor in such a way that their impact on the productivity of the system is minimal. In particular, the contract should stipulate that maintenance tasks will be kept to a minimum during the hours of sunlight. The O&M contract will typically define the terms by which the contractor is to:

- Provide, at intervals, a visual check of the system components for visible damage and defects.
- Provide, at intervals, a functional check of the system components.
- Ensure that the required maintenance will be conducted on all components of the system. As a minimum, these activities should be in line with manufacturer recommendations and the conditions of the equipment warranties.
- Provide appropriate cleaning of the modules and the removal of snow (site specific).
- Make sure that the natural environment of the system is maintained to avoid shading and aid maintenance activities.
- Replace defective system components and system components whose failure is deemed imminent.
- Provide daily remote monitoring of the performance of the PV plant to identify when performance drops below set trigger levels.

Obligations on the Owner

In an O&M contract for the proposed PV plant, the obligations on NSF are generally limited to:

- Granting the O&M contractor access to the system and all the associated land and access points.
- Obtaining all approvals, licenses and permits necessary for the legal operation of the plant.
- Providing the O&M contractor with all documents and information available to them and necessary for the operational management of the plant.

Standards, Legislation and Guidelines

This section of the contract outlines the various conditions to which the O&M contractor must comply while carrying out the O&M of the plant. These conditions are contained within the following documentation:

- Building or construction permits.
- Planning consents and licenses.
- Grid connection statement, the grid connection agreement and PPA (or similar).
- System components installation handbooks.
- Applicable legislation
- Local engineering practices (unless the documents and conditions listed above require a higher standard).

Payment

The cost and remuneration of the O&M contract is generally broken down in to:

- Fixed remuneration and payment dates.
- Other services remuneration and expenditure reimbursement.

Fixed remuneration outlines the payment for the basic services that are to be provided by the maintenance contractor under the O&M contract. This section should include the following:

- Cost – this is usually a fixed price per kWp installed.
- Payment structure (that is, monthly, quarterly or annually).
- Payment indexation over the duration of the contract.

Remuneration for other services includes payment for any services above the basic requirement. This should include:

- Method for determining level of other services carried out.
- Agreed rates for conducting these services.
- Agreed method for approving additional expenses or services with the owner.
- Any required spare parts and other components that are not covered by individual warranties.

Warranties

An availability warranty can be agreed between the maintenance contractor and the owner of the system. It then becomes the responsibility of the maintenance contractor to make sure that the system operates at a level greater than the agreed value. If the system operates below the warranted level, then the maintenance contractor may be liable to pay a penalty.

Legal

The contract will have a section outlining the governing law and jurisdiction of the O&M contract. The governing law is normally the law of the country in which the project is located. A legal succession or a transfer of rights condition is required for the developer to reserve the right to assign the O&M contract to a third party. It is also recommended that every contract has a nondisclosure agreement. This agreement between the O&M contractor and the developer will outline the information that is to be treated as confidential and that which could be disclosed to third parties.

Insurance

The contract should have a section outlining the insurance responsibilities of the contractor for the operations and maintenance activities. This insurance should cover damage to the plant, as well as provide cover for employees conducting the maintenance. It is normal for the O&M contractor to also arrange and pay for the full site insurance.

Term of Agreement

Every O&M contract needs to have a section that outlines when the O&M contract shall become effective and the duration of the contract from the effective date. This section will also include provisions to renew or extend the contract upon conclusion of the originally agreed term. It is also recommended that this section includes the circumstances in which either the maintenance contractor or the developer would be entitled to terminate the contract.

Response Time

The guaranteed response time of a maintenance contractor is an important component of the O&M contract. As soon as notification of a fault occurs, it is the responsibility of the contractor to go to the site within a set period of time. The faster the response time, the swifter the issues can be diagnosed and resolved towards the aim of returning the system to full production. The distance between the PV plant and the contractor's premises has a direct correlation to the duration of the guaranteed response time. The time of year coupled with the accessibility to the site can have a bearing on the actual response time for any unscheduled maintenance event. Restrictions in access roads, at certain times of the year, can delay response. Adverse conditions can also reduce the size of the payload that can be transported to the site, thus extending the duration of the maintenance work.

Selecting a Contractor

When choosing an O&M contractor, his experience should be thoroughly examined. In particular, the following aspects should be considered:

- Familiarity of the contractor with the site and equipment.
- Location of the contractor's premises.
- Number of staff.
- Level of experience.
- Financial situation of the contractor.

The intention will be to select a suitably experienced contractor able to meet the requirements of the contract for the duration of the project.

3.19.6 Environmental Management System

NSF shall, during the operation and maintenance (O&M) phase, ensure management of its environmental programs in a comprehensive, systematic, planned and documented manner. The system shall include the organizational structure, planning and resources for developing, implementing and maintaining policy for environmental protection.

NSF's Environmental Management System (EMS) shall be in line with the IFC Environmental, Health, and Safety (EHS) Guidelines. The EMS shall also:

- Serve as a tool to improve its environmental performance;
- Provide a systematic way of managing NSF's environmental affairs;
- be the aspect of NSF's overall management structure that shall address immediate and long-term impacts of its proposed PV based solar power plant on the environment;
- Give order and consistency for NSF to address environmental concerns through the allocation of resources, assignment of responsibility and continuous evaluation of practices, procedures and processes; and
- Focuses on continual improvement of the system.

Expected Emissions

The emissions from the operational and maintenance phase of the NSF proposed PV based solar power plant shall fall into the following categories:

Water Pollution

Solar technologies do not discharge any water while creating electricity. However, the expected water pollutants from the plant shall be:

- Rain water drainage and
- Sewage from various buildings in the plant.

Rain (Storm) Water Drainage

The rain (storm) water removed from the building roofs and yard area grade level surfaces will be directed through the open ditches and culverts to the storm drainage piping. All ditches will be concrete lined and located along the roads. All drainage ditches will be located to provide the shortest practical drainage path while providing efficient drainage for the yard. Grade level will be contoured such that storm water runoff is directed on the ground by sheet flow, to well defined drainage paths leading to the ditches.

Sewage from Various Buildings in the Plant

Sewage from various buildings in the power plant area will be conveyed through separate drains to septic tanks. The effluent from septic tanks will be disposed off in the soil by providing dispersion trenches. There will be no ground pollution because of leaching. Sludge will have to be removed and disposed off as land fill.

Gaseous Emissions

Emissions associated with generating electricity from PV based solar technologies are negligible because no fuels are combusted. However, gaseous emissions to air during the operational phase will result from vehicular combustion of fossil fuel.

Solid Waste Generation

PV-based solar technologies do not produce any substantial amount of solid waste while creating electricity. The production of photovoltaic wafers creates very small amounts of hazardous materials that must be handled properly to avert risk to the environment or to people.

3.20 Decommissioning and Abandonment Plan

Decommissioning after the construction phase

In order to support site operations/activities during construction, temporary structures (storage yard, site offices, cafeteria, etc.) would be installed. Upon completion of the construction of the power plant, temporary structures areas would be cleared.

Project closure and abandonment

Decommissioning refers to the process of dealing with the operating assets of the project after completion of the operating life cycle. This very last phase of the project is expected to last at least 60 years after operations start-up. Decommissioning procedures at this stage are generic. However, the general process of decommissioning would be as follows:

- Operating processes are systemically shut down in a safe manner.
- Liquid, solid contents and wastes are removed for treatment and disposal
- The fate of the emptied and cleaned structures and equipment are then decided by a feasibility study as part of an “Abandonment Assessment” to determine the best environmental and economic solution consistent with Nigerian regulatory requirements.

The general order decommissioning options available for redundant structures and equipment are as follows:

- **Re-use**: by sale and/or transport to another project or company;
- **Re-cycle**: breaking down structures and equipment for raw materials. This is expected to be the fate of the great majority of metalwork. The break-up of structures can be done on location or after transport to a breaking or salvage yard, dependent upon ease of transport and safety considerations;
- **Disposal**: some materials are not suitable for recycling and must be disposed to a licensed waste management facility.
- **Leave in-situ**: in some cases the best environmental and economic option may be to leave material in-situ. The most obvious case in this respect is pipelines as once emptied and cleaned empty steel pipes do not impose a significant environmental hazard, however pulling such pipes out would cause additional damage.

Prior to closure, NSF will produce an environmental, social and health impact assessment which will describe the processes and activities needed for the closure/decommissioning and abandonment. The study will make a full assessment of potential impacts and describe methods of minimising adverse environmental effects. It is currently impossible to give precise details concerning the way in which the process will proceed because technology and modern science will have changed during the project life. There will, however, be certain principles during the de-commissioning, closure and abandoned phase which can be set, such as:

- The decommissioned plant will be cleaned and dismantled and the site will be thoroughly cleaned;
- Discussions with authorities and land owners would be carried out to assess reuse of the sites; and
- If the site is no-longer to be used, full restoration and landscaping will be carried out. This would involve consultation with authorities, land owners and re-instatement to the original vegetation type as is practicable.

3.21 Requirements for Project Implementation Phases

This section discusses the time, manpower, equipment etc. requirements of the different phases of the NSF proposed 125MWp utility scale PV-based solar power plant.

3.21.1 Pre-construction and Construction phase

PV Plant Component

The main activities during this phase will be excavation and earthworks for the internal access roads, building of the plant structures and facilities, and installation of photovoltaic panels and modules. The excavation will be conducted to prepare the land of the site for erecting of the structures needed for installing the photovoltaic system.

The equipment to be used in the site preparation and construction phase will require various forms of energy which will include manpower, and charged of fossil fuel. Fossil-fuel-based equipment to be used will include Bulldozers, loaders, mixers, vibrators, compressors, etc. This phase also comprises the construction and the paving of the internal roads that have lengths of about 2.5 km to connect the photovoltaic plant facilities together and with the major access road (Kankiya – Katsina A9 highway).

The duration of this phase is expected to be 18 months It will require construction equipment and labour. The required equipment include; crane, dozer , jack hummer, loaders, compressors, service-vehicles, in addition to the construction material (aggregates, sand, cement, steel, and water and other needed materials). During this phase, offices and other infrastructure will be constructed. In addition to these equipments, 500 persons (skilled and unskilled) will needed to run all activities of this phase. Those are divided into low skilled workers (construction labor, security staff), semi skilled workers (drivers, equipment operators), and skilled personnel (engineers, land surveyors, project managers). NSF will ensure that the majority of low skilled employment opportunities associated with the project is to the benefit of members from the local communities.

Connection Works

The main activities during the construction phase will be excavation of materials for the poles foundation and installation of poles, conductors, and their support components. Following are the main activities of the construction phase.

Seclusion of project way leave and clearing

The way leave will be carried out before the implementation of the project commencement.

Excavation for foundation works

The project area is made of different types of soils and geological conditions. The excavations will be conducted to create holes for erecting the concrete poles and trenching for cable installation. The trenching will include concert duct bank and the cables will be buried directly. The excavation and construction of the foundation shall involve the use of hand tools like crowbars, mixers, vibrators, and trappers. In case of rocky areas compressors and drills will be used. The equipment to be used in project construction will require various forms of energy which will include manpower, charge of fossil fuel. The varieties of manual equipment to be used in the development project include crowbars, spanners and ropes. Fuel based equipment to be used will include mixers, vibrators, compressors and drills.

These activities shall utilize available labour from host communities to supplement some machinery works such as that by the concrete mixers, thus creating employment for the local population. As the line route passes near paved roads, the contractor will work in full coordination with the Katsina State Ministry of Works and Katsina State Ministry of Lands and Housing.

Stringing and Tensioning

The conductors will be installed using a trolley to unwind them from the cable holders, and using lift crane to elevate the conductors on the pole.

Landscaping
After successful completion of the transmission line construction work, the project contractor will rehabilitate the project right of way (ROW) that could be subjected to clearing by planting indigenous plant species.

3.21.2 Operation and Maintenance Phase

This phase is considered the main project's phase during which the electricity will be generated and dispatched to the Grid. The activities of this phase are considered the most important ones in the project as they are continuous activities over the lifetime of the proposed project and will have impacts on in-site and neighboring.

PV Plant
The photovoltaic plant needs a control room to control all process in the plant. The activities of this phase create noise, solid and liquid wastes, oil spillages, work accidents. These activities may impact the occupational health and the biodiversity in the PV plant site. The needed staff for the operation of the photovoltaic plant includes engineers, technicians, and working labors. The duration of this phase is expected to be 25 years, in which permanent jobs will be created. The total staff for this phase is estimated to be about 50 person including low skilled, semi-skilled and skilled employees. The majority of work opportunities associated with the operational phase is likely to be taken up by members from the surrounding villages.

Connection Works
General Maintenance
Activities undertaken during the transmission line operation phase are minimal and will include clearing of overgrown vegetation and repairs of any defect that can be detected along the transmission line.

Waste Management
NSF will manage the waste generated during the operation phase of the transmission line appropriately. This will be done by providing facilities for temporary storage or handling of the solid and liquid waste generated during the maintenance period. Such facilities shall be in the form of the following:

- Open air and fenced temporary warehouse on the project land
- 20 and 40 feet containers for electric, electronic devices, tools and modules
- Bungalows for temporary offices.

The services of government-accredited waste management contractors will be contracted during all the phases of the project.

Decommissioning phase
This phase includes the following activities in the two project's components:

Demolition and material removal Works
Upon decommissioning, the components of the PV plant and the transmission line will be uninstalled. This will produce a lot of solid waste, which can be reused for other projects and construction works or if not reusable, disposed of appropriately by a proponent waste disposal company.

Site Rehabilitation
Once all the waste resulting from demolition and dismantling works is removed from the site, the site will be rehabilitated through replenishment of the topsoil. The expected pollutants and wastes that may result from the above mentioned activities during the construction phase are the following:

- Dust caused by earthworks using heavy equipment and trolley;

- Gases Emissions (fossil fuel charged equipment and Vehicles);
- Noise generated from the heavy equipment and machinery;
- Solid and Liquid wastes;

The impacts of this phase are temporary and are related to the period of accomplishing this project. The equipment requirements of this phase are Jack Hummers, Loaders and large trucks for material transporter; this phase needs 200 people for a relatively short period.

3.21.3 Project Personnel Requirements

The program of work is a special document that describes the construction process in detail, the work schedule, the amount of man power and machinery used. It will be developed by the contractor selected following an invitation to tender (ITT). Nevertheless, the standard practice in constructing PV plant and the transmission line is discussed in the following paragraphs.

PV Plant Components

Pre-construction and Construction phase requirements

This phase requires the temporary construction equipments and labours, the equipments include; crane, dozer, jack hummer, loader compressors, service-vehicles, in addition to the construction materials (aggregates, sand, cement, steel, and water). In addition to this equipment, 500 persons will be needed to run all activities of this phase including construction skilled and non skilled labours, security staff, drivers, equipment operators, etc.

Operation phase requirements

The needed staff for the operation of the photovoltaic plant includes engineers, technicians, and working labors for each working shift. The total staff for this phase is estimated to be about 50 persons.

Decommissioning phase requirements

The requirements of this phase are Jack Hummer, Loader and large trucks for material transporter; this phase needs 200 people for a relatively short period, including construction skilled and non skilled labors, drivers, and equipment operators, etc..

Connection Works Personnel Requirements

Construction phase

The construction process is put into practice by groups of single purpose workers that execute their particular front of work. The construction teams will be about 50 people divided to crews, working one after another, with each crew responsible for one of the construction assignment (laying the foundations for the poles and trenching for cables, assembling the poles on the ground, erecting of the poles and installing of trenching cables and wires and testing and commissioning the line). Workers involved in the construction will have working camp dwell within the PV plant for the workers in the two project components. There will be transport (Pick-Up) link arranged between the construction sites and the places of residence of the construction bridges.

Operation phase

During the operation phase of the project, way leaves will be maintained through manual vegetation clearing. Once the poles and the other components are erected and structural integrity established, minimal maintenance is required and a routine aerial inspection and ground inspection will however be done annually.

Decommissioning phase

The connection works will not be decommissioned, as more users will be connected to those facilities.

Table: 3.11 Equipment Requirements for Construction Phase

Equipment	Quantity	Function
Dozer	10	Will be used for land digging, and removing of the dislocated material
Jack hummer	20	Will be used for material dislocation from the bed rock, removal, and breaking to smaller size
Loaders	10	Will be used for material removal, cleaning, collection, and loading on the large transport trucks
Compressors	20	Will be used for excavation in the bedrock
Trucks	20	Will be used for loading, transport, and unloading earth works material at allocated disposal sites
Pick Up (Double Cabin)	20	Will be used as a supportive vehicle needed for the work on site
Lifting Crane	10	Will be used to install the conductors to unwind them from the cable holders

Table 3.12: Man Power Requirements for Construction Phase

Position	Number
PV Plant	
Engineer	10
Skill labor	50
Forman	20
Loader Operator	20
Dozer Operator	20
Jack hummer driver	20
Mechanics	40
Pick Up Driver	20
Site Labor	250
Connection Works	
Engineer	2
Skill labor	5
Forman	4
Compressor Operator	5
Packhole Operator	4
Crane Operator	4
Mechanics	2
Pick Up Driver	4
Site Labor	20
Total	500

The equipment machinery and manpower required for the operation and maintenance phase for the two project components are shown in tables 3.14 and 3.15.

Table 3.13: Equipment Requirements for Operation and Maintenance Phase

Equipment	Quantity	Function
Lifting Crane	3	Will be used to lift up workers to the isolators' level
Mobile Water Tanks	3	Will be used for washing isolators and PV cells
Pick Up (Double Cabin)	3	Will be used for inspection visits and transporting the working crew

Table 3.14: Manpower Requirements for Operation and Maintenance Phase

Position	Number
PV Plant	
Security	20
Cleaning staff	8
Technicians	16
Managers	3
Connection Works	
Engineer	1
Technicians	2
TOTAL	50

CHAPTER FOUR

EXISTING ENVIRONMENTAL CONDITION

CHAPTER FOUR

DESCRIPTION OF EXISTING ENVIRONMENT

4.1 General

This chapter provides description of the biophysical and socio-economic/health profiles of the proposed study area. The establishment of a comprehensive environmental baseline condition of the study area is required as part of the ESIA process, to provide information on the characteristics and features of the proposed project environment. In addition, it also provides background/scientific basis for predicting, evaluating and mitigating impacts of planned project activities on the environment, monitoring environmental changes in the area, as well as support the decision making in future project design, operation and management.

The information/ data on the environmental condition of the study area were acquired through desktop research, field observation, one season sampling and measurements as well as laboratory testing of sampled ecological components.

4.2 Baseline Data Acquisition Methods

The acquisition of data basically involved field data gathering, measurements and the collection of representative samples used to establish the environmental condition of the study area. This exercise involved a multi-disciplinary approach and was executed within the framework of a QHSE management system approach. This approach assured that the required data and samples were collected in accordance with agreed requirements (scientific and regulatory) using the best available equipment, materials and personnel. Elements of this approach include:

- review of existing reports that contain environmental information on the study area;
- designing and development of field sampling strategy to meet work scope and regulatory requirements;
- pre-mobilisation activities (assembling of field team, sampling equipment/materials calibrations/checks, review of work plan and schedule with team, and job hazard analysis);
- mobilisation to field; fieldwork implementation - sample collection (including positioning and field observations), handling, documentation and storage protocols and procedures; and
- demobilisation from field; transfer of sample custody to the laboratory for analysis.

The following sections present the field data gathering methodology/procedures and the descriptions of the environmental baseline conditions of the study area. The detailed documentation of the fieldwork execution including descriptions of the laboratory analytical methods and procedures, the detection limits for the various parameters analysed as well as an overview of the general QHSE plan adopted for field data gathering and laboratory analysis is presented in **Appendix 4.1**.

4.2.1 Desktop Studies

Desktop studies involved the acquisition of relevant background information on the environment of the study area. Materials that were consulted included reports on previous environmental surveys in the area (i.e Sokoto IPP EIA, Mambilla HEPP, 2014), publications, textbooks, articles, maps, satellite images, etc. on the area and similar environments. **Figure 4.1** is the satellite image of the study area showing its features.

4.2.2 Field Sampling/Measurement

In order to effectively characterise the ecology and meteorology of study area and determine seasonal variations of specific environmentally related parameters, a two season field data gathering exercise was programmed for the study. The first season (dry) was carried out in February 2015, while the wet season was carried out in August, 2015. The specific objectives of the ecological field sampling were to:

- Determine the ambient air quality and noise level of the study area;
- Determine the physio-chemical and microbiological characteristics of the soil within the study area;
- Determine the physico-chemical and biological characterisation of water and sediment samples (if available) within the study area;
- Determine the fisheries abundance and characterisation (if available) of the study area;
- Determine contemporary wildlife abundance and diversity of the study area and environs;
- Determine the vegetation characteristics of the area; and
- Establish the socio-economic and health status of the host community.

Soil samples were collected with hand auger at two depth intervals (0-15cm and 15-30cm). These samples were preserved in plastic bags and stored in coolers.

4.2.3 Sampling Design

Sampling was designed in order to comprehensively capture all the ecological and socio-economic components peculiar to the study area. The design involved the following:

- Soil sample collection at 12 locations designated randomly.
- Air quality and noise measurements at 11 locations.
- Groundwater collection at 3 existing boreholes.
- Biodiversity studies across the study area.
- Socio-economic study of the immediate host communities

4.2.4 Analytical Methods

Samples collected from the field were analysed in FNL laboratory, a FMEnv Accredited laboratory located at No. 91 Odani Road, Off PH-Eleme Expressway, Elelenwo, Port Harcourt, Rivers State, Nigeria. The methods presented in **Table 4.1** were employed in the samples analyses**.** Also shown on the table are the equipment detection limits for the different parameters analysed.

Table 4.1: Laboratory Analytical Methods

Parameters for Water Analysis	Methods	Detection Limits
Temperature (^oC)	APHA 2110B	-
pH	APHA 4500H^+B	-
Turbidity (NTU)	APHA 2130B	1.0
Salinity (mg/l)	APHA 2520B	0.01
TSS (mg/l)	APHA 2540D	1
TDS (mg/l)	APHA 2510A	-
Conductivity (µS/cm)	APHA 2510A	-
THC (mg/l)	ASTM D3921	1.0
DO (mg/l)	APHA 4500-O G	-
BOD (mg/l)	APHA 5210A	0.5
COD (mg/l)	APHA 5220D	0.8
Reactive Silica (mg/l)	APHA 4500-SiO_2	0.1
Nitrate (mg/l)	EPA 352.1	0.02
Phosphate (mg/l)	APHA4500-P D	0.002
Ammonium (mg/l)	APHA 4500-NH_3	0.02
Calcium (mg/l)	APHA 3111B/ASTM D3561	0. 1
Magnesium (mg/l)	APHA 3111B/ASTM D3561	0.1
Potassium (mg/l)	APHA 3111B/ASTM D3561	0. 1
Sodium (mg/l)	APHA 3111B/ASTM D3561	0.1

Table 4.1: Laboratory Analytical Methods cnt'd.

Parameters for Water Analysis	Methods	Detection Limits
Lead (mg/l)	APHA 3111B	0.20
Total Iron (mg/l)	APHA 3111B	0.05
Copper (mg/l)	APHA 3111B	0.05
Zinc (mg/l)	APHA 3111B	0.05
Manganese (mg/l)	APHA 3111B	0.10
Cadmium (mg/l)	APHA 3111B	0.02
Total Chromium (mg/l)	APHA 3111B	0.10
Mercury (mg/l)	APHA 3112B	0.0002
Arsenic (mg/l)	APHA 3030B/3114B	0.001
Parameters for Sediment / Soil Analysis		
pH (H_2O)	ASTM D4972	-
TOC/TOM (mg/kg)	BS 1377	-
Conductivity (mg/kg)	APHA 2510B	-
THC (mg/kg)	ASTM D3921	10.0
Nitrate (mg/kg)	EPA 352.1	0.02
Phosphate (mg/kg)	APHA 4500-P D/CAEM	0.002
PSD (mg/kg)	ASTM D422	-
Calcium (mg/kg)	APHA 3111D	0.1
Magnesium (mg/kg)	APHA 3111B/ASTM D3561	0.1
Potassium (mg/kg)	APHA 3111B/ASTM D3561	0.1
Sodium (mg/kg)	APHA 3111B/ASTM D3561	0.1
Zinc (mg/kg)	ASTM D5198/APHA	0.05
Lead (mg/kg)	ASTM D3111B /D5198	0.20
Mercury (mg/kg)	APHA 3112B/ASTM D	0.0002
Arsenic (mg/kg)	APHA 3030F/3114B	0.001
Total Iron (mg/kg)	APHA 3111B/ASTM D5198	0.05
Copper (mg/kg)	APHA 3111B/ASTM D5198	0.05
Cadmium (mg/kg)	APHA 3111D/ASTM D5198	0.02
Total Chromium (mg/kg)	APHA 3111B/ASTM D5198	0.10

4.3 Climate and Meteorology

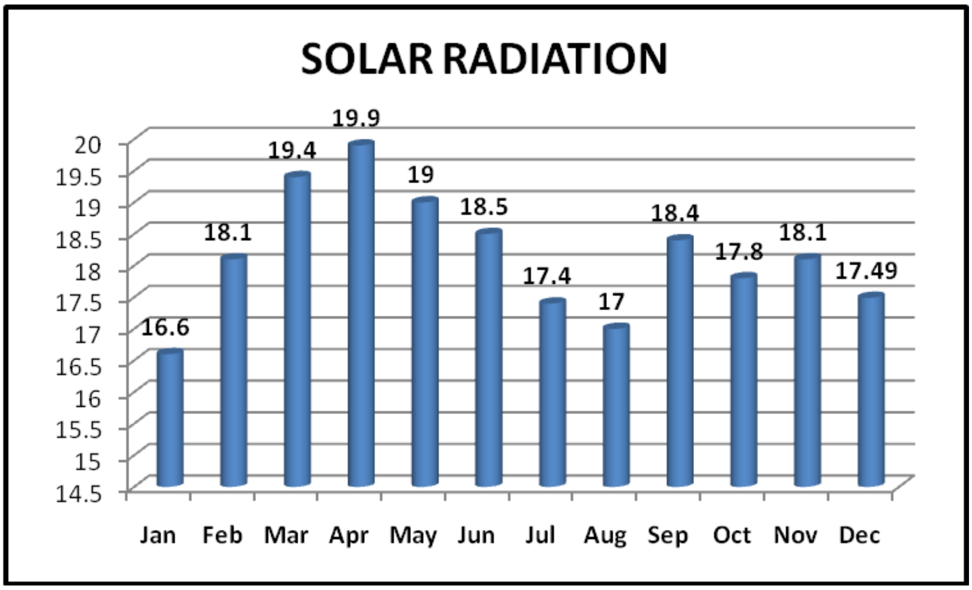
Climate encompasses the statistics of temperature, humidity, atmospheric pressure, wind, rainfall, atmospheric particle count and other meteorological elements in a given region over long periods of time. The climate of a location is affected by its latitude, terrain, altitude, as well as nearby water body and their currents. Climates can be classified according to the average and typical ranges of different variables, most commonly temperature and rainfall.

The climate of Nigeria is characterised by two regimes-the dry season and the wet season. These are dependent on two prevailing air-masses blowing over the country at different times of the year: the north-easterly air mass of Sahara origin (the tropical continental air mass) and the humid maritime air-mass blowing from the Atlantic (the tropical maritime air mass). The two air masses blowing from nearly opposite directions meet along a slanting surface (the Inter-Tropical Front). The area about this front, where the air masses to some extent mix, is called the inter-tropical discontinuity (ITD) or the inter-tropical convergence zone (ITCZ). This zone moves north and south with the front depending on which air mass gains ground over the other. The influence of the north-easterly air-mass causes dry season while that of the humid maritime air-mass causes the rainy season.

The project area is within the tropics, it is dominated by two contrasting seasons, the dry and wet (rainy) seasons. The two season regimes are dependent on the two prevailing air masse blowing across the country at different times of the year, the south-westerly humid maritime air mass blowing from across the Atlantic and the north-easterly air mass of Saharan origin (Harmattan).

4.3.1 Sunshine

The mean daily sunshine for the months of the year in the project area is between eight (8) and ten (10) hours in the dry season and six (6) and nine (9) hours in the wet season (Federal Surveys, 1978). The study area experiences a mean annual sunshine of 3,048 hours, which represents (31 %) of maximum possible amount of sunshine in the environment.



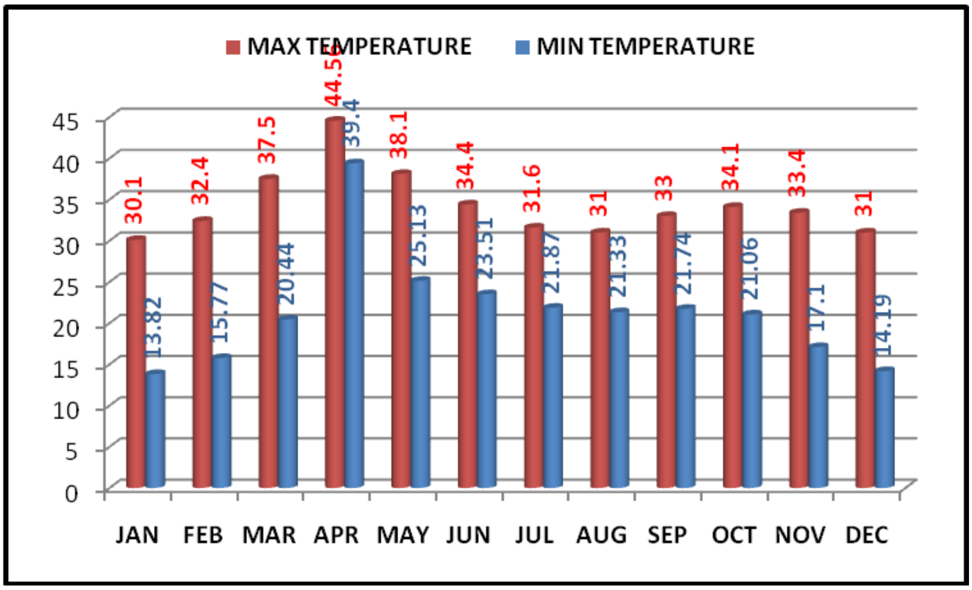
Source: Nigerian Meteorological Agency (NIMET), 1980 -2010

Figure 4.1: Mean Daily Solar Radiation for Months of the year

The lowest values of sunshine are recorded in July (about 6 hours) and August (about 7 hours) due to greater amount of cloudiness in the sky (Federal Surveys, 1978).

4.3.2 Temperature

The maximum and minimum temperatures recorded for Katsina by the Nigerian Meteorological Agency (NIMET) is shown in **Figure 4.1** below.



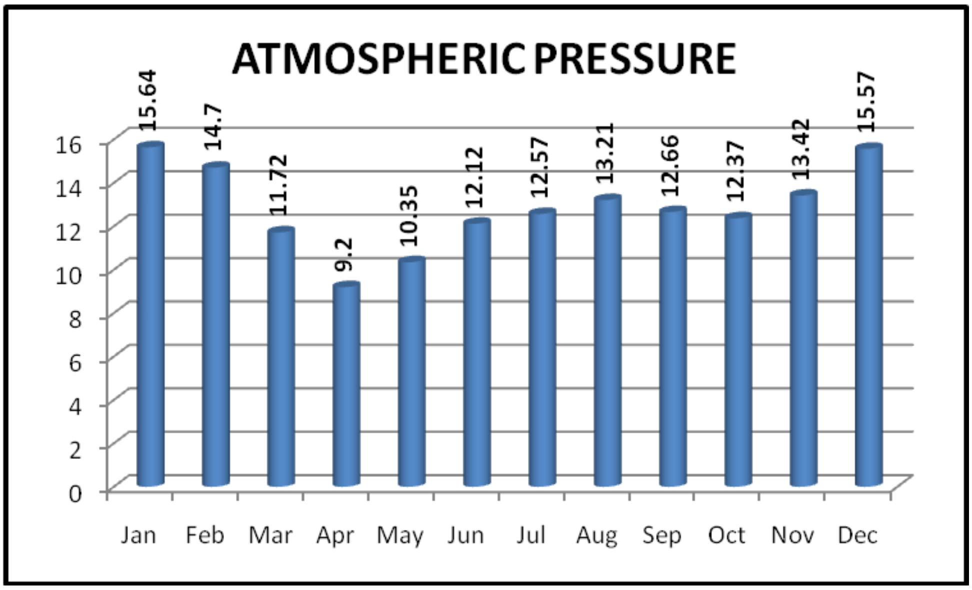
Source: Nigerian Meteorological Agency (NIMET), 1980 -2010

Figure 4.2: Mean Monthly Maximum and Minimum Temperatures

As shown in **Figure 4.2** above, the highest mean maximum temperature was recorded during the month of April (44.5°C) while the lowest mean maximum temperature value was recorded in August (31°C). The highest mean minimum temperature value recorded was 39.4^{0}C in April and the lowest was 17.1^{0}C in November.

4.3.3 Atmospheric Pressure

Pressure is the weight of air on the ground. Variations in atmospheric pressure are closely related to air temperature, water vapour content and vertical and horizontal air movements. Cool or cold air subsides; increasing its pressure on the air and the earth beneath it, but warm air expands and rises relative to its surroundings, thus decreasing pressure locally. **Figure 4.3** below shows the mean monthly atmospheric pressure readings in Katsina.



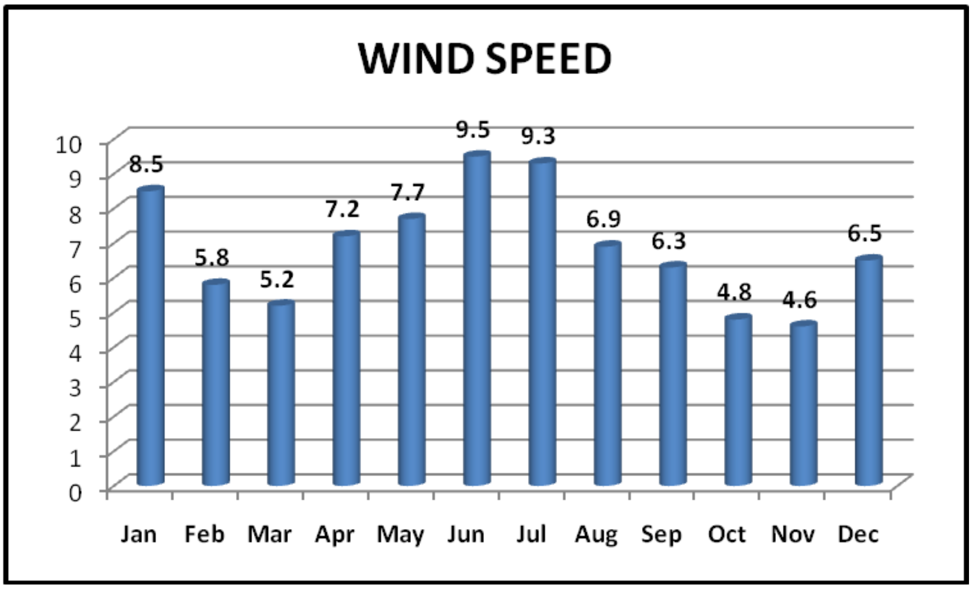
Source: Nigerian Meteorological Agency (NIMET), 1980 -2010

Figure 4.3: Mean Monthly Atmospheric Pressures

The highest mean monthly atmospheric pressure was recorded during the month of January while the lowest mean atmospheric pressure value was recorded in April.

4.3.4 Wind Conditions

The most prevalent winds in Nigeria are the north-westerly and south-easterly winds. The former is dominant towards the beginning and end of the dry season while the latter predominates in the peak of the rainy season. These winds are due to the advancement of the Maritime Tropical Air Mass, an extension of the St Helena Anticyclone, and its retreat/replacement by the Continental Air Mass (Sahara) from the North African Anticyclone, with the onset of the dry season (Oguntoyinbo and Dereck, 1987). Wind speed in Katsina is shown in **Figure 4.4** below.



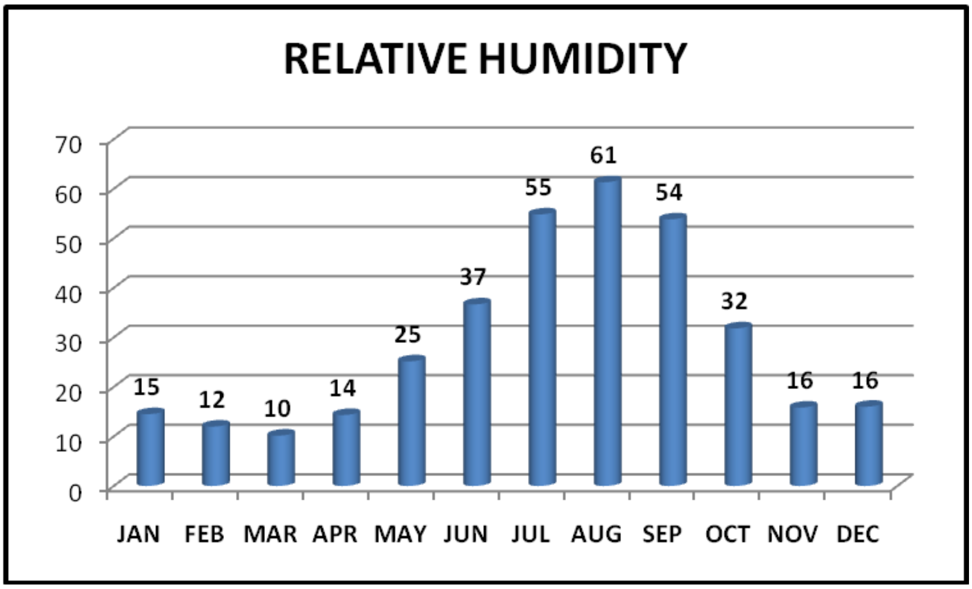
Source: Nigerian Meteorological Agency (NIMET), 1980 -2010

Figure 4.4: Average Wind Speed in Katsina

Winds speed of up to 7.2 metres/second (m/s) and above were recorded in January, April, May, June, and July for the period, 1980 to 2010. The lowest wind speed recorded (4.6m/s) was in the month of November.

4.3.5 Relative Humidity

Relative humidity is the ratio of the amount of water vapour in the air at a specific temperature to the maximum amount that the air could hold at that temperature, expressed as a percentage. For example, a reading of 100 percent relative humidity means that the air is totally saturated with water vapour and cannot hold any more, creating the possibility of rain. See **Figure 4.5** below for recorded values of relative humidity in Katsina for the period, 1980 to 2010.



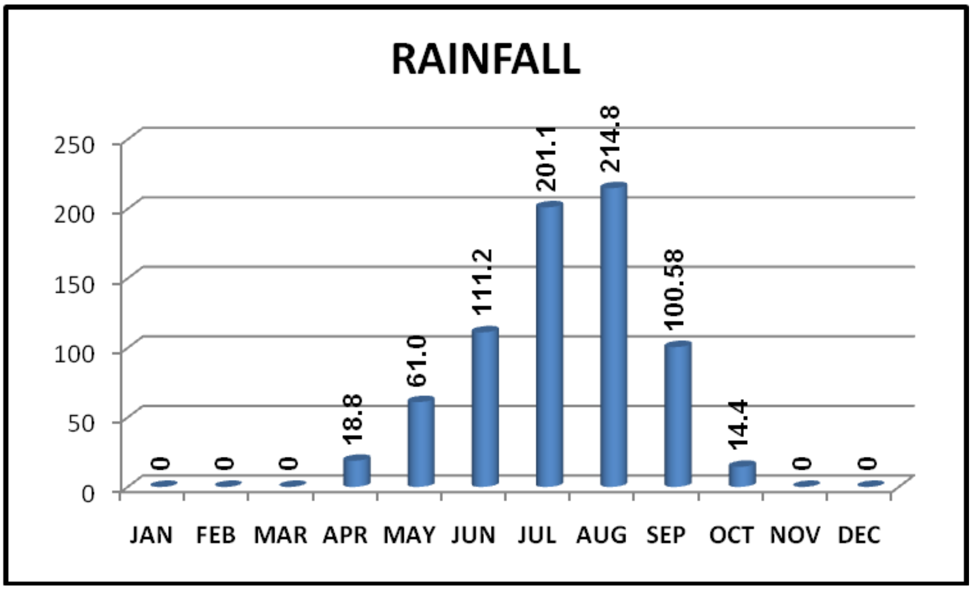
Source: Nigerian Meteorological Agency (NIMET), 1980 -2010

Figure 4.5: Average Relative Humidity in Katsina

Relative humidity is higher in the wet season than the dry season because of rainfall caused by precipitation of vapour in the atmosphere. The least mean (10.0%) monthly relative humidity was recorded in the month of March while the highest recorded mean monthly relative humidity (61.0%) was in August.

4.3.6 Rainfall

Rain forms as a result of uplift of the air, thus leading to condensation of water vapour and the creation of cloud, from which the water droplets fall. Some causes of uplift are convection due to the heating of the ground, or the forced ascent of moist air over high ground. **Figure 4.6** below presents the mean monthly values recorded in the study area for the period, 1980 to 2010.



Source: Nigerian Meteorological Agency (NIMET), 1980 -2010

Figure 4.6: Mean Monthly Rainfall

Mean monthly rainfall recorded in Katsina was zero in the months of January, February, March, November, and December and highest in the month of August (214.8mm).

4.3.7 Cloud

Solar radiation, temperature and humidity have direct relationship with cloud development and thus precipitation. Cloud formation is preceded by upward movement of humid air, which leads to its expansion (against the diminishing resistance of the lowering pressure of the surrounding atmosphere), and cooling. This cooling will lead to immediate condensation in saturated air or to eventual condensation if the cooling is sufficiently prolonged. As the rainy season approaches in Katsina, there is a trend towards increased cloudiness. Decline in sunshine hours (and radiation) becomes more intense as the rainy season progresses.

4.4 Ambient Air Quality and Noise Level

4.4.1 Ambient Air Quality

Air generally contains water vapour, gases, and particulate matter in small but very variable quantities (Oguntoyinbo and Derek, 1987). Air pollution is the presence in the atmosphere of one or more contaminants in such quantities, characteristics, duration as to make them actually or potentially injurious to human, plant, or animal life or to property, or which unreasonably interfere with the comfortable enjoyment of life and property.

The mean concentrations of the air pollutants (CO, SO_x, VOC, NO_x, C_xH_x, H_2S) and noise levels were measured in the study area within a radius of 1.5km (zone of influence) from the centre of the project site. Measurements were taken during the wet and dry seasons as presented in **Table 4.2**. Generally, measurements indicated that the ambient air was free from pollution by these measured parameters as at time of study. The noise levels in the study area were higher in the wet season than in the dry season. Despite this, the noise levels were below the statutory level for industrial areas. The study area is designated by Katsina State Government for industrial development.

Table 4.2: Air Quality Measurements in the Study Area

Sample Stations	SPM (mg/m3)		CO (ppm)		NH_3 (ppm)		NOx (ppm)		CxHy (%)		H_2S (ppm)		Noise (dB)A	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
AQ1	0.054	0.009	<0.10	<0.10	<0.10	<0.10	1.00	<0.10	<0.10	<0.01	<0.01	<0.10	34.7	42.1
AQ2	0.094	0.006	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.01	<0.01	<0.10	36.8	32.1
AQ3	0.061	0.007	<0.10	<0.01	<0.10	<0.01	<0.10	<0.01	<0.10	<0.01	<0.01	<0.10	37.9	36.9
AQ4	0.063	0.009	<0.10	<0.01	<0.10	<0.01	2.00	<0.01	<0.10	<0.01	<0.01	<0.10	25.3	25.5
AQ5	0.049	0.008	<0.10	<0.10	<0.10	<0.10	1.00	<0.10	<0.10	<0.01	<0.01	<0.10	34.6	34.0
AQ6	0.059	0.006	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.01	<0.01	<0.10	34.3	50.7
AQ7	0.189	0.006	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.01	<0.01	<0.10	48.7	36.5
AQ8	0.065	0.008	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.01	<0.01	<0.10	36.4	49.5
AQ9	0.103	0.005	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.01	<0.01	<0.10	38.7	44.1
AQ10	0.069	0.009	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.01	<0.01	<0.10	29.3	30.0
AQ11	0.044	<0.001	<0.10	<0.10	<0.10	<0.10	1.00	<0.10	<0.10	<0.01	<0.01	<0.10	36.7	26.6
FMENV Limits	250		10 – 20		0.01– 0.1		0.04 – 0.06		-		-		90	
WHO Ambient Air Quality Guidelines														

Station	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9	SS10
Wind Direction	E	E	E	SW	SW	SW	E	E	NE	NE

NE: Northeast; E: East; SW: Southwest; NE: Northeast. Source: FNL Field Survey, 2015

The spatial distribution of air quality/noise, soil, and groundwater sample stations are shown in A3 map attached overleaf. Note that air quality sample stations (AQ1 to AQ11) coincide sequentially with soil sample stations (SS1 to SS11).

Suspended Particulate Matter

These are finely divided particles (solid and liquid) of 0.01 to over 100 microns in diameter, suspended in ambient air (Larry and Loren, 1977). These particles existing above tolerable limit in the atmosphere can initiate a variety of respiratory diseases (bronchitis, emphysema and cardiovascular diseases). Also fine particulates may cause cancer and aggravate morbidity and mortality from respiratory dysfunctions (CCDI, 2001). The SPM levels in the study area ranged from 0.044mg/m^3 to 0.189mg/m^3 during the dry season, and <0.001 to 0.009mg/m^3 during the wet season. These were below the regulatory limit of 250mg/m^3.

Carbon Monoxide

Carbon monoxide (CO) is a colourless, odourless and tasteless gas produced by the incomplete combustion of carbonaceous materials or fossil fuels – gas, oil, coal and wood. Adverse health effect has been observed with carbon monoxide concentrations of 12 – 17ppm for 8 hours (Canter and Hill, 1977) while prolonged (45 minutes to 3 hours) exposure to concentrations of CO between 200ppm and 800ppm often results in severe headache, dizziness, nausea and convulsions (CCDI, 2001). The recorded level of CO was <0.10ppm at all the sample stations for dry and wet seasons.

Hydrogen Sulphide

Hydrogen sulphide is a chemical compound with the formula H_2S. It is a colourless gas with the characteristic foul odour of rotten eggs; it is heavier than air, very poisonous, corrosive, flammable, and explosive. Hydrogen sulphide often results from the bacterial breakdown of organic matter in the absence of oxygen gas, such as in swamps and sewers; this process is commonly known as anaerobic digestion. H_2S also occurs in volcanic gases, natural gas, and in some sources of well water. It is also present in natural halite type rock salts. Hydrogen sulphide occurs naturally and is also produced by human activities. Just a few breaths of air containing high levels of hydrogen sulphide can cause death. Lower, longer-term exposure can cause eye irritation, headache, and fatigue. It is also produced by human and animal wastes. Bacteria found in your mouth and digestive tract produce hydrogen sulphide during the digestion of food containing vegetable or animal proteins. Hydrogen sulphide can also form from industrial activities, such as food processing, coke ovens, paper mills, tanneries, and petroleum refineries. H_2S was generally below detectable level of <0.01ppm in the study area during the dry and wet seasons.

Nitrogen Oxides

Nitrogen oxides (NO_x) are the family of highly reactive gases also called oxides of nitrogen, which are formed during combustion processes NO_x is a generic term for the mono-nitrogen oxides NO and NO_2 (nitric oxide and nitrogen dioxide). They are produced from the reaction of nitrogen and oxygen gases in the air during combustion, especially at high temperatures. In areas of high motor vehicle traffic, such as in large cities, the amount of nitrogen oxides emitted into the atmosphere as air pollution can be significant. NO_x gases are formed whenever combustion occurs in the presence of nitrogen – as in an air-breathing engine; they also are produced naturally by lightning. In atmospheric chemistry, the term means the total concentration of NO and NO_2. NO_x gases react to form smog and acid rain as well as being central to the formation of tropospheric ozone. NO_x should not be confused with nitrous oxide (N_2O), which is a greenhouse gas and has many uses as an oxidizer, an anaesthetic, and a food additive. NO_y (reactive, odd nitrogen) is defined as the sum of NO_x plus the compounds produced from the oxidation of NO_x which include nitric acid.

Nitrogen oxides (NO_x) consist of nitric oxide (NO), nitrogen dioxide (NO_2) and nitrous oxide (N_2O) and are formed when nitrogen (N_2) combines with oxygen (O_2). Their life spans in the atmosphere range from one to seven days for nitric oxide and nitrogen dioxide, to 170 years for nitrous oxide. Nitric oxide has no colour, odour, or taste and is non-toxic. In the air it is rapidly oxidized to nitrogen dioxide. Nitrogen dioxide is a reddish-brown gas with a pungent, irritating odour. It absorbs light and leads to the yellow-brown haze sometimes seen hanging over cities. It is one of the important components of smog. Nitrous oxide is a colourless, slightly sweet-smelling, non-toxic gas which occurs naturally in the atmosphere. Man-made nitrous oxide is used as the anesthetic commonly called "laughing gas". Nitrogen oxides occur naturally and also are produced by man's activities. In nature, they are a result of bacterial processes, biological growth and decay, lightning, and forest and grassland fires. The primary source of man-made nitrogen oxides is from the burning of fossil fuels. Of the nitrogen oxides emitted, most is nitric oxide, some is nitrous oxide and less than 10 per cent is nitrogen dioxide. The amount of nitrogen dioxide emitted varies with the temperature of combustion; as temperature increases so does the level of nitrogen dioxide. Agriculture also plays a role in nitrogen oxide emissions with the use of fertilizers contributing nitrous oxide to the atmosphere.

NO_x levels in the study area ranged from <0.10ppm - 2.00ppm during the dry season, and was below equipment detection limit of 0.10 ppm during the wet season.

Methane

Methane is a colourless, odourless gas with a wide distribution in nature. It is the principal component of natural gas, a mixture containing about 75% CH_4, 15% ethane (C_2H_6), and 5% other hydrocarbons, such as propane (C_3H_8) and butane (C_4H_{10}). The "firedamp" of coal mines is chiefly methane. Anaerobic bacterial decomposition of plant and animal matter produces marsh gas, which is also methane.

At room temperature, methane is a gas less dense than air. It is not very soluble in water. Methane is combustible, and mixtures of about 5 to 15 percent in air are explosive. Methane is not toxic when inhaled, but it can produce suffocation by reducing the concentration of oxygen inhaled. A trace amount of smelly organic sulphur compounds (*tertiary*-butyl mercaptan, $(CH_3)_3CSH$ and dimethyl sulphide, $CH_3–S–CH_3$) is added to give commercial natural gas a detectable odour. This is done to make gas leaks readily detectible. An undetected gas leak could result in an explosion or asphyxiation.

Methane is synthesized commercially by the distillation of bituminous coal and by heating a mixture of carbon and hydrogen. It can be produced in the laboratory by heating sodium acetate with sodium hydroxide and by the reaction of aluminium carbide (Al_4C_3) with water. The energy released by the combustion of methane, in the form of natural gas, is used directly to heat homes and commercial buildings. It is also used in the generation of electric power. Methane gas was largely absent in the ambient air of the study area during dry and wet seasons as at times of survey with values <0.10% in all stations.

Ammonia

Ammonia (NH_3), colourless, pungent gas composed of nitrogen and hydrogen. It is the simplest stable compound of these elements and serves as a starting material for the production of many commercially important nitrogen compounds. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to food and fertilizers. Although in wide use, ammonia is both caustic and hazardous. Ammonia is found in trace quantities in the atmosphere, being produced from the putrefaction (decay process) of nitrogenous animal and vegetable matter. Ammonia and ammonium salts are also found in small quantities in rainwater, whereas ammonium chloride and ammonium sulphate are found in volcanic districts. In the environment, ammonia is part of the nitrogen cycle and is produced in soil from bacterial processes. Ammonia is also produced naturally from decomposition of organic matter, including plants, animals and animal wastes.

Most people are exposed to ammonia from inhalation of the gas or vapors. Since ammonia exists naturally and is also present in cleaning products, exposure may occur from these sources. The widespread use of ammonia on farms and in industrial and commercial locations also means that exposure can occur from an accidental release or from a deliberate terrorist attack. Ammonia interacts immediately upon contact with available moisture in the skin, eyes, oral cavity, respiratory tract, and particularly mucous surfaces to form the very caustic ammonium hydroxide. Ammonium hydroxide causes the necrosis of tissues through disruption of cell membrane lipids (saponification) leading to cellular destruction. As cell proteins break down, water is extracted, resulting in an inflammatory response that causes further damage.

Immediate Health Effects of Ammonia Exposure

Inhalation: Ammonia is irritating and corrosive. Exposure to high concentrations of ammonia in air causes immediate burning of the nose, throat and respiratory tract. This can cause bronchiolar and alveolar edema, and airway destruction resulting in respiratory distress or failure. Inhalation of lower concentrations can cause coughing, and nose and throat irritation. Ammonia's odour provides adequate early warning of its presence, but ammonia also causes olfactory fatigue or adaptation, reducing awareness of one's prolonged exposure at low concentrations. Children exposed to the same concentrations of ammonia vapour as adults may receive a larger dose because they have greater lung surface area-to-body weight ratios and increased minute volumes-to-weight ratios. In addition, they may be exposed to higher concentrations than adults in the same location because of their shorter height and the higher concentrations of ammonia vapour initially found near the ground.

Skin or eye contact: Exposure to low concentrations of ammonia in air or solution may produce rapid skin or eye irritation. Higher concentrations of ammonia may cause severe injury and burns. Contact with concentrated ammonia solutions such as industrial cleaners may cause corrosive injury including skin burns, permanent eye damage or blindness. The full extent of eye injury may not be apparent for up to a week after the exposure. Contact with liquefied ammonia can also cause frostbite injury.

Ingestion: Exposure to high concentrations of ammonia from swallowing ammonia solution results in corrosive damage to the mouth, throat and stomach. Ingestion of ammonia does not normally result in systemic poisoning.

NH_3 was largely absent in the ambient air of the study area during dry and wet seasons as at time of survey with values <0.10% in all stations.

4.4.2 Noise Level

Noise is a periodic fluctuation of air pressure causing unwanted sound. Apart from causing disturbance to the affairs of man, long term exposure to excessive noise can damage health and have psychological effects (SIEP, 1995). The effects of noise on residents generally relate to the annoyance/nuisance caused by the short and long term high noise levels. Also, disturbance to wildlife is significant especially during breeding seasons and/or when rare species are present.

The rate at which these fluctuations of air pressure occur is the frequency, expressed in hertz (cycles per second). The range of sound pressures encountered is very large and to keep numbers in manageable proportions, noise levels are measured in decibels (dB), which have a logarithmic scale. Most legislation and measurements refer to the 'A' frequency weighting, dB(A) which covers the range audible to the human ear. A 10dB(A) increase typically represents a doubling of loudness.

Sound pressure or acoustic pressure is the local pressure deviation from the ambient (average, or equilibrium) atmospheric pressure caused by a sound wave. Sound pressure in air can be measured using a microphone, and in water using a hydrophone. The SI unit for sound pressure p is the Pascal (symbol: Pa). Sound pressure level (SPL) or sound level is a logarithmic measure of the effective sound pressure of a sound relative to a reference value. It is measured in decibels (dB) above a standard reference level. The commonly used "zero" reference sound pressure in air is 20µPa RMS, which is usually considered the threshold of human hearing (at 1kHz).

Noise levels are usually altered with the introduction of power plants. The regulatory limit for noise provided by the FMENV is specific to the workplace (90dB(A)). However, noise due to construction of the power plant infrastructure and associated facilities is expected to rise. Hence, the WHO Guidelines for Community Noise have been provided in **Table 4.3** as a benchmark for noise levels in areas other than the workplace.

Table 4.3: WHO Guidelines for Community Noise

Specific Environment	Critical health effect(s)	LAeq(dB)	Time base (hours)	LAmax, fast (dB)
Outdoor living area	Serious annoyance, daytime and evening Moderate annoyance, daytime and evening	55 50	16 16	- -
Dwelling, indoors Inside bedrooms	Speech intelligibility and moderate annoyance at daytime and evening. Sleep disturbance at night-time	35 30	16 8	45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
School class rooms and pre-schools, indoors	Speech intelligibility, disturbance of information extraction, message communication	35	During class	-
Pre-school bedrooms, indoors	Sleep disturbance	30	Sleeping time	45
School, playground outdoor	Annoyance (external source)	55	During play	-
Hospitals, ward rooms, indoors	Sleep disturbance at night-time. Sleep disturbance at daytime and evenings.	30 30	8 16	40
Hospitals, treatment rooms, indoors	Interference with rest and recovery	#1	-	-
Industrial, commercial shopping and traffic areas, indoors and outdoors	Hearing impairment	70	24	110
Ceremonies, festivals and entertainment events	Hearing impairment (patrons:<5 times/year)	100	4	110
Public addresses, indoors and outdoors	Hearing impairment	85	1	110
Music through headphones/earphones	Hearing impairment (free-field value)	85#4	1	110
Impulse sounds from toys, fireworks and firearms	Hearing impairment (adults) Hearing impairment (children)	-	-	140#2 120#2
Outdoors in parkland and conservation areas	Disruption of tranquility	#3		

#1: as low as possible; #2: peak sound pressure (not LAmax, fast), measured 100mm from the ear;

#3: existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background so should be kept low; and #4: under headphones, adapted to free-field values.
Source: WHO Guidelines for Community Noise, 1999

It is expected that the measured ambient noise levels and the regulatory guidelines will be standards against which noise will be assessed during the course of developing the planned PV based solar power plant.

The ambient noise level levels within the study area ranged between 35.3 to 48.7dB (A) for dry season, and 25.5 to 50.7 dB(A) for wet season.

4.5 Geology

Katsina State, covering an area 23,938 sq. km., is located between latitudes 11Â°08'N and 13Â°22'N and longitudes 6Â°52'E and 9Â°20'E. The state is bounded by Niger Republic to the north, by Jigawa and Kano States to the east, by Kaduna State to the South and by Zarnfara State to the West. Katsina State forms part of the extensive plains known as the High Plains of Hausaland. The state is composed of undulating plains which generally rise gently from 360m in the northeast around Daura, to 600m around Funtua in the southwest. Generally, the state has two geological regions. The south and central parts of the state are underlain by crystalline rocks of the Basement Complex (from Funtua to Dutsenma), but in the northern parts cretaceous sediments overlap the crystalline rocks.

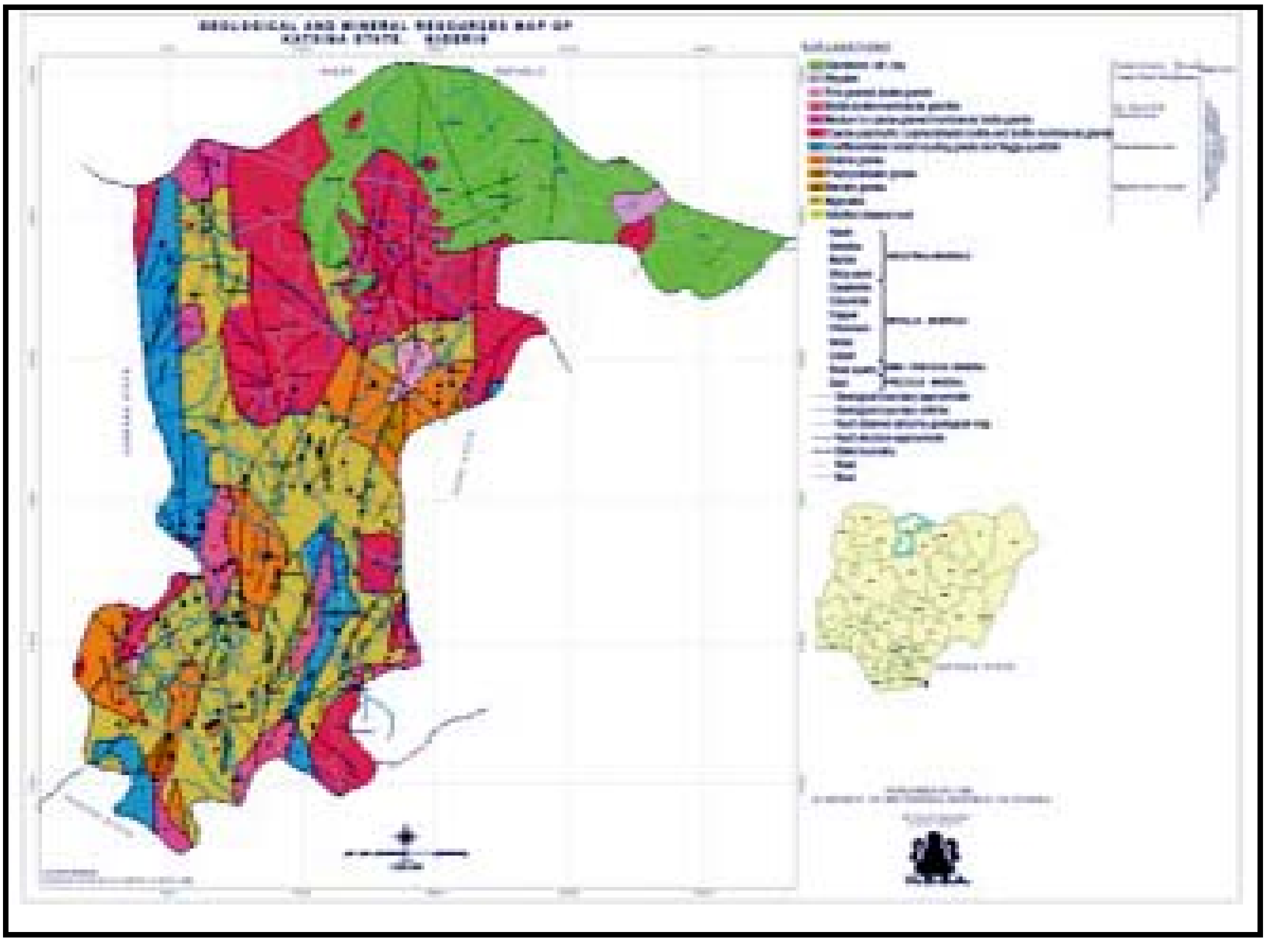


Figure 4.7: Geological Map of Katsina State

The Katsina Daura Plains lie at a lower base level than other parts of the state. Southwards of the Katsina Daura plains, is the flat to gently undulating surface which is the end result of years of erosion action on the surface rock. In areas around Funtua and DutsinMa, there are numerous Quartzatic and granitic hills which rise 60200m above the surrounding plains.

These hills are probably the result of the intrusion of older granites into the basement complex which have undergone long periods of denudation (Buchanan and Pugh, 1955).

Katsina is in the region with gently undulating sandy drift plains with scattered ironstone hills and low outcrops overlying Pre-Cambrian Basement Complex rocks formed by gneisses and other igneous rocks (FORMECU, 1998). The aquifer consists mainly of laterite clay, coarse sands, gravels and decomposed granite (at the bottom). The pump test boreholes dug in the region produced free flow yields of up to 8,160 litres/hour and an average specific yield of about 33,120 litres/hour/metre. The boreholes were dug to 75.8m below the surface soil. The high yields may be from deeply fractured zones of the basement rocks (Offodile 1992).

Katsina State, like Kaduna State, is geologically underlain by the Precambrian migmatites and gneisses, the metasediments/metavolcanics and the Older Granites. The migmatites (mixed rocks, generally consisting of a metamorphic host invaded by granitic material), biotite and granitic gneisses are the largest group of rocks, extending from Birnin-Gwari area to Jema'a Ikara areas. They are characterized by a variety of structures and textures, and they represent reactivated older metasediments. The metasediments / metavolcanics are metamorphosed sedimentary and metavolcanic rock group which consists of ferruginous quartzites, (Banded Iron Formation), amphibolites and pelitic slightly migmatized schists. The Older (Pan African) granites are characterized by lofty topography and inselbergs with lithological varieties of rock formation believed to have been emplaced during the Late Palaeozoic era (550±100 my). They consist of coarse-grained porphyritic granite, biotite hornblende granite and fine-grained granites, and fayalite-quartz monzonite (Ajibade and Wright, 1988; Oluyide, 1995).

4.5.1 Hydrogeology

The area under the Basement complex rocks in Nigeria is considerably large, covering about 50% of the total land area, and mostly falling within the semi-arid parts of the country where surface water is either seasonal or sometimes non-existent such that groundwater is an indispensable source of fresh water. Hence, despite its poor hydrogeological characteristics, this formation is still very important in groundwater studies. Groundwater exploration in this region, therefore, requires good understanding of the lithologic characteristics of the area.

In the northern and semi-arid climatic conditions of Nigeria, almost entirely underlain by crystalline formations, groundwater and surface water availability are scarce and problematic. The igneous and metamorphic rocks are mostly crystalline and they occur as granites, gneisses, migmatites, schists, phyllites, pegmatites or quartzites. They also include metasediments and volcanic rocks of different ages and petrography. Crystalline rocks weather more easily and deeply under humid conditions, and more water is available for storage under favourable rainy environments. But in arid and semi-arid conditions, the extent of weathering, fracturing and erosion is generally limited (Offodile, 1992). Despite this limitation, the prolonged in-situ weathering under tropical conditions has produced a lithologic sequence of unconsolidated material whose thickness and lateral extent vary extensively. The localization of groundwater within the lithologic zones is controlled by a number of factors such as type of parent rock, depth, extent and pattern of weathering, thickness of the weathered materials, the sand/clay ratio and the degree of fracturing, fissuring and jointing (Amadi and Teme, 1987; Odusanya, 1990).

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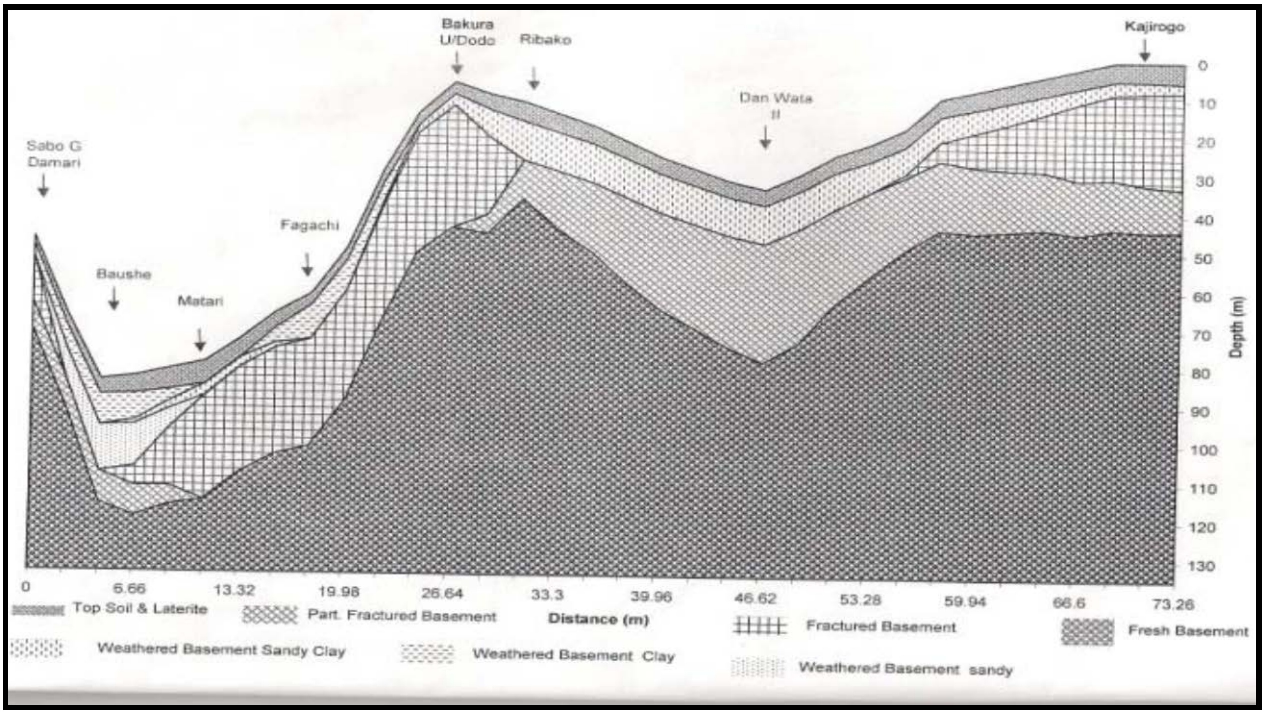
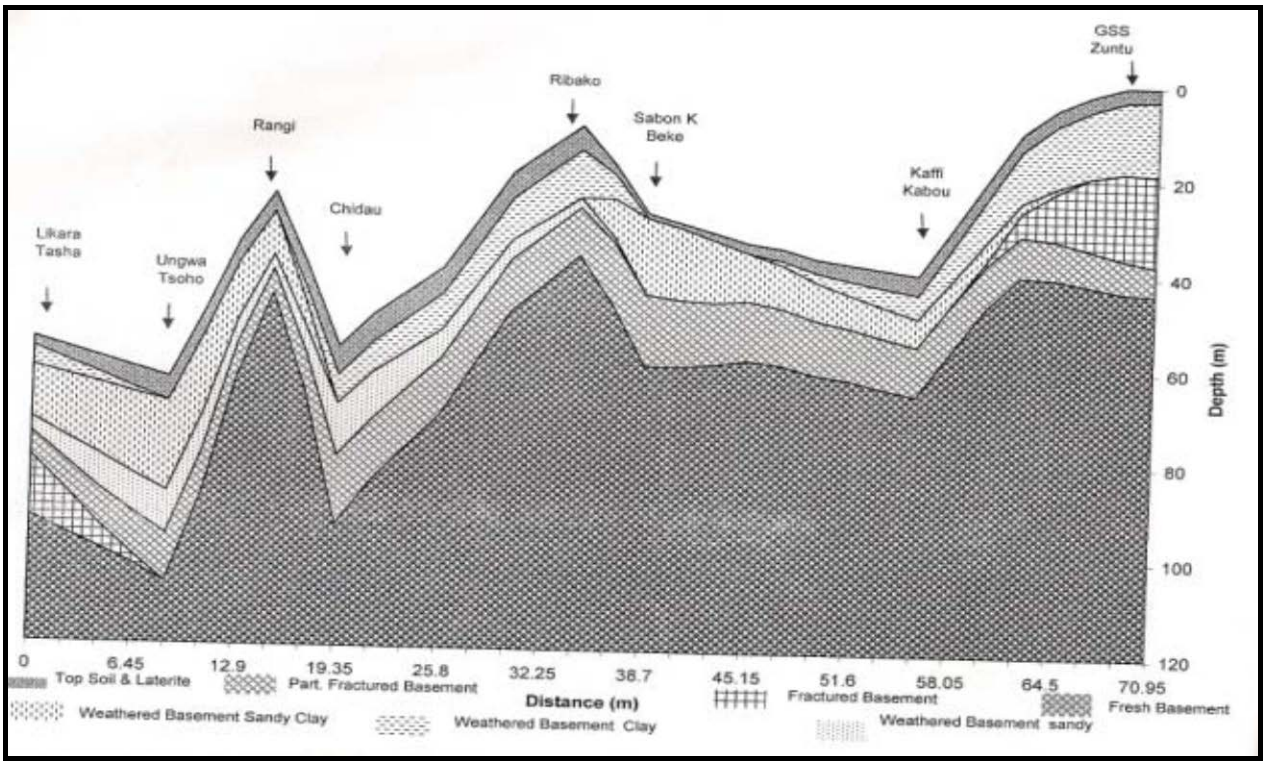
The Galma river basin is situated mainly in Kaduna State with a small portion of it extending to Kano and Katsina States. The basin is geographically located on Sheets 102, 103, 124 and 125 on a scale of 1:100,000 of Nigeria Surveys topographical maps. It is situated between latitudes 10^{o} 27'N and 11^{o} 24'N, and longitudes 7^{o} 23'E and 8^{o} 45'E. Its total catchment area covers approximately 6,940 km^2 at its mouth. The Galma Basin lies on an extensive peneplain developed on crystalline Basement rocks, which extends continuously over most parts of northern Nigeria. It is located in a transition zone between the tropical hinterland and the tropical continental north. The mean monthly temperature varies between 20 ^{0}C and 29 ^{0}C, depending on the season, but may increase up to 35 0C at the end of the dry season (Nassef and Olugboye, 1979).



Source: ARPN Journal of Engineering and Applied Sciences, VOL. 5, NO. 7, JULY 2010

Figure 4.8: West-East Direction Geologic Profile of Galma Basin



Source: ARPN Journal of Engineering and Applied Sciences, VOL. 5, NO. 7, JULY 2010

Figure 4.9: North West-South East direction Geologic Profile of Galma Basin

Groundwater in exploitable quantities sufficient for rural water supply occurs in the basin in three forms. The river alluvium which is irregularly distributed throughout the state, the Newer basalts with associated alluvial deposits which are limited to Kafanchan and Manchok areas in the south, and the weathered zone of the Basement Complex which is the most extensive, and often time poorly aquiferous (WAPDECO, 1991; Eduvie and Olaniyan, 2006).

4.6 Hydrology

The source of water for the irrigation and other domestic uses in the study area is River Saki Jiki that stretches in the north south direction of Jibia, thereby draining into Jibia Dam in the north. Shallow hand-dug wells are constructed along river channels in the dry period to irrigate farm plots as well used for domestic water supply. In a study on the hydrological properties of River Tagwai and its tributaries conducted by Muhammad (2000) the results from two hydrological stations; one at Ajiwa dam site and another at Makurdi bridge indicated that, at the Ajiwa station, the average days of discharge were 99 days, with an average discharge of twenty five (25) million cm3 and the other at the Tagwai/Makurda station with a catchment area of 1900km2 has a discharge of twenty (20) million cm3. The Saki Jiki River and its tributaries provide a dense hydrological network which provides high potentials for irrigation and other domestic uses in the area; as such the hydrology of the area can sustain regional surface and ground water development.

The hydrometeorological data obtained from Katsina airport meteorological station exhibits good values of precipitation in Katsina state of about 780mm per annum on the average. Infiltration value is also high owing to the gently undulating topography and the absorptive topsoil made up of composites of sand and sandy lateritic formation which discourage excess run off. Hence the recharge of the sub-surface water bearing formations is encouraging (Innocent, 1998). On the basis of land use, the Saki Jiki valley may be put into use, for the flood plains be put under intensive cultivation. The grass lands of Saki jiki area was left fallow for many years while the uplands farmlands are intensively cultivated essentially available only for rain fed cultivation (Danjuma, 2008). This has made the lowland area becoming more fertile and fully becoming a land suitable for agricultural productions.

Saki-jiki is a village few kilometres away from Batsari town, but the location of the river made it agrarian communities particularly dry season farming. The river brings potentials for agricultural development which made the area to attract migrant farmers. River Saki-jiki is the major source of water for both dry season farming and domestic uses in the area. Use of chemical fertilizer has to some extent show a sign of contamination of both ground and surface water in the area. The study therefore, intends to investigate the level of contamination of the water in the area.

4.6.1 Surface Water Physico-chemistry

At the times of field data gathering (dry and wet seasons), no surface water was found within the zone of influence of the proposed utility scale solar power plant, thus no surface water samples were available to be collected.

4.7 Ground Water

4.7.1 Ground Water Physico-chemistry

Groundwater samples were collected in the study area within a radius of 1.5km (zone of influence) from the centre of the project site. A total of three (3) existing boreholes located within the study area were sampled and the water analysed for quality. Water samples were collected in appropriate containers. *In-situ* measurements were carried out to determine parameters with short holding time such as pH, temperature, turbidity, conductivity, total dissolved solids, salinity and dissolved oxygen. Water samples for heavy metal analyses were collected in 2ml plastic bottles and acidified with 10% HNO_3, while those for TPH were acidified with H_2SO_4. A summary of the physico-chemical characteristics of the samples are presented in **Table 4.4** below. (See attached A3 map for spatial distribution of sample stations).

Table 4.4: Physico-chemical Characteristics of Kankiya Ground Water

Parameter		Sample Station Result/ Coordinates						WHO Limits
		BH 1		BH 2		BH3		
		Dry	Wet	Dry	Wet	Dry	Wet	
Colour (Pt-Co)		27.0	32.0	71.0	103	118	64.0	Clear
pH		6.73	5.96	6.80	6.26	6.18	5.81	6.5 – 8.5
Temperature (^oC)		27.9	24.3	26.7	24.3	25.7	24.1	
Elect. Conductivity (µS/cm)		360	384	634	242	737	766	-
Turbidity (NTU)		3.00	3.00	21.0	12.0	24.0	7.00	5
Salinity (g/l)		0.26	0.25	0.46	0.16	0.54	0.49	-
TSS (mg/i)		<1.00	12.0	<1.00	12.0	60.0	34.0	-
Total Hardness (mg/l)		92.0	105	194	58.0	106	95.0	100
THC (mg/l)		<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	-
DO (mg/l)		3.64	3.37	3.07	2.87	4.50	3.51	-
BOD (mg/l)		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	-
COD (mg/l)		<0.80	115	76.2	244	191	39.1	-
Nutrients	Nitrate (mg/l)	43.0	0.39	56.9	0.07	64.3	0.08	10.0
	Sulphate (mg/l)	10.1	10.2	40.1	7.39	17.3	11.9	250
	Phosphate (mg/l)	0.26	0.54	0.24	0.10	0.17	0.07	-
Heavy Metals	Potassium (mg/l)	4.20	4.09	7.88	3.84	3.69	6.48	-
	Lead (mg/L)	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	0.05
	Total Iron (mg/L)	0.04	<0.03	0.06	0.84	9.22	<0.03	0.3
	Copper (mg/l)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	1.0
	Barium (mg/l)	<0.30	<0.03	<0.30	<0.03	<0.30	<0.03	

Source: FNL Survey 2015

Table 4.4: Physico-chemical Characteristics of Kankiya Ground Water cnt'd.

Parameter	Sample Station Result						WHO Limits
	BH 1		BH 2		BH3		
	Dry	Wet	Dry	Wet	Dry	Wet	
Heterotrophic Bacteria (cfu/g)	330	3,600	1,150	6,100	3,600	1,760	0.00
Heterotrophic Fungi (cfu/g)	1.0	30	40	74	300	7	0.00
Hydrocarbon Utilising Bacteria (cfu/g)	1.0	136	260	93	18	47	0.00
Hydrocarbon Utilising Fungi (cfu/g)	3,600	21	300	60	10	22	0.00

Source: FNL Survey 2015

The pH of the groundwater samples during dry season ranged from 6.18 to 6.8, and 5.81 to 6.26 during the wet season. These were within the WHO limits for drinking water.

The turbidity and total hardness for dry season were not completely compliant with the WHO limits for drinking water (3.00 - 24 NTU and 92.0 – 194 respectively) during the dry season. During the wet season, turbidity ranged from 3 to 12 NTU extended beyond the WHO limit of 5 NTU. Only one (BH1: 3 NTU) out of the three sample stations had turbidity level that was compliant with WHO limit during the wet season. The hardness levels (92mg/l, 1060mg/l, and 194mg/l) in the groundwater for dry season were only compliant with the WHO limits in one out of the three boreholes (BH1; 92mg/l). During the wet season, total hardness levels were 105, 58, and 95mg/l. These were all compliant with WHO limit of 100mg/l.

The nutrients (nitrates, sulphates, and phosphates) levels were 43.0 – 64.3mg/l, 10.1 – 40.1mg/l, and 0.17mg/l – 0.26mg/l in dry seasons. Nitrates and sulphate levels were not compliant with their respective WHO limits. During the wet season, nitrates, sulphates, and phosphates levels were 0.07 – 0.39mg/l, 0.07 – 0.54mg/l, and 0.07 – 0.54mg/l.

The metals levels in the groundwater sampled in dry season were:

- Potassium: BH1; 4.20mg/l, BH2; 7.88mg/l, BH3; 3.69mg/l – dry season. BH1; 4.09mg/l, BH2; 3.84mg/l, BH3 6.84mg/l – wet season (there is no regulatory limit);
- Lead: BH1; <0.008mg/l, BH2; <0.008mg/l, BH3; <0.008mg/kg – dry season. BH1; <0.008mg/l, BH2; <0.008mg/l, BH3; <0.008mg/kg – wet season. (compliant with WHO limits);
- Iron: BH1; 0.04mg/l, BH2; 0.06, BH3; 09.22 – dry season (BH 3 not compliant with WHO limits). BH1; <0.03mg/l, BH2; 0.84 mg/l, BH3; <0.03mg/l – wet season (BH 3 not compliant with WHO limits).
- Copper: BH1; <0.02mg/l, BH2; <0.02mg/l, BH3; <0.02mg/l – dry season. BH1; <0.02mg/l, BH2; <0.02mg/l, BH3; <0.02mg/l – wet season (compliant with WHO limits);
- Barium: BH1; <0.30mg/l , BH2mg/l; <0.30mg/l, BH3; <0.30mg/l – dry season. BH1; <0.30mg/l, BH2mg/l; <0.30mg/l, BH3; <0.30mg/l – wet season (compliant with WHO limits).

The microbial content in the groundwater sampled were:

- Heterotrophic Bacteria (cfu/g): BH1; 3.30×10^{2}, BH2; 1.15×10^{3}, BH3; 3.60×10^{3}- dry season. BH1; 3.60×10^{3}, BH2; 6.1×10^{3}, BH3; 1.76×10^{3}- wet season ;
- Heterotrophic Fungi (cfu/g): BH1; 1.0, BH2; 40, BH3; 3.00×10^{2} – dry season. BH1; 30.0, BH2; 74, BH3; 7.0 – wet season;
- Hydrocarbon Utilising Bacteria (cfu/g): BH1; 1.0, BH2; 2.60×10^{2}, BH3; 18 – dry season. BH1; 136.0, BH2; 93, BH3; 47 – wet season;
- Hydrocarbon Utilising Fungi (cfu/g): BH1; 3.60×10^{3}, BH2; 3.00×10^{2}, BH3; 10 – dry season. BH1; 21, BH2; 60.0, BH3; 22 – wet season;

The groundwater microbial content levels were not compliant with WHO limits for drinking water.

4.8 Soil

In Katsina state, underlying rocks are overlain by sandy 'drift' deposits laid down during the last arid phase about twelve thousand years ago. In the Southern part of the state, the covering material is largely clayey soil, about five metres in depth and very fine in texture. The soils are difficult to work, tending to become waterlogged with heavy rains and to dry out and crack during the dry season. The characteristic crops of this area include: cotton, maize and guinea corn. In the north, the drift deposits are coarser, resulting in light sandy soils of buff or reddish colours of low medium fertility. These soils are easily worked and well suited to crops

4.8.1 Soil Physico-Chemical Characteristics

Soil samples of the proposed project site were collected during the dry and wet seasons. Samples were collected within a radius of 1.5km (zone of influence) from the centre of the project site. There were 15 soil sample stations in all. At each station, soil samples were collected from two depth levels: 0 – 15cm, and 15 – 30cm. Result from analyses is summarized in **Table 4.5** while detailed analytical results are included in **Appendix 4.2**. (See attached A3 map for spatial distribution of sample stations).

Table 4.5: Soil Samples Physico-chemical Characteristics

Parameter	Sample Station Result																			
	SS 1 (0-15cm)		SS 1 (15-30cm)		SS 2 (0-15cm)		SS 2 (15-30cm)		SS 3 (0-15cm)		SS 3 (15-30cm)		SS 4 (0-15cm)		SS 4 (15-30cm)		SS 5 (0-15cm)		SS 5 (15-30cm)	
Co-ordinates	N: 12.579268 E: 7.835032				N: 12.576099 E: 7.838441				N: 12.572110 E: 7.835386				N: 12.574930 E: 7.832444				N: 12.593461 E: 7.824994			
Season	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
Colour	**Light Brown**	**Brown**	**Light Brown**	**Brown**	**Pale Brown**	**Light yellowish brown**	**Pale Brown**	Light yellowish brown	**Pale Brown**	Pale brown	**Pale Brown**	Pale brown	**Pale Brown**	Pale brown	**Pale Brown**	Brown	**Pale Brown**	**Pale brown**	**Pale Brown**	**Pale brown**
pH (H_2O) @ 29.7°C	6.26	6.01	6.48	6.68	6.66	6.06	6.73	5.81	7.30	5.60	7.92	5.55	6.09	5.43	6.33	5.11	5.85	5.81	4.95	5.98
Moisture Content (%)	<0.10	15.1	<0.10	12.9	0.18	15.9	1.17	16.9	0.16	14.2	0.60	13.9	<0.10	12.9	0.58	15.1	<0.10	144	0.24	17.7
THC (mg/kg)	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
<u>PSD</u> Clay (%)	3.00	-	3.00	-	2.00	-	2.00	-	2.00	-	3.00		2.00	-	2.00	-	6.00		5.00	-
Silt (%)	22.0	13.0	20.0	16.0	28.0	10.0	14.0	11.0	12.0	15.0	17.0	13.0	13.0	12.0	16.0	16.0	28.0	16.0	29.0	15.0
Sand (%)	75.0	87.0	77.0	84.0	70.0	90.0	84.0	89.0	86.0	85.0	80.0	87.0	85.0	88.0	82.0	84.0	66.0	84.0	66.0	85.0
Ext. Nitrate (mg/kg)	1.10	0.09	2.27	0.13	3.29	0.21	2.01	0.23	8.56	0.22	14.4	0.24	0.29	0.19	1.71	0.19	2.99	0.45	9.47	0.28
Ext. Sulphate (mg/kg)	<2.00	90.0	<2.00	50.0	<2.00	20.0	<2.00	60.0	108	20.0	17.5	<2.00	<2.00	<2.00	<2.00	<2.00	105	<2.00	97.5	<2.00
Ext. Phosphate (mg/kg)	<0.02	95.8	<0.02	11.0	<0.02	6.75	<0.02	8.13	<0.02	6.38	0.90	0.63	<0.02	3.50	<0.02	4.63	<0.02	4.88	<0.02	4.88
Total Iron (mg/kg)	5,765	7,871	6,396	9,558	18,230	8,295	16,530	9,986	10,520	6,703	18,570	7,465	6,110	9,087	6,145	7,647	8,546	4,835	6,611	6,545
Copper (mg/kg)	2.50	9.20	2.90	6.50	7.50	6.50	6.50	7.40	<0.50	1.60	5.70	8.70	2.70	5.30	0.90	5.50	6.00	3.70	2.80	3.90
Lead (mg/kg)	31.9	4.20	31.2	2.70	32.1	1.40	33.5	10.2	30.4	<1.00	32.4	1.50	34.2	8.70	33.3	9.70	16.4	2.60	37.0	6.20
Nickel (mg/kg)	20.3	12.9	18.2	17.5	21.8	5.90	22.1	5.60	18.6	7.20	23.5	3.90	14.9	9.70	19.6	4.70	27.3	2.10	23.2	5.10
Zinc (mg/kg)	29.0	28.9	15.4	17.1	33.6	12.3	29.2	8.90	13.3	10.7	29.2	11.3	28.1	13.4	21.2	13.6	20.4	5.90	18.9	5.90
Vanadium (mg/kg)	<1.00	20.3	<1.00	16.7	<1.00	21.7	<1.00	16.7	<1.00	13.0	<1.00	4.40	2.40	15.3	<1.00	2.80	<1.00	14.4	2.40	22.7

Table 4.5: Soil Samples Physico-chemical Characteristics cnt'd.

Parameter	Sample Station Result																			
	SS 6 (0-15cm)		SS 6 (15-30cm)		SS 7 (0-15cm)		SS 7 (15-30cm)		SS 8 (0-15cm)		SS 8 (15-30cm)		SS 9 (0-15cm)		SS 9 (15-30cm)		SS 10 (0-15cm)		SS 10 (15-30cm)	
Co-ordinates	N: 12.593461 E: 7.824994				N: 12.570274 E: 7.825255				N: 12.574976 E: 7.819404				N: 12.567271 E: 7.826770				N: 12.572129 E: 7.819900			
Season	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Colour	Reddish Yellow	Reddish yellow	Reddish Yellow	Reddish yellow	Light Yellow Brown	Strong brown	Light Yellowish Brown	Strong brown	Reddish Brown	Reddish yellow	Reddish Yellow	Strong brown	Reddish Yellow	Reddish brown	Reddish Yellow	Reddish brown	Strong Brown	Strong brown	Strong Brown	Red
pH (H_2O) @ 29.7^oC	5.46	5.28	5.11	5.51	5.63	5.36	5.80	5.61	5.74	5.91	5.59	5.66	5.36	6.09	5.20	6.62	5.69	5.36	5.74	5.34
Moisture Content (%)	<0.10	15.4	0.58	12.7	0.58	14.3	0.55	11.7	0.10	12.4	0.15	15.7	2.38	14.6	3.37	11.9	1.51	16.6	3.67	14.5
THC (mg/kg)	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
PSD																				
Clay (%)	2.00	-	3.00	-	3.00	-	3.00	-	1.00	-	1.00		21.0	-	21.0		21.0	3.00	4.00	2.00
Silt (%)	19.0	15.0	11.0	15.0	11.0	20.0	30.0	19.0	23.0	17.0	42.0	18.0	33.0	12.0	34.0	15.0	20.0	26.0	12.0	27.0
Sand (%)	79.0	85.0	86.0	85.0	86.0	80.0	67.0	81.0	76.0	83.0	57.0	79.0	46.0	88.0	45.0	85.0	59.0	71.0	84.0	71.0
Ext. Nitrate (mg/kg)	4.60	0.10	6.26	0.28	1.57	0.39	1.60	0.39	2.29	0.17	1.02	0.29	2.05	0.14	1.97	0.36	2.49	0.15	3.41	0.32
Ext. Sulphate (mg/kg)	<2.00	140	<2.00	<2.00	<2.00	10.0	<2.00	<2.00	<2.00	55.0	<2.00	<2.00	<2.00	<2.00	12.5	60.0	12.5	<2.00	<2.00	95.0
Ext. Phosphate (mg/kg)	<0.02	4.63	<0.02	4.88	<0.02	7.25	<0.02	9.88	<0.02	50.3	<0.02	15.5	<0.02	47.4	<0.02	21.5	<0.02	7.50	1.78	2.50
Total Iron (mg/kg)	6,849	5,906	7,461	6,545	8,031	8,769	4,443	10,510	8,031	13,630	8,240	16,550	19,440	6,161	36,365	7,750	33,910	10,480	26,350	6,984
Copper (mg/kg)	2.50	5.10	1.80	3.90	7.80	1.40	9.60	2.20	7.80	4.60	7.30	6.60	9.40	9.60	16.6	3.30	9.10	12.4	12.9	10.5
Lead (mg/kg)	4.70	5.40	32.2	6.20	12.4	11.7	12.5	12.2	12.4	15.1	15.8	18.2	36.2	2.20	49.4	17.5	58.4	68.8	33.6	36.6
Nickel (mg/kg)	29.2	4.50	21.1	5.10	6.30	6.40	2.50	8.90	6.30	9.80	3.00	10.8	75.3	6.20	31.0	7.00	37.0	14.6	29.7	22.7
Zinc (mg/kg)	17.4	7.00	16.8	5.90	17.4	10.8	10.8	10.3	17.4	17.5	12.7	29.2	18.6	12.0	21.6	8.90	29.0	11.7	30.8	13.8
Vanadium (mg/kg)	2.70	2.20	<1.00	22.7	13.4	18.7	7.20	16.5	13.4	15.7	17.8	29.1	30.5	4.70	63.5	28.2	84.9	19.8	79.3	12.8

pH

Soil pH or soil reaction is an indication of the acidity or alkalinity of soil and is measured in pH units. Soil pH is defined as the negative logarithm of the hydrogen ion concentration. The pH scale goes from 0 to 14 with pH 7 as the neutral point. As the amount of hydrogen ions in the soil increases, the soil pH decreases thus becoming more acidic. From pH 7 to 0 the soil is increasingly more acidic and from pH 7 to 14 the soil is increasingly more alkaline or basic.

pH of the soil sampled were generally acidic (slightly to moderately acidic). These values ranged from 4.95 to 7.792 during the dry season, and 5.11 to 6.68 during the wet season.

Total Hydrocarbon Content (THC)

Hydrocarbons are a common and natural occurrence in the environment and varying concentrations in soils are not unusual. Microbes in the soils and water have a natural ability to breakdown many of these compounds and any hydrocarbon which is exposed to the air will also have an affinity to volatilize. As well, reactions including photochemistry and the various transformations of the hydrocarbon through these reactions can enhance the hydrocarbon decomposition. Industrial processes and man induced activities often result in the increased loading of hydrocarbons in soil. The natural abilities of the soil to decompose the hydrocarbons become overwhelmed.

The THC analysed from the soil samples during the dry and wet seasons were below equipment detection limit of <5.0mg/kg in all stations. These values were not within the natural background concentration of 50mg/kg for standard soils (SIEP, 1995).

PSD

Particle-size distributions (PSDs) of soils are often used to estimate other soil properties, such as soil moisture characteristics and hydraulic conductivities. Prediction of hydraulic properties from soil texture requires an accurate characterization of PSDs. The textural composition of soil samples collected from the area was dominantly sand with an admixture of silt and clay. Mean particle size of 72.8% sand, 21.7% silt and 5.5% clay were recorded during the dry season, and 82.9% sand, 16.71% silt and 0.39% clay were recorded during the dry season.

Heavy Metals

Human activities have dramatically changed the composition and organisation of soils. Industrial and urban wastes, agricultural application and also mining activities resulted in an increased concentration of heavy metals in soils.

Soils normally contain low background levels of heavy metals. Excessive levels of heavy metals can be hazardous to man, animals and plants. Heavy metals of greatest concern are iron (Fe), copper (Cu), lead (Pb), nickel (Ni), Zinc (Zn), and Vanadium (V).

During dry season, values obtained were 5,765mg/kg – 36,365mg/kg for Fe; <0.50mg/kg – 16.60mg/kg for Cu; 4.70mg/kg – 58.4mg/kg for Pb; 2.50mg/kg – 75.3mg/kg for Ni; 10.8mg/kg – 30.8mg/kg for Zn; and <1.00mg/kg - 84.9mg/kg for V. During wet season, values obtained were 4,835mg/kg – 16,550mg/kg for Fe; <3.0mg/kg – 16.60mg/kg for Cu; <1.00mg/kg – 16.6mg/kg for Pb; 2.10mg/kg – 22.7mg/kg for Ni; 5.60mg/kg – 29.2mg/kg for Zn; and <1.00mg/kg - 29.1mg/kg for V.

Ecological soil investigation involved sampling of soil (0-15cm and 15-30cm depth) at the 10 designated stations within the study area.

4.8.2 Soil Microbiological Characteristics

The two groups of microorganisms studied are fungi and bacteria, which are the most important organic matter decomposers in the soil. Bacteria and fungi (microbes) counts provide information on the level of on-going biochemical activities in the soil. Microbial counts under normal circumstances increases with an increase in soil organic matter. About 1g of fertile soil should contain 1×10^6 to 1×10^8cfu/g bacteria and fungi (Odu et al., 1985).

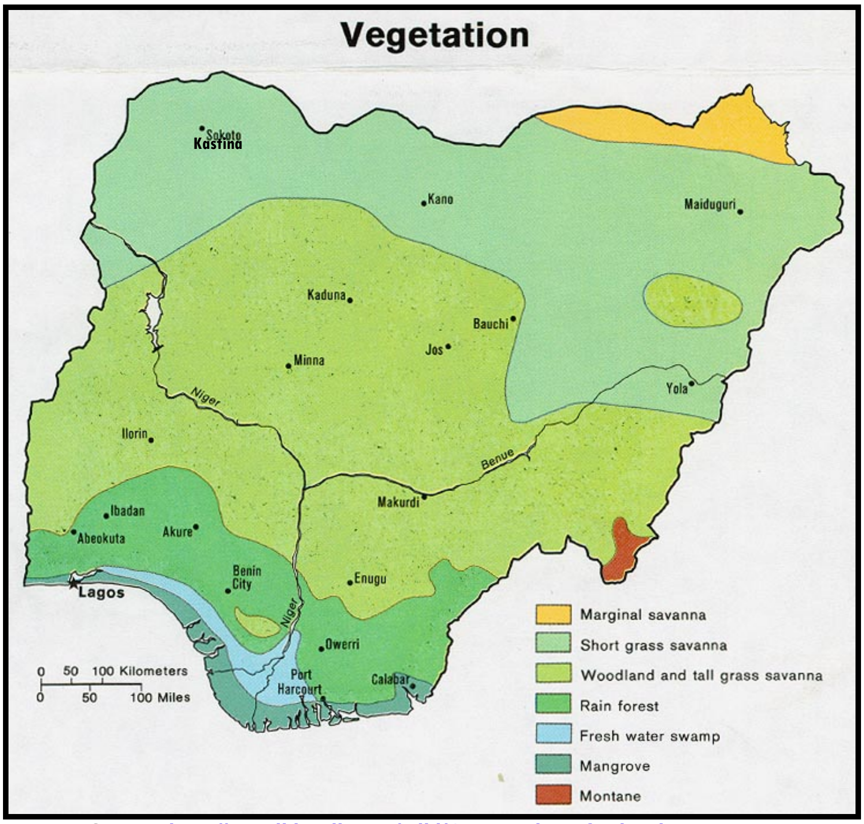
Table 4.6: Soil Samples Microbiological Characteristics

Parameter	Sample Station Result																			
	SS 1		SS 2		SS 3		SS4		SS5		SS6		SS7		SS8		SS9		SS10	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Heterotrophic Bacteria (cfu/g)	$1.44x10^{5}$	$1.02x10^{6}$	$9.20x10^{4}$	$6.10x10^{5}$	$1.80x10^{5}$	$7.40x10^{5}$	$2.46x10^{5}$	$8.40x10^{5}$	$2.50x10^{4}$	$6.70x10^{5}$	$7.00x10^{4}$	$5.10x10^{5}$	$2.45x10^{5}$	$5.50x10^{5}$	$1.60x10^{5}$	$6.00x10^{5}$	$6.40x10^{4}$	$9.60x10^{5}$	$6.10x10^{4}$	$9.90x10^{5}$
Heterotrophic Fungi (cfu/g)	$4.80x10^{3}$	$6.50x10^{2}$	$5.20x10^{2}$	$6.60x10^{2}$	$7.30x10^{2}$	$1.85x10^{3}$	$5.70x10^{2}$	$1.85x10^{3}$	$6.40x10^{2}$	$6.50x10^{2}$	$6.40x10^{2}$	$1.00x10^{2}$	$2.40x10^{2}$	$1.50x10^{3}$	$1.40x10^{2}$	$1.04x10^{3}$	$4.00x10^{2}$	$3.00x10^{2}$	$3.00x10^{2}$	$1.12x10^{3}$
Hydrocarbon Utilising Bacteria (cfu/g)	$5.10x10^{4}$	$3.30x10^{4}$	$6.20x10^{3}$	$2.30x10^{4}$	$4.70x10^{3}$	$5.00x10^{4}$	$4.00x10^{3}$	$5.00x10^{4}$	$6.00x10^{3}$	$8.10x10^{3}$	$6.00x10^{3}$	$2.30x10^{3}$	$9.20x10^{3}$	$9.80x10^{3}$	$7.00x10^{3}$	$1.66x10^{4}$	$9.00x10^{3}$	$3.50x10^{4}$	$7.00x10^{4}$	$3.10x10^{4}$
Hydrocarbon Utilising Fungi (cfu/g)	$3.80x10^{2}$	$4.70x10^{2}$	$4.60x10^{2}$	$2.90x10^{2}$	$6.00x10^{2}$	$1.66x10^{3}$	$4.20x10^{2}$	$1.66x10^{3}$	$2.40x10^{2}$	$3.00x10^{2}$	$2.40x10^{2}$	40	$1.90x10^{2}$	$9.40x10^{2}$	$1.00x10^{2}$	$9.40x10^{2}$	$3.60x10^{2}$	$9.30x10^{2}$	$2.0x10^{2}$	$9.30x10^{2}$

Pseudomonas sp, Bacillus sp, Micrococcus sp, and Actinobacillus sp., Proteus sp, *Citrobacter sp, Staphylococcus sp* were the bacteria isolated as heterotrophic bacteria (HB). *Pseudomonas sp, Bacillus sp, Staphylococcus sp, Alcaligenes sp, Micrococcus sp.* were hydrocarbon utilising bacteria (HUB) during the dry season. The heterotrophic bacteria count ranged from $1.15x10^3$– $6.40x10^5$cfu/ml while the hydrocarbon utilising bacteria count was 1.0 – $5.10x10^4$cfu/ml. *Aspergillus sp, Penicillium sp, Mucor sp, Cladosporium sp., Rhizopus sp*. were the heterotrophic fungi (HF) isolated during the dry season. The hydrocarbon utilizing fungi count ranged from 1cfu/ml – $6.00x10^2$cfu/ml. During the wet season, *Bacillus sp, Pseudomonas sp, Proteus sp, Staphylococcus sp, Micrococcus sp* were isolated as heterotrophic bacteria. The heterotrophic bacteria count ranged from 2.5×10^4 – 1.02×10^6 cfu/ml. During the wet season, *Epicoccum sp Aspergillus sp, Candida sp, Mucor sp, Penicillium sp* were isolated as heterotrophic fungi. The heterotrophic fungi count ranged from 100 – 4.8×10^3 cfu/ml. *Bacillus sp, Pseudomonas sp, Staphylococcus sp,* and *Proteus sp* were isolated as hydrocarbon utilising bacteria. The hydrocarbon utilising bacteria count ranged from 2,300 – 7×10^4 cfu/ml. *Aspergillus sp, Penicillium sp, Mucor sp, Candida sp,* and *Geotrichum sp* were isolated as hydrocarbon utilising fungi. The hydrocarbon utilising fungi count ranged from 100 – 1,660 cfu/ml.

4.9 Vegetation

Vegetation type in the project area is the Sudan Savannah Vegetation and consists largely of shrubs, short grasses with a few scattered wooded savanna trees. **Figure 1.1** shows the vegetation zones within Nigeria and to the far north is Kastina State (project location).



Source: ***http://en.wikipedia.org/wiki/Geography_of_Nigeria***

Figure 4.10: Map of Nigeria Vegetation Zones

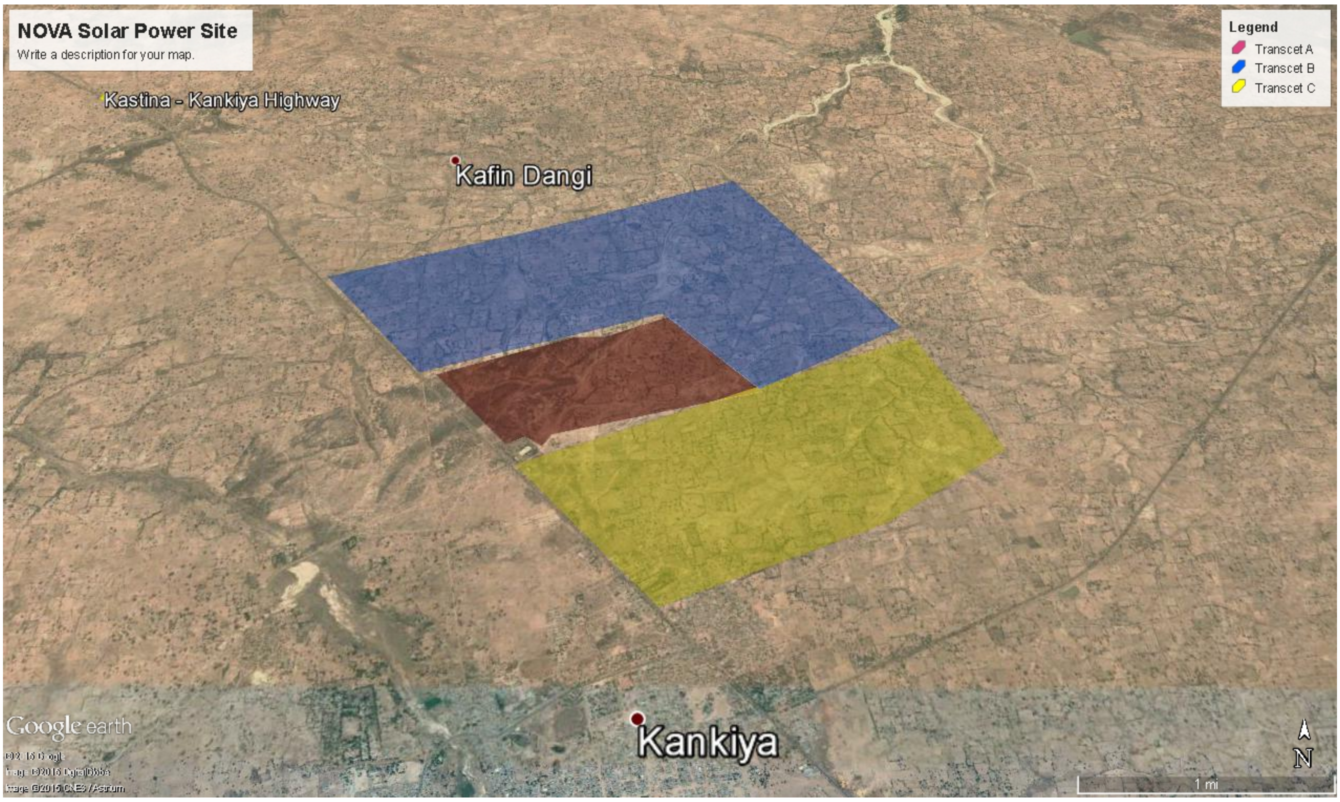
Katsina State is one of the few states in the country where crops are grown all year round. Apart from farming during the rainy season, dry season farming is done along river banks and along the numerous dams built by the State and Federal Governments (Rabi et, al., 2013).

4.9.1 Biodiversity Study Methodology

The biodiversity study was carried out through observations, interviews and documentation of vegetation and wildlife characteristics of the area in two surveys (dry and wet seasons). This was achieved by dividing the study area into three (3) transects for easier classification and evaluation. The following transects were obtained as a result:

- Transect A: Limited to project site only;
- Transect B: Section about 1.5km northeast of project site; and
- Transect C: Section about 1.5km southwest of project site.

Transect A is the project area (i.e 200 hectares) which would be cleared in the future for the assembling and construction of the solar power plant, while Transect B and C fall into the area of influence (i.e areas beyond the project site) to about 1.5km (see **Figure 4.11** below). . It should be noted that as at the time of field survey there were no farmlands, no cash crops, and no economic trees of significant importance.



Source: Google Earth Map

Figure 4.11: Vegetation Transects

Photographs taken during the study were used as objective evidence in this report as presented in subsequent sessions. Plant and animal species recorded are those observed or have been previously reported within the study area.

4.9.2 Vegetation Description

A total of 20 plant species belonging to 16 taxonomic families were observed within the entire area. The number of species in transect A was 7, while that in Transect B and C were 25 and 17 respectively. The IUCN ranking and economical uses of plant and animal species are also included.

4.9.3 Plants Species within Transect A

Transect A is the portion of land delineated for the solar power plant project. This transect covers a total area of 1km by 2km. It is plain with vegetation devoid of canopies. Plants were directly exposed to sunlight. Transect A is shown in **Figure 4.12** below, alongside pictures captured there. As stated earlier, at the time of field survey there were no farmlands, no cash crops, and no economic trees of significant importance.

A few plant species were observed in this transect. A total of 7 plant species belonging to 6 taxonomic families were observed.

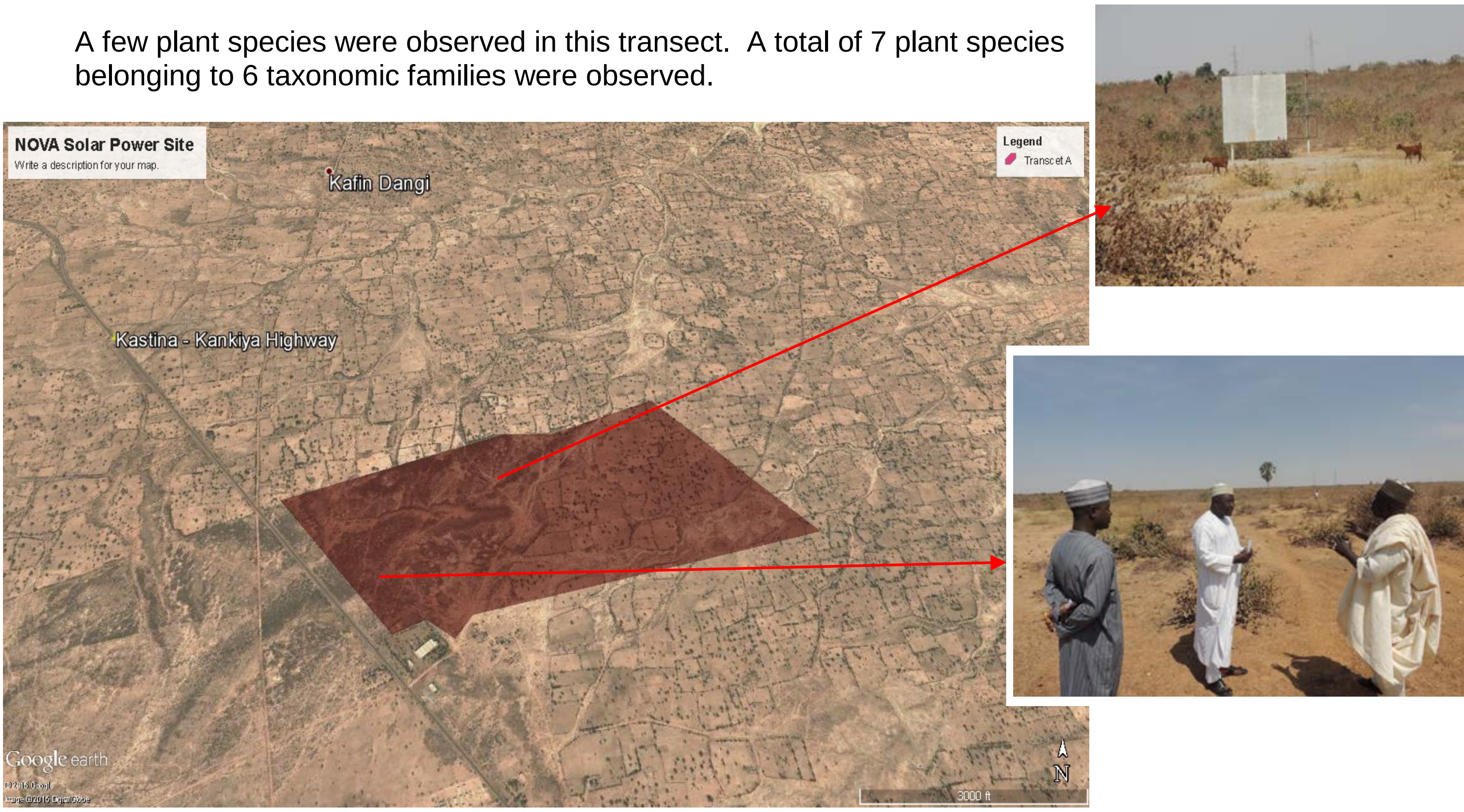


Figure 4.12: Transect A View

A number of grasses, shrubs (being the highest) and two trees were observed within this transect during the visits. **Table 4.7** below presents the plant species found within this transect, common/ local names, plant type and IUCN ranking (2014)

Table 4.7: Plants Observed within Transect A

Plant Species	Family	Common Name	Local Name	Type	IUCN Ranking
Calatropis procera	Asclepiadaceae	Sodom apple	Tumfafiya	Shrub	-
Borassus aethiopum	Arecaceae	African fan palm	Giginya	Tree	-
Eragrostis gangetica	Poaceae	Slim flower love grass	Durburwa	Grass	-
Grewia mollis	Malvaceae	-	Kamomowa	Shrub	-
Grewia villosa	Malvaceae	-	-	Shrub	-
Commiphora africana	Burseraceae	African myrrh	-	Tree	Least Concern
Cynodon dactylon	Poaceae	Bermuda grass	Tsírkììyár dámóó	Grass	-

Plants observed were naturally occurring. As stated earlier t here were no cultivated crops within this transect as there were no settlement or farmland. It was evident that vegetation within this transect had undergone secondary re-growth or succession over time.

The most abundant plant was *Grewia mollis*, a shrub. It covered about 55% of the entire transect. It grows to about 2m and is found clustered together. *Grewia mollis* specie was conspicuously greener and widespread in the wet season than in the dry season (see **Figure 4.13**).

The next most abundant was *Grewia villosa*, a shrub, it covers about 25% of the area and grows as high as 2m. The third most abundant was *Calatropis procera,* a shrub that grows to about 1m.

There were only two trees observed; *Borassus aethiopum* and *Commiphora africana. Borassus aethiopum,* specie of the palm tree family is the tallest plant within this transect, with height of about 12m. *Commiphora africana* was about 5m high and contains spines on its stem. Commiphora are gum bearing trees. **Figure 4.13** shows a cross-section of plants within the area.

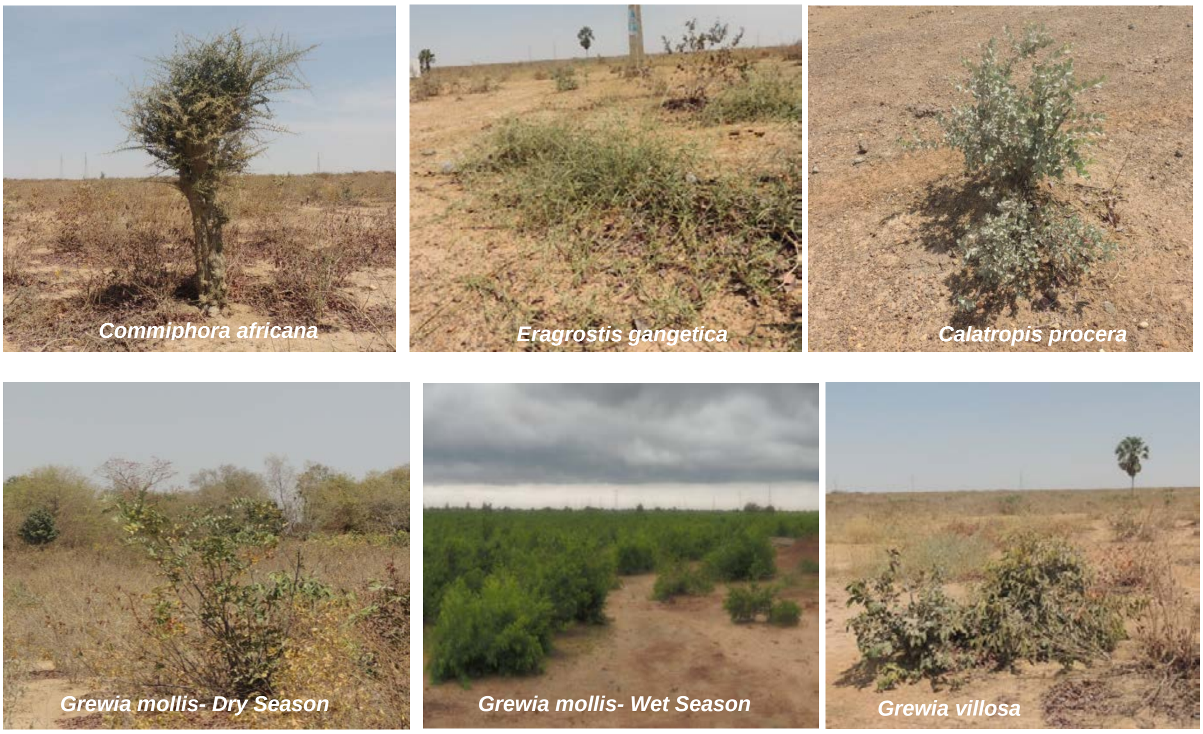


Plate 4.13: Plant Species within Transect A

4.9.4 Plants Species within Transect B

Transect B covers a total area of 3km by 1.5km and lies to the North and East of the project site (i.e area of influence). As at time of survey, a number of grasses, shrubs and trees were observed. Within this transect is an hamlet (extension of Kanfi Dangi). Transect B is shown in **Figure 4.14** alongside pictures captured there.

In this transect a total of 25 plant species belonging to 16 taxonomic families were observed.

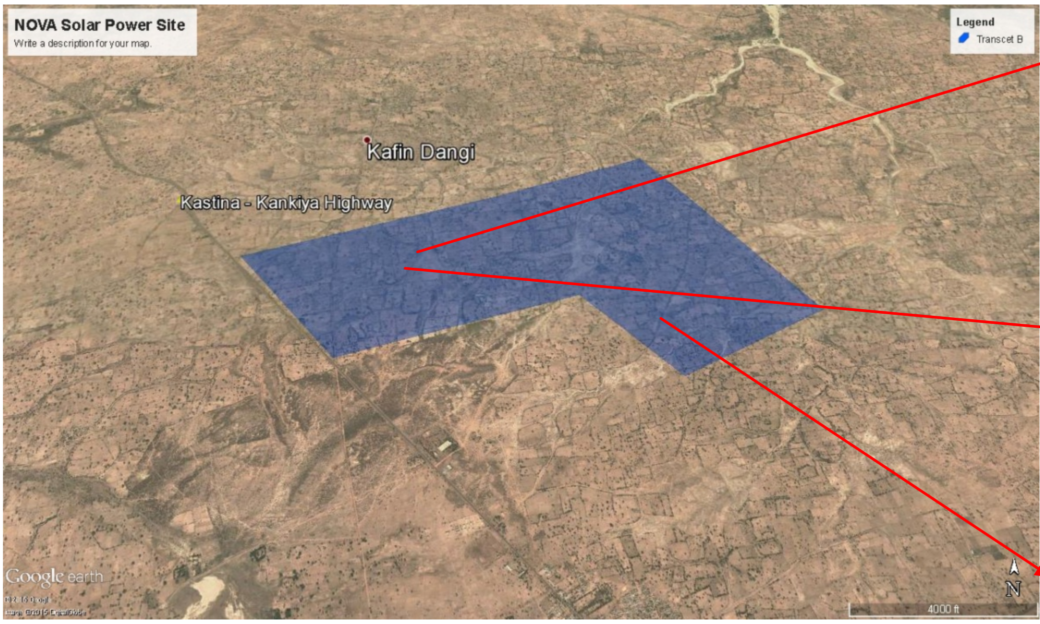


Figure 4.14: Transect B View

Naturally occurring plants and food crop were observed in this transect. **Table 4.8** below presents the naturally occurring plant species found in the area.

Table 4.8: Plants Observed within Transect B

Plant Species	Family	Common Name	Local Name	Type	IUCN Ranking
Ziziphus mauritiana	Rhamnaceae	Chinese date	Magarya	Tree	-
Acacia albida	Fabaceae	Anna tree	-	Tree	Least Concern
Acacia nilotica	Fabaceae	Gum Arabic tree	Bagaruwa	Tree	Least Concern
Adansonia digitata	Malvaceae	Baobab	Kuka	Tree	Least Concern
Azadirachta indica	Meliaceae	Neem	Dar bejiya, Dogonyaro	Tree	-
Ziziphus spina-christi	Rhamnaceae	Christ's Thorn jujube	Kándíídà	Tree	-
Borassus aethiopum	Arecaceae	African fan palm	Giginya	Tree	-
Phoenix dactylifera	Arecaceae	Date plam	Dúnshe	Tree	-
Combretum icranthum	Combretaceae	Kinkeliba	Géézàa	Tree	-
Combretum erythrophyllum	Combretaceae	River bushwillow	-	Tree	-
Vitellaria paradoxa	Sapotaceae	Shea	Kadanya	Tree	Vulnerable
Detarium microcarpum	Caesalpiniaceae	Sweet dattock	Taura	Tree	Least Concern
Combretum micranthum	Combretaceae	-	Geiza	Shrub	-
Gmelina arborea	Lamiaceae	Beechwood	-	Tree	-
Guibourtia coleosperma	Fabaceae	African rosewood	-	Tree	-
Balanites aegyptiaca	Zygophyllaceae	Desert date	Aduwa	Tree	-

Table 4.8: Plants Observed within Transect B cnt'd.

Plant Species	Family	Common Name	Local Name	Type	IUCN Ranking
Boscia Senegalensis	Capparaceae	Rough-leaved Shepherds	Ànzáá	Tree	Least Concern
Eragrostis gangetica	Poaceae	Slim flower love grass	Durburwa	Grass	-
Tamarindus indica	Fabaceae	-	Yàtúúyàtúú	Tree	-
Eriosema psoraleoides	Fabaceae	Canary pea	Yar □	Tree	-
Celtis integrifolia	Cannabaceae	Nettle tree	Zu	Tree	-
Moringa oleifera	Moringaceae	Horseradish tree	Zóógálé	Tree	
Cynodon dactylon	Poaceae	Bermuda grass	Tsírkììyár dámóó	Grass	-
Salvadora persica	Salvadoraceae	Mustard tree	Bento	Tree	-
Salix ledermannii	Salicaceae	Basket willow	Ìnáá rúwáánáá	Tree	-

This area has more number of tress compared to any other transect. Tress here are tall, decidious and fully grown that provide shade to inhabitants. Also observed, were shrubs and grasses. The most abundant trees were *Acacia nilotica, Acacia albida* and *Vitellaria paradoxa*, they collectively cover about 30% of the entire transect. These trees were as tall as 20m in height. *Adansonia digitata* (baobab) was found only in this transect. Also common was *Azadirachta indica* (neem tree). See **Figue 4.15** below for plant species observed.

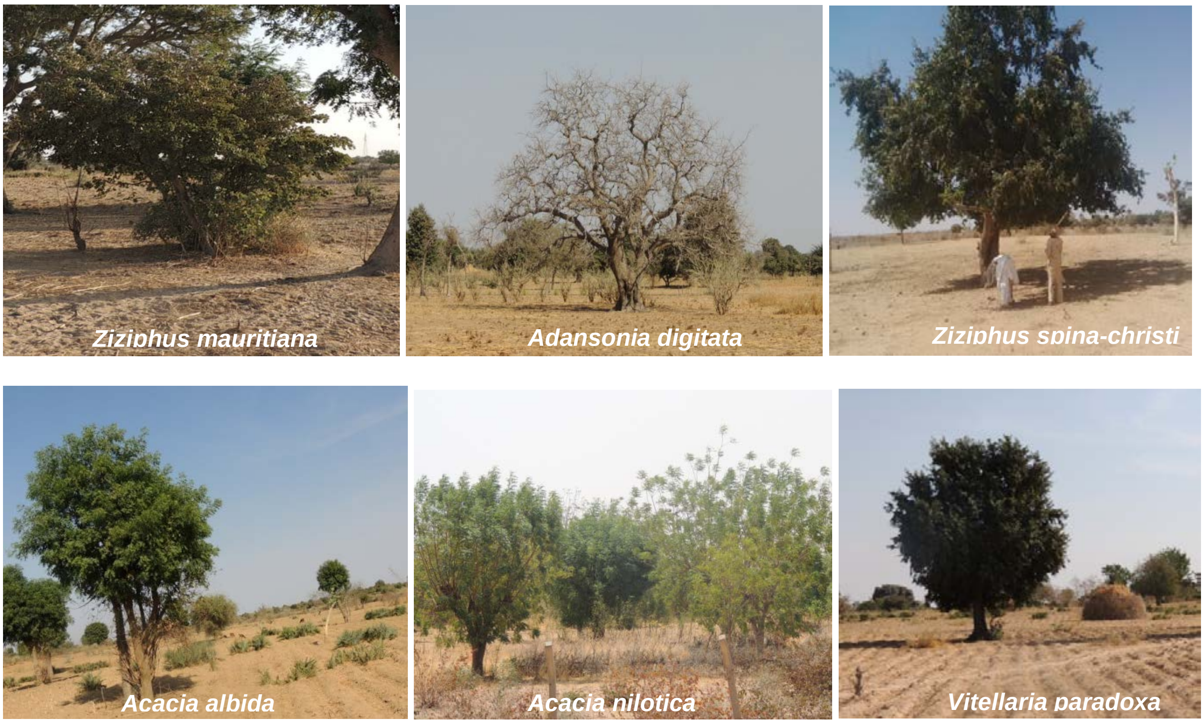


Figure 4.15: Plant Species within Transect B

4.9.5 Plants Species within Transect C

Transect C also covers a total area of 3km by 1.5km and is to the South of the project site (i.e within area of influence). An hamlet (extension of Kaweminai Community) was located close to this transect. This transect is shown on the next page in **Figure 4.16**.

In this transect a total of 17 plant species belonging to 11 taxonomic families were observed.

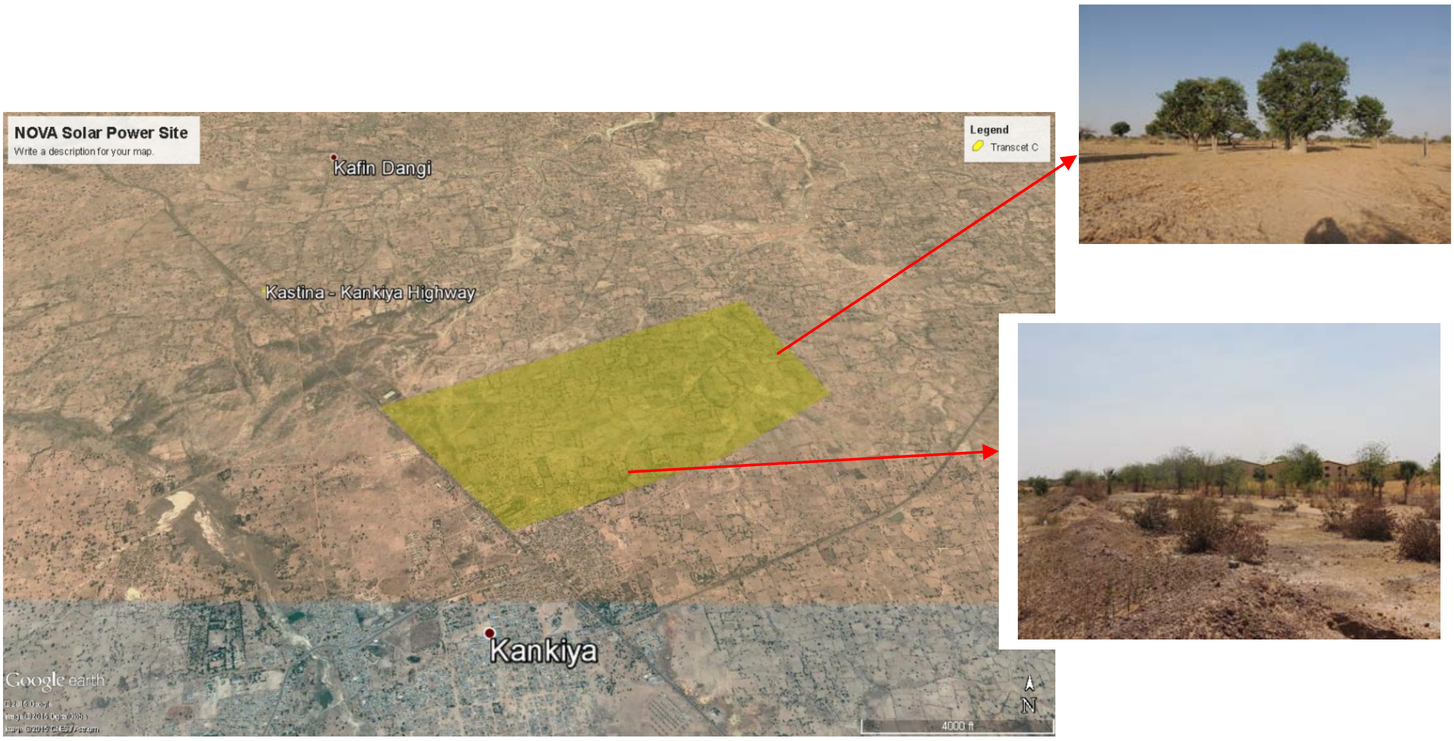


Figure 4.16: Transect C View

Grasses, shrubs and trees were also observed in this transect. Both naturally occurring plants and food crop were observed here. **Table 4.9** below presents the naturally occurring plant species found in the area.

Table 4.9: Plants Observed within Transect C

Plant Species	Family	Common Name	Local Name	Type	IUCN Ranking
Azadirachta indica	Meliaceae	Neem tree	Dar bejiya, Dogonyaro	Tree	-
Acacia albida	Fabaceae	Anna tree	-	Tree	-
Acacia nilotica	Fabaceae	Gum Arabic tree	Bagaruwa	Tree	-
Ziziphus abyssinica	Rhamnaceae	Catch thorn	Magarya	Tree	-
Ziziphus mauritiana	Rhamnaceae	Chinese date	Magarya	Tree	-
Prosopis africana	Fabaceae	False locust	Kíryà	Tree	-
Borassus aethiopum	Arecaceae	African fan palm	Giginya	Tree	-
Combretum micranthum	Combretaceae	-	Geiza	Shrub	-
Vitellaria paradoxa	Sapotaceae	Shea	Kadanya	Tree	Vulnerable
Detarium microcarpum	Caesalpiniaceae	Sweet dattock	Taura	Tree	Least Concern
Guibourtia coleosperma	Fabaceae	African Rosewood	-	Tree	-
Olea europea	Oleaceae	Olive tree	Zàitûn	Tree	
Boscia Senegalensis	Capparaceae	Rough-leaved shepherds	Ànzáá	Tree	Least Concern
Eragrostis gangetica	Poaceae	Slim flower love grass	Durburwa	Grass	-
Eriosema psoraleoides	Fabaceae	Canary pea	Yar □ma	Tree	-
Cynodon dactylon	Poaceae	Bermuda grass	Tsírkìỳár dámóó	Grass	-
Corchorus tridens	Malvaceae	Jute	Tùrgúnùùwáá	Tree	

In this transect, tall, scattered decidious trees were observed. Some trees noted in Transect B were also seen here. The unique trees here include; *Prosopis africana* and *Borassus aethiopum*. *Azadirachta indica* (neem tree) was the most abundant. *Borassus aethiopum* was the tallest tree in the area. It measures to about 30m. See **Figure 4.17** below for plant species recorded.

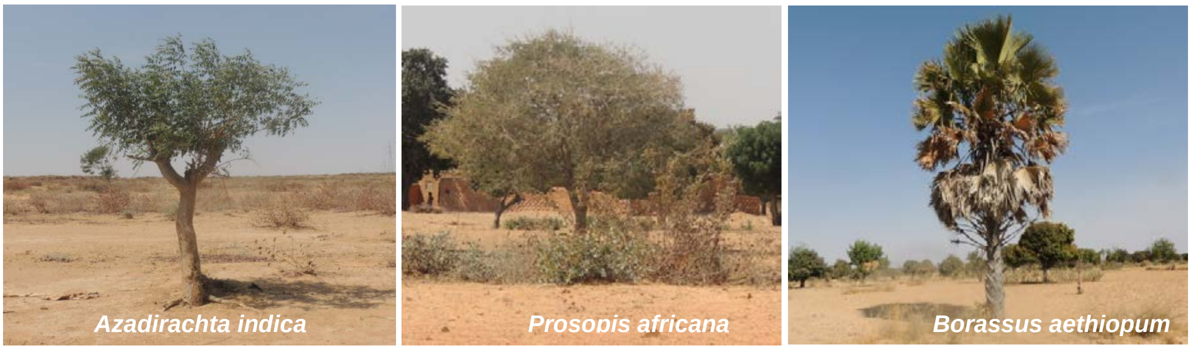


Figure 4.17: Plant Species within Transect C

4.9.6 Cultivated Crops

A number of farmlands were observed within the study area (i.e in transect B and C). Farming activities were observed more during the wet season than in the dry season. Community members were actively involved in farming and livestock rearing. Crops cultivated and observed are presented below.

Table 4.10: Cultivated Crops within Study Area

Plant Species	Family	Common Name	Local Name	Type	IUCN Ranking
Mangifera Indica	Anacardiaceae	Mango	Mangoro, Mangwaro	Tree	Data Deficient
Sorghum bicolor	Poaceae	Guinea corn	Bà Fíláátánáá	Grass	-
Pennisetum glaucum	Poaceae	Pearl millet	Zángóó	Grass	-
Paspalum scrobiculatum	Poaceae	Kodo millet	Tùmbín jààkíí	Grass	Least Concern
Zea mays	Poaceae	Maize	Másárá	Grass	-
Anacardium occidentale	Anacardiaceae	Cashew	Físáá	Tree	-

Figure 4.18: Evidence of Cultivated Crops

4.9.7 Economical Uses of Flora Resources

Plants mentioned above and within the study area are known to be of high economical importance. A number of these plants have multipurpose uses and play a vital role in the socio-economic development of the people that make use of them. Plants parts are known to be used for medicinal purposes, livestock feeding, trading, ornaments etc. The table below presents the economical uses of plants observed within the study area.

Table 4.11: Economical Uses of Some Plants in Study Area

Plant Species	Economical Uses
Natural Occurring Plants	
atropis procera (Sodom apple)	• The roots and barks are used in medicine for digestive disorder, diarrhea, constipation etc; • Used in treating snakebites and boils.
Borassus aethiopum (African fan palm)	• Fruits and tender roots produced by young plant are edible; • Fibres are obtained from leaves; • Woods (reputed to be termite-proof) can be used in construction.
Grewia mollis	• Bark and root preparations are taken to treat cough, snake bite, ulcer, cut, sore; • The mucilage has been used by indigenes as thickener in soups; • As food for livestock animals; • The wood used for house construction, bed frames, walking sticks, tool handles, clubs, bows and arrows, shields, spear shafts and whips; • Also used as firewood and made into charcoal.
Grewia villosa	• Seeds are pounded and consumed; • Roots are used to treat body pains; • Bark is used in the treatment of wounds, syphilis and smallpox
Commiphora africana (African myrrh)	• Fruits are used for the treatment of typhoid fever and stomach problems; • Powdered bark is mixed with porridge to cure malaria; • Resin is used in sealing and disinfecting wounds while fumes of burnt resin are used as an insecticide and as aphrodisiac; • Leaves are browsed by goats, especially at the end of dry season; • Reputation of being termite resistant, though soft. It is used in the construction of local houses, tool handles, beehives, spoons, water troughs, and for musical instrument; • Roots, leaves, and fruits are edible, also extracted is edible oil.
Cynodon dactylon (Bermuda grass)	• Used to feed livestock; • Known to be rich in calcium, phosphorous, potash, potassium, sodium, manganese, protein, enzymes, carbohydrate, fiber, flavonoids and alkaloids; • Used to treat stomach acidity, stomach ulcer, stomach pain, colitis, and stomach infections.
Acacia albida (Anna Tree)	• Good for raising bees, since its flowers provide bee forage at end of rainy season, when most other local plants do not; • Seed pods are important for raising livestock, and used as camel fodder; • Wood is strong and used for making canoes, mortars, pestles; • Ashes of wood are used in making soap as a depilatory and tanning agent for hides.

Sources: Rulangaranga 1989, Von Maydell 1990; B and P van Wyk, 1997; Mohammed, 2000; Gebauer, 2002

Table 4.11: Economical Uses of Plants in Study Area – cont'd

Plant Species	Economical Uses
Acacia nilotica (Gum Arabic tree)	• Its pods are used as supplement to poultry rations. • Branches are commonly lopped for fodder; • The plant makes a good protective hedge because of its thorns; • The wood is very durable is used making boats
Azadirachta indica (Neem tree)	• The leaves and barks are used for treating malaria
Adansonia digitata (Baobab)	• Leaves are used in the preparation of soup; • Flower is eaten raw, the seeds provide flour, which is very rich in vitamin B and protein, and it is used as baby food. • The fruit pulp obtained from the seed provides a refreshing drink when dissolve in water or milk. The spongy and soft nature of the tree makes it easy to store water during the extreme scarcity of water; • The back of the young baobab tree is used in making fishing nets, baskets, mats and clothes
Moringa oleifera (Horseradish tree)	• It is used in medicine for anemia, arthritis, joint pain (rheumatism), asthma, diabetes, diarrhea, epilepsy. stomach pain; and intestinal ulcers treatment as well as bacterial, fungal, viral, and parasitic infections; • Moringa is also used to reduce swelling, increase sex drive (as an aphrodisiac), prevent pregnancy, boost the immune system, and increase breast milk production. Some people use it as a nutritional supplement or tonic.
Balanites aegyptiaca (Desert date)	• Its wood is highly resistance to insects, hence widely used for making wooden handles, bowls, mortars and many household utensils
Vitellaria paradoxa (Shea tree)	• Is an important source of edible oil (shea butter), derived from the seed. Shea butter is also used in cosmetics, skin emollients, and pharmaceuticals; • Has been extensively used for timber, firewood (see **Plate 1.5**) and charcoal production; • The fruits are edible and constitute 50-80% of the whole fruit
Eriosema psoraleoides (Canary pea)	• Roots are boiled with water and the decoction taken as tea or the powder made from dried roots is taken with porridge for treatment of Malaria and used as aphrodisiac.
Corchorus tridens (Jute)	• Young tender leaves are cooked into a mucilaginous product that is either used as a sauce or as relish with maize or other cereal; • It is grazed by animals such as livestock; • Its stem fibres are used for rope making;
Cultivated Plants	
Mangifera Indica (Mango)	• Its fruit are fleshy and edible; • t is used in clearing digestion and acidity due to heat; • It is sought for its timber but occasionally preferred
Sorghum bicolor (Guinea corn)	• Its grains are used to make flat breads; • Significantly used as food to animal (see **Plate 1.5**); • Used as source for making ethanol fuel; • Reclaimed stalks are used to make a decorative millwork material marketed as Kirei board.

Sources: Rulangaranga 1989, Von Maydell 1990; B and P van Wyk, 1997; Mohammed, 2000; Gebauer, 2002

The pictures below shows guinea corn heap stored for processing or as fodder for animal consumption and the harvesting of Shea tree part for firewood to be used to cook.

Figure 4.19: Economic Use of Plant Parts

4.10 Wildlife

4.10.1 Fauna Description

The study area is known for its low fauna composition. This is as a result of the harsh (dry) environmental conditions that ensure the adaptation and survival of only drought tolerant animals. In the study area, livestock animals were majorly observed. Water was made available for the livestock through dug wells or boreholes.

Fauna observed or have been recorded in this area are discussed as follows. **Table 4.12** presents all fauna resources as described by hunters, members of the communities and those recorded during the study.

Mammals

A total of ten mammal species were observed or have been previously recorded in the area. The rodents were represented by the Greater Cane rat (*Thryonomys swinderianus*) and Giant Pouched rat (*Cricetomys gambianus*). Livestock species makes up bulk of the mammalian species.

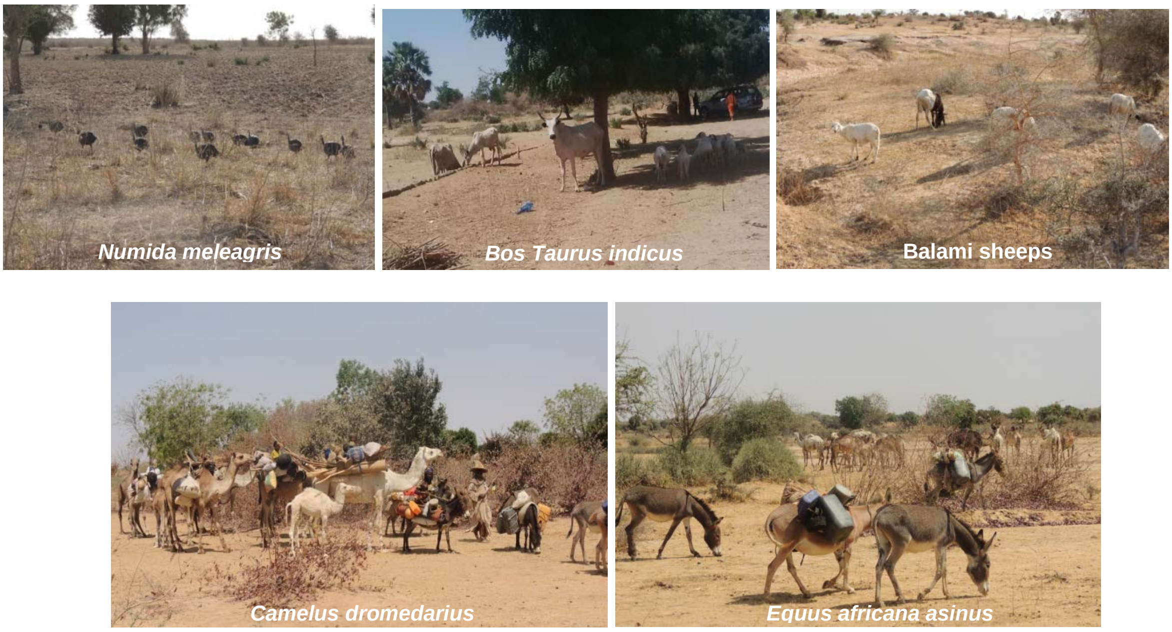


Figure 4.20: Livestock in the Area

Aves

The bird group consists of the Black kite, Francolin, Cattle egret, Finch, Sunbird, Weaver and White stork. The Vultures once common in the study area have become locally extinct.

Reptiles

Cobra, Pythons and Lizards makes up the reptile groups. According to the hunters, the snakes have become locally extinct due to over exploitation.

This species is reported to occur in high abundance in the area. Mammalian species and their IUCN ranking are presented on **Table 4.12** below.

Table 4.12: Checklist of Mammalian Groups in the Study Area

Animal Species	Family	Common Name	Local Name	Current Status	IUCN Ranking
Mammals					
Thryonomys swinderianus	Thryonomyidae	Greater cane rat	Gafiya	Observed	Least Concern
Cricetomys gambianus	Nesomyidae	Giant pouched rat	Dabba	Reported	Least Concern
Lepus capensis	Leporidae	Brown hare	Zomo	Reported	Least Concern
Lepus microtis	Leporidae	African savanna hare	Zomo	Reported	Least Concern
Aves					
Milvus migrans	Accipitridae	Black kite	Shirwa	Observed	Least Concern
Pternistis bicalcaratus	Phasianidae	Double-spurred francolin	-	Reported	Least Concern
Bubulcus ibis	Ardeidae	Cattle egret	Balbela	Reported	Least Concern
Nignia canicapilla	Estrildidae	Negro finch	-	Reported	-
Cinnyris coccinigastrus	Nectariniidae	Splendid sunbird	-	Reported	Least Concern
Ploceus cucullatus	Polceidae	Village weaver	-	Reported	-
Ciconia ciconia	Ciconiidae	White stork	-	Observed	Least Concern
Reptiles					
Naja melanloeuca	Elapidae	Black cobra	Kumurci	Reported	Least Concern
Naja nigricollis	Elapidae	Black-necked spitting cobra	Kumurci	Reported	Least Concern
Agama agama	Agamidae	Rainbow agama	Dadangare	Observed	-
Python sebae	Pythonidae	Rock python	Muduwa	Reported	-
Livestock					
Numida meleagris	Numididae	Helmeted guinea fowl	Zabo	Observed	Least Concern
Bos taurus indicus	Bovidae	Cattle	Marai	Observed	Least Concern
Camelus dromedarius	Camelidae	Camel	Rakumi	Observed	Least Concern
Equus africanus asinus	Equidae	Donkey	Jaki	Observed	
Capra aegagrus hircus	-	African dwaft goat	Akwiya	Observed	Least Concern
-	-	Sokoto red goat	Maradi	Observed	-
-	Bovidae	Balami sheep	Tinkiya	Observed	-

4.11 Socio-economic and Health Studies and Consultation

4.11.1 Study Design and Strategy.

The study was designed to obtain all relevant socio-economic and health data on the community from primary and secondary sources. To this end a strategy was adopted which entailed:

- Conducting literature searches and reviews.
- Design and pretesting of household questionnaire used in the study.
- Determination of the target population and sample size for administering the household questionnaire.
- Conducting field visits to the project area.
- Conducting Focus Group Discussions (FGDs) and General Group Discussions (GGDs) with various stakeholder groups and in-depth interviews with key informants in the project area within 25km radius of the Kankiya L.G.A. Headquarters.
- Collation and analysis of data obtained from all the sources.
- Report preparation.

4.11.2 Target Population and Sample Size.

The household questionnaire was administered on 150 households in the study area and 141 of these were retrieved. The questionnaire was administered on willing households, selected randomly from the community. FGDs and interviews were also held in the study area. Respondents to the questionnaire and participants in the FGDs and interviews were all 18 years and above.

Table 4.13 presents the age and sex distribution of respondents to the household questionnaire. It shows that 14.2% of respondents were within the 15-24 years age bracket, 70.9% within the 25-64 years bracket while 14.9% were 65 years and above. The sex distribution shows that about 60% of respondents are males and about 40% are females. The dominance of respondents within 25-64 years bracket is mainly due to the wide age range while that of males among respondents is due to socio-cultural conditions that encourage male representation in most social issues.

Table 4.13: Age and Sex Distribution of Respondents to the Household Questionnaire.

Age Groups (Years)	Male	Female	Total	
			(No.)	(%)
18-24	12	8	20	14.2
25-64	62	38	100	70.9
65 and above	11	10	21	14.9
Total	85	56	141	100.0

Source: FNL Field Survey, 2015.

4.11.3 Data Collection

The data used in this study were obtained from primary and secondary sources. The primary sources of data were the household questionnaire, the FGDs, GGDs, key informant interviews (KIIs))and observations made during field visits while secondary data were sourced from published and unpublished documents obtained from various sources. All the published documents are indicated in the bibliography at the end of this report.

4.11.4 Analytical Techniques

Various statistical techniques and tools were used in this report. The most common were summary statistics like percentages, ratios and averages. The data were presented mostly in tables and charts. Population size and issues of its distribution relevant to the study, as well as crude birth rate, were determined using the following formulae:

I. Population projection using the exponential model

$P_n = P_o (1 + r)^n$; where P_o is population in the base year, r is the estimated annual growth rate of population, and n is time lapse in years.

II. Sex Ratio = $\frac{\text{Number of males in the LGA}}{\text{Number of females in the LGA}} \times 100$

III. Dependency Ratio = $\frac{\text{Population aged 0-14years + population aged 65years and above}}{\text{Population aged 15-64years}} \times 100$

IV. Crude Birth Rate (CBR) = $\frac{\text{Number of births in the community in one year}}{\text{Mid-year population}} \times 100$

4.11.5 Stakeholder Consultations and Integration in the Study.

Consultations were considered very important in the socio-economic and health study of the EIA process. The socio-economic and health consultations involved all segments of Kankiya community including its leadership, farmers, hunters, women and youth who would be affected by the proposed NSP project, one way or the other. Consultations aim to inform relevant stakeholders about the proposed project, intentions / plans of project proponents, scope of the EIA process and potential impacts of the project. During consultations, the perceptions, concerns and expectations of stakeholders are discussed. The entire consultation process serves to inform and educate stakeholders, and therefore, ensure acceptance of the project among stakeholders. The consultation process involved the following;

- Visits were made to Kankiya community and LGA to meet with key stakeholders including local government officials and traditional rulers. The purpose of these visits was to inform relevant civil and traditional authorities about the proposed project and to secure permission and co-operation for the EIA study and the project.
- Direct Consultations were held with Identified Stakeholders. This phase was conducted by EIA consultants and representatives of NSP. It involved visits to the District Head, and consultations with groups representing Farmers, Hunters, Women and Youths from Kankiya.A schedule of these meetings and the issues discussed are presented in **Table 4.14**.
- Involvement of community members in the study activities with a view to ensuring their participation, informing them about the proposed project as well as obtaining relevant information from them, where possible. In this regard residents accompanied the study team as guides and assistants. The household questionnaire was administered by community assistants.

This phase consisted of the utilization of participatory tools to elicit information from stakeholders on community baseline data and expected impacts (direct / indirect, adverse / beneficial, short / long term etc.) Focus Group Discussions (FGDs), In-depth Discussion and Interviews (IDIs) and General Group Discussions (GGDs) were held with community representatives (**Table 4.14**). Non-participatory observation techniques and visual photography sessions were utilised as complementary data collection tools. Attempts were also made to ascertain stakeholders' concerns as well as identify ways in which the community and stakeholders may be assisted to mitigate or enhance potential project impacts. The assistance could be from project proponent alone, or project proponent in conjunction with relevant NGOs and government agencies at various levels.

It is important to note that consultation activities are continuous as such every successful consultation provides feedback for development, community integration and sustainable co-existence for the benefit of all stakeholders and the environment.

Meetings and interviews were held with community members including male and female representatives and youth leaders. Others were Principal of the public secondary school and teachers in the public primary school and health workers at the State Government owned hospital in the area. Apart from the visits to the project area, meetings, FGDs and interviews with key stakeholders, other forms of engagement were also adopted in the study area. Identified stakeholders in this project will include Kankiya community, representing the interests of residents, community leadership, farmers, hunters, women and youth. Institutional stakeholders include Kankiya LGA, Katsina State Ministries of Environment, and Lands and Urban Development. Others are stakeholders at Federal level including the Federal Ministry of Environment and National Electricity Regulatory Commission.

Table 4.14: Schedule of Meetings in Kankiya

Meetings	Date	Issues Discussed
Community Leadership (District Head and Leaders). 	06/02/15	The proposed NSP project and scope of the ESIA study. Socio-cultural resources, traditional administrative set up, land ownership, use and tenure, livelihood activities. Health conditions in the household and nutrition. Demographic and developmental issues, infrastructural framework, conflict management and security situation in the community. Perceptions, concerns and expectations about the proposed project.
Framers 	07/02/15	The proposed NSP power plant and scope of the ESIA study. Socio-cultural resources, land ownership, livelihood activities, household income levels and expenditure pattern. Farming input, use of fertilizer and modern techniques, cropping methods, crops produced. Internal security and current conflict situation. Infrastructural framework and development. Commonly reported disease conditions in households. Perceptions and concerns about the proposed project.
Hunters 	07/02/15	The proposed NSP and scope of the ESIA study. Socio-cultural resources, land ownership, livelihood activities, household income levels and expenditure pattern. Hunting methods and equipment, crops produced. Internal security and current conflict situation. Infrastructural framework and development. Commonly reported disease conditions in households. Perceptions and concerns about the proposed project.

Table 4.14: Schedule of Meetings in Kankiya

Women Group 	08/02/15	The proposed NSP and scope of the ESIA study. Socio-cultural resources, livelihood activities, household income levels and expenditure pattern. Infrastructural framework and development. Commonly reported disease conditions in households. Availability and utilization of health facilities, Community health issues, personal hygiene and nutrition. Social vices (especially prostitution, drug use and alcoholism). Perceptions and concerns about the proposed project.
Youth Group 	08/02/15	The proposed NSP and scope of the ESIA study. Youth employment and development, participation in community development. Socio-cultural resources, land ownership, livelihood activities, household income levels and expenditure pattern. Internal security and current conflict situation. Infrastructural framework and development. Commonly reported disease conditions in households. Social vices. Perceptions and concerns about the proposed project.
Elders 	08/02/15	The proposed NSP project and scope of the ESIA study. Socio-cultural resources, traditional administrative set up, land ownership, use and tenure, livelihood activities. Health conditions in the household and nutrition. Demographic and developmental issues, infrastructural framework, conflict management and security situation in the community. Perceptions, concerns and expectations about the proposed project.

Table 4.14: Schedule of Meetings in Kankiya

Meetings	Date	Issues Discussed
 **Elders/Government representatives**	06/02/15	The proposed NSP project and scope of the ESIA study. Socio-cultural resources, traditional administrative set up, land ownership, use and tenure, livelihood activities. Health conditions in the household and nutrition. Demographic and developmental issues, infrastructural framework, conflict management and security situation in the community. Perceptions, concerns and expectations about the proposed project.
Public Forum   	03/08/15	The disclosure of proposed NSP power plant: • Fears of stakeholders • Aspirations of stakeholders • Expectations of stakeholders etc

		
With Katsina State Government Representatives 	07/08/15	• The proposed NSP project and scope of the ESIA study. • Land compensation methodology adopted by KSG. • Documentation to support land compensation methodology

4.11.6 Population and Demographic Characteristics of Households

Population Size and Growth

Following a national census in 2006, the National Population Commission (NPC) published the population of Nigeria as 140,431,790 comprising 71,345,488 males and 69,086,302 females, NPC Priority Table Vol. IV, 2010. NPC estimated annual population growth across Nigeria at 3.2% (NDHS, 2008). Current population, projected at 3.2% annual growth and using the exponential model, will be 186,519,256. Current population density is 205 per square kilometre. Conversely, in 2006, Katsina State had a population of 5,801,584 comprising 2,948,279 males and 2,853,305 females. Current projected population of the State is 7,703,348 and population density is 327 per square kilometre.

Kankiya LGA had a population of 151,395in 2006 which was made up of 77,061 males and 74,334 females. Current population is projected at 201,018. Projected population of Kankiya LGA from 2015 to 2020 is presented in **Table 4.20**.Population of the LGA is projected to grow from 201,018 in 2015 to 235,268 by 2020.

Birth and death rate figures, which are available at national and state levels (Annual Abstract of Statistics, 2010), indicate that Nigeria has an average Crude Birth Rate (CBR) of 13.65% and Katsina State has a CBR of 18.54%. The national Crude Death Rate (CDR) is 1.78% while the CDR for Katsina State is 2.71%. The rates imply that Katsina State has more births and more deaths than the national averages.

Table 4.15: Projected Population of Kankiya LGA.

Year	Projected Population (3.2% annual growth)
2006	151,395
2015	201,018
2016	207,411
2017	214,073
2018	220,885
2019	228,001
2020	235,268

Source: NPC estimates (2006) and FNL projections (2015-2020).

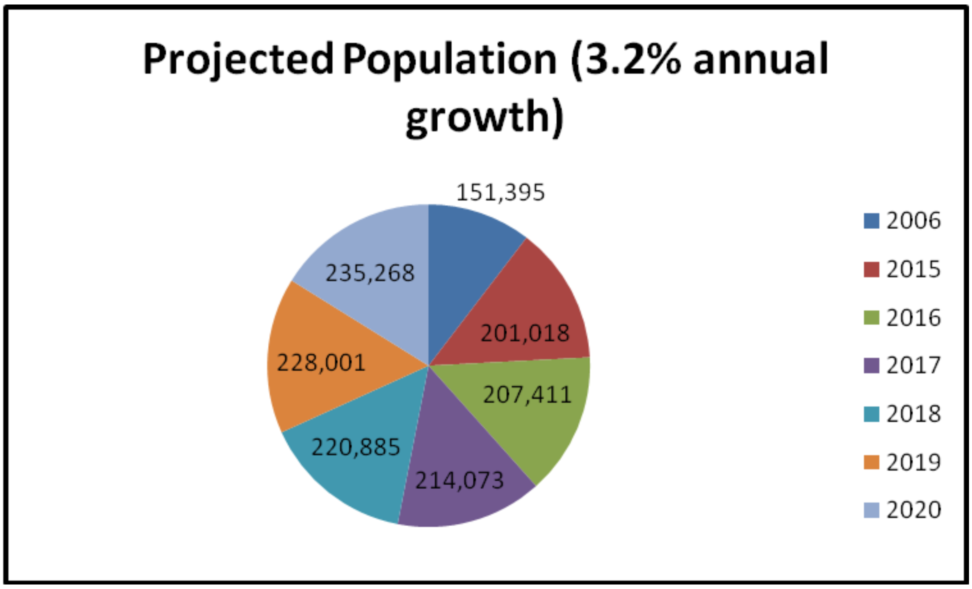


Figure 4.21: Projected Population of Kankiya L. G. A.

Household Composition, Structure and Size

The typical household unit in the study area has a head and several members. In many cases the head is the father and members include his wives, children and wards. The wards often include children of relations. However, members of the household are not necessarily related biologically. The household, as used in this study, has been defined as people living together for a period on a common source which one or more of them contribute financially to; and accepting the authority of the head of household. Members of the household are fed and generally catered for from the resources of the household. Average household size in Nigeria is 4.9. Average household size in Katsina State is 5.3 and average household size in Kankiya LGA is 5.1 (NPC Priority Table Vol. IX, 2010).

Population Distribution.

Age and Sex Distribution

In Nigeria in 2006, children (age 0-14) constituted 41.8% of the population while those less than 20 years were 52.3% and those less than 25 years 61.9%. The elderly (65 years and above) were 3.2% of the population. The age dependency ratio was 82.0 as at 2006. Given these proportions, the population of Nigeria is quite young. Children (age 0-14 years) constituted 48.5% of the population in Katsina State while those less than 20 years were 58.2% and those less than 25 years 66.6%, **Table 4.16**. The elderly (65 years and above) were 2.8% of the population.

Children (age 0-14 years) in Kankiya LGA made up 48.2% of the population while those less than 20 years were 57.6% and those less than 25 years 66.1%. The elderly made up 2.7% of the population. The populations of Katsina State and Kankiya LGA are younger than the general population of Nigeria. By the age distribution, the population of the State is slightly younger than that of the LGA. At less than three percent, the proportion of the elderly in the populations of the State and LGA is small, suggesting that there is not much aging.

Sex ratio shows the number of males in a population to every 100 females in same population (Haupt and Kane, 2004). The 2006 population figure showed that Nigeria had a higher male population and sex ratio of 103. Both Katsina State and Kankiya LGA have higher male than female populations, **Table 4.16**.The sex ratio in Katsina State is 103 and in Kankiya LGA it is 104. This indicates there are about 103 males to every 100 females in the State and 104 males to every 100 females in communities in the LGA. The sex ratio in Katsina State is same as the sex ratio in Nigeria while the sex ratio in Kankiya LGA is slightly higher.

Table 4.16: Age and Sex Distribution in Katsina State and Kankiya LGA, 2006.

Age Groups (Years)	Frequency							
	Katsina State				Kankiya LGA			
	Male	Female	Total		Male	Femal e	Total	
			(No.)	(%)			(No.)	(%)
0-4	626,686	581,148	1,207,834	20.8	16,825	15,293	32,118	21.2
5-9	499,315	450,427	949,742	16.4	12,887	11,390	24,277	16.0
10-14	353,874	304,408	658,282	11.3	8,843	7,736	16,579	11.0
15-19	280,905	284,254	565,159	9.7	6,998	7,246	14,244	9.4
20-24	204,233	281,585	485,818	8.4	5,199	7,656	12,855	8.5
25-29	189,747	261,756	451,503	7.8	4,925	6,912	11,837	7.8
30-34	171,466	193,115	364,581	6.3	4,702	5,123	9,825	6.5
35-39	135,295	127,277	262,572	4.5	3,674	3,383	7,057	4.7
40-44	129,273	112,642	241,915	4.2	3,604	2,954	6,558	4.3
45-49	85,579	62,021	147,600	2.5	2,235	1,662	3,897	2.6
50-54	90,943	68,030	158,973	2.7	2,435	1,761	4,196	2.8
55-59	34,376	22,911	57,287	1.0	877	602	1,479	1.0
60-64	52,074	38,195	90,269	1.6	1,365	965	2,330	1.5
65-69	16,581	12, 856	29,437	0.5	400	313	713	0.5
70-74	31,723	21,089	52,812	0.9	868	533	1,401	0.9
75-79	10,991	7,280	18,271	0.3	302	195	497	0.3
80-84	19,531	13,892	33,423	0.6	492	325	817	0.5
85+	15,687	10, 419	26,106	0.5	430	285	715	0.5
Total	2,948,279	2,853,305	5,801,584	100.0	77,061	74,334	151,395	100.0

Source: NPC Priority Table Vol. IV, 2010.

Dependency Ratio
The dependency ratio shows the relationship of the population of children (0-14 years) and the elderly (65 years and above) to the population of those aged 15-64 years. It is an indication of the burden of providing for the dependent in the economy. It is assumed that the potential workforce (those aged 15-64 years) bear the economic burden of the dependent. The higher the dependency ratio, the lower the labour input per capita. The age dependency ratio in Nigeria is 72.0 while it is 105 and 104 in Katsina State and Kankiya LGA, respectively. The dependency ratios in Katsina State and Kankiya LGA are quite high, implying that the proportion of dependent population is higher than the potential workforce. This type of age distribution reduces the values of both labour input and income per capita (UNDP, 2006). It also implies that resources in households in Kankiya LGA and Katsina State are largely devoted to the up keep of children.

Ethnic Composition and Religious Affiliations of the Population
Indigenous residents of Kankiya are mostly of the Hausa ethnic group. Besides the Hausa, the Fulani represent a significant proportion of indigenous residents of both Kankiya town and LGA. Apart from the indigenous Hausa and Fulani there are residents from other parts of Nigeria. Notable among these are Yorubas, Igbos and Idomas. Local sources suggest that these non-indigenous residents account for about15% of all residents.

The predominant religion in Kankiya town and Kankiya LGA is Islam. Indigenes of the community are mostly Muslims. A few non-Muslims live in Kankiya town. These are mostly found among the non-Hausa and Fulani residents.

Marital Status of Household Members

The marriage institution is revered in Kankiya, and marriages are contracted between males and females. There are no records of same sex marriages in the community. The family is a basic social unit in the study area and there are both nuclear and extended families in the community.

Traditionally, the marriage process involves the participation of members of the families of the intending couple. The process usually brings members of the families of the groom and bride together and tends to forge close ties among them. Marriage rites are conducted according Islamic injunction. The process begins with the man asking for the lady's hand in marriage from her parents and on their approval a period of courtship ('zache') begins. They decide on a wedding date at which time the groom provides gifts "kaya'nbaiko" for the bride's parents. Following this the groom gives gifts of cloths and wrappers to the bride "kaya'nlefe". Finally the wedding ceremony, the 'fatiha' is conducted on the fixed day.

Marital status of household members is presented in **Table 4.17**. Analysis indicates that 70.7% of respondents are married, 23.6% are single and about 5.7% are either separated or formally divorced. The majority of adults are married. It is common practice, called 'kwule', for young married women to stay at home and to restrict their movement outside the house. Individuals also put out a notice 'bashiga' to restrict men from entering into houses where there are married women. Most married residents want to remain married and couples make great sacrifices to remain married. Polygamy and monogamy are both practiced in the community. Polygamy is quite common and 31 of 72 male respondents (43.1%) who are more than 25 years have more than one wife.

Table 4.17: Marital Status in the Study Area.

Category	No.	(%)
Married	99	70.7
Single	33	23.6
Separated or Divorced	8	5.7
Total	140	100.0

Source: FNL Survey, 2015

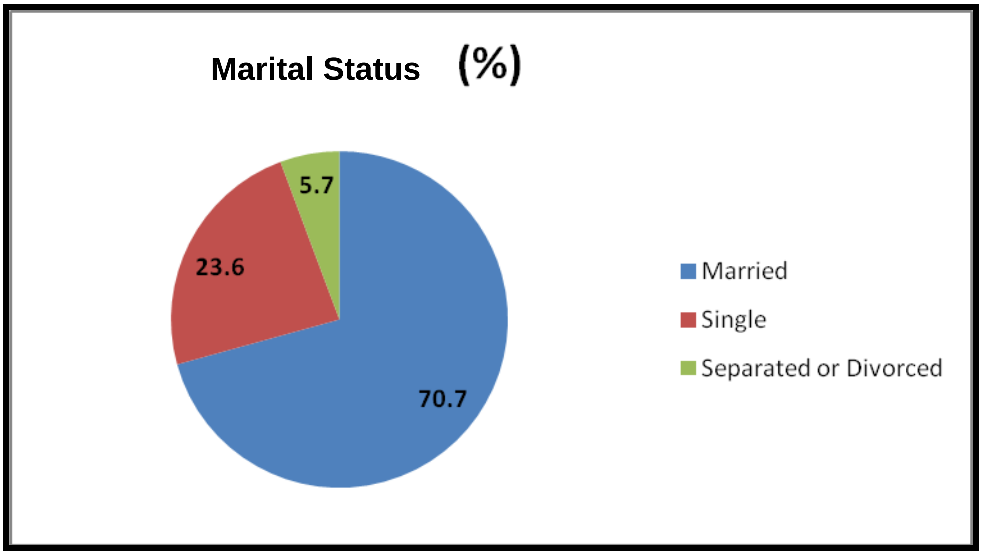


Figure 4.22: Marital Status of Study Area

4.11.7 Migration Trends and Patterns.

There have not been accessible records of migrations within the community. Migration in Nigeria has generally been characterized by a rural to urban movement of individuals and families. The most common reasons for relocation are work, marriage, and school. Among children and the youth, especially between the ages of 10 years and 45 years, several have left the rural for urban communities in order to attend school or learn trades. The length of residence of households in Kankiya provided an indication of the character of migration in the study area. Respondents indicated that 28.6% of households have lived in Kankiya for less than ten years. Considering those households that have lived for less than ten years as largely migrant, it would appear that the migrant population makes up more than a quarter of residents.

Apart from residents, there are migrant Fulani herdsmen in the study area. These live mostly in temporary houses within and in close proximity to their grazing grounds. They move from time to time. There is no definite pattern, in terms of specific number of years that they stay in a particular location before migrating to another. The seasons and availability of grazing grass and fodder seem to determine their length of stay in a particular location.

4.11.8 Fertility, Mortality and Life Expectancy.

Fertility, mortality and life expectance rates in the study area are influenced by a number of factors. These factors include the general acceptance of the universality of marriage, relatively early marriage and procreation, and the existence of the practice of polygamy. The specific fertility, mortality and life expectancy rates for Kankiya have not been determined but existing State and regional values provide an indication.

A good measure of fertility is the Total Fertility Rate (TFR) which is an indication of the total number of children a woman is estimated to have in her reproductive life time. The TFR for Katsina State is 6.7 while the national average is 5.7 (NBS, Annual Abstract of Statistics, 2010). This TFR is an indication that the average woman in Katsina State will have more children than the national average. Another measure of fertility is the Crude Birth Rate (CBR) which is estimated at 18.54%. Comparing with the national average which is 13.65%, there are more births in Katsina State than most other states in Nigeria (NBS, Annual Abstract of Statistics, 2010).

Available mortality measures include the Neonatal Mortality Rate (NMR), Infant Mortality Rate (IMR) and Under Five Mortality Rate. These rates are assessed per 1000 recorded live births. The NMR, IMR and Under Five Mortality Rate for Katsina State are 55, 114 and 269 per 1000 live births, respectively. The national averages are NMR 48, IMR 100 and Under Five Mortality Rate 201 per 1000 live births (National Bureau of Statistics-NBS, Annual Abstract of Statistics, 2010). The NMR, IMR and Under Five Mortality Rates indicate that there are more deaths among neonates, infants and Under Five in Katsina State than what obtains generally in Nigeria.

Life Expectancy estimates for Katsina State are the same as the available national estimates. The World Health Organization (WHO) in its World Health Statistics 2006 estimated that life expectancy for males and females in Nigeria were 42 years and 47 years, respectively, as per population surveyed.

4.11.9 Adult Literacy Rate and Schools Attainment.

The adult literacy rate is determined by the proportion of population aged 15 years and above that has completed a normal course of primary education and can read and write in the English language. The NBS National Literacy Survey, 2010 indicates that the adult literacy rate in Nigeria is 57.9% and in the North West geopolitical zone it is 31.7%. Adult literacy in English in Katsina State is 34.5% among males, 20.1 among females and 27.5% for both. In Kankiya LGA the rates are 17.7% among males, 9.6% among females and 13.9% for both. The adult literacy rates in Katsina State and Kankiya LGA are lower than the national average. The rate in Kankiya LGA is also lower than the average for the North West.

The level of school attainment in Kankiya LGA, published by NPC is presented in **Table 4.18**. A large proportion of the population (61.0%) has not attended school. There are more females than males among this group, to the ratio 54.5%: 45.5%. Among those currently in school and those who have ever attended school, the highest proportions in the LGA are at the level of secondary school (15.9%) and nursery school (10.2%). This level of school attainment among household members would imply that the local workforce is largely illiterate in English, and the proposed project may not get all its supply of a literate workforce locally.

Table 4.18: School Attainment in Population Aged 6 Years and Above, Kankiya LGA by Sex, 2010.

Category	**Male**	**Female**	**Total**	
			(No.)	**(%)**
No Education	31,383	37,611	68,994	61.0
Nursery	6197	5329	11,526	10.2
Primary	4695	3918	8613	7.6
JSS/Modern School	3380	2424	5804	5.1
SSS/SEC/TTC	6854	5373	12,227	10.8
OND/NCE	2337	847	3184	2.8
University/HND	1084	231	1315	1.2
Post Graduate	385	104	489	0.5
Other	564	378	942	0.8
Total	56,879	56,215	113,094	100.0

Source: NPC Priority Table Vol. VII, 2010.

Household Members Currently Attending School in the Study Area.

Children and household members in the study area are at different levels of schooling, **Table 4.19**. There are 30.3% of children from sampled households currently in nursery school and 22.7% in primary school. The highest proportion of those currently in school is the 32.6% in secondary schools. Tertiary institutions have 14.4% of those in school in the study area. technical schools have 3.2% of those in school in the study area. There is also no public technical educational institution in the study area, an indication of the lack of technical training in the area.

Among children and household members currently in school in the study area the highest proportion, 38.2%, are in primary schools. Next to these are 29.8% of household members in secondary schools and 23.0% of children in nursery school. The least are 3.2% of household members in technical school.

Table 4.19: Children and Household Members Currently in School in the Study Area.

Level of School	**Frequency**			
	Males	**Females**	**Total**	
			(No.)	**(%)**
Nursery	21	23	44	23.0
Primary	35	38	73	38.2
Secondary	37	20	57	29.8
Vocational/Technical	4	2	6	3.2
Tertiary	9	2	11	5.8
Total	106	85	191	100.0

Source: FNL Survey, 2015

Status of Available Education Facilities

Schools in Kankiya include Nuhu Primary School, Hassan Usman Primary School, Sada Primary School, Suleiman Primary School, Kiddies International Nursery and Primary School, and Al Bashira Nursery and Primary. At secondary level the schools include Government Girls Secondary School (Junior and Senior schools), Government Day Secondary School (Junior school), Government Secondary School Kanti, Al Bustan School and Community Arabic and Science Secondary School. There is a technical school (Business and Apprenticeship Training Centre), a private school (Hassan Sada Model Quranic School), and a tertiary institution (Katsina School of Health Technology). The primary schools offer primary 1-6 classes, the junior secondary schools JS 1-3 classes and the senior schools SSS 1-3.

Some of the school buildings and classrooms in the public schools, at both the primary and secondary school levels, need to be renovated. This especially affects roofs, doors and windows in the classrooms. There is also a general need for additional utilities like toilets for pupils and teachers, private water supply and electric fans for the classrooms. Desks and chairs provided for both pupils and their teachers need to be repaired, and in some cases replaced. The schools also do not have enough teaching aids and instructional materials for teachers' use.

The public schools experience some truancy. This is related to lateness of some children to school in the mornings. There is also the phenomenon of school dropout which usually occurs at the end of the school session. School teachers have estimated dropout in the student population at about 5%, at the end of each session. School dropout has been attributed to a number of reasons including transfers of parents and guardians who work in the public sector from Kankiya to other parts of the State; marriage and starting families; and lack of interest in formal education. Some have also added the fact that the cost of providing school materials has caused some parents and guardians to withdraw their children and wards from school and kept them on their farms.

Access to Education Facilities.

Effective access to education facilities could be a factor influencing the level of literacy attained in some communities. This is because where facilities are easily accessible and within reach, some household members have been encouraged to use them. Public primary and secondary schools are located close to households in the study area such that members of the households sampled live within 30 minutes of the schools, **Table 4.20**. A majority of these households, 59.8%, pay nothing or less than ₦50 to get to the public primary or secondary school they attend.35.55 pay between ₦50 and ₦100 and 4.7% pay between ₦110 and ₦200 to get to school.

Table 4.20: Travel Time and Cost to Public Schools Nearest to Household Members

Time			Cost		
Time Range	Frequency		Cost Range	Frequency	
	(No.)	(%)		(No.)	(%)
0-10mins.	36	33.6	₦0 - ₦50	64	59.8
11-30mins.	71	66.4	₦51 - ₦100	38	35.5
31mins.-1hr.	-	-	₦110 - ₦200	5	4.7
More than 1hr.	-	-	More than ₦200	-	-
Total	107	100.0	Total	107	100.0

Source: FNL Survey, 2015.

4.11.10 Socio-Cultural Resources

Historical Accounts of Origin

There are various accounts of the origin of the Hausa but three of these are most common. Many Hausa believe they descended from Arabs. Their progenitor, Bayajida, settled in Daura in present day Katsina State and had children who are ancestors and founders of the Hausa city states. Another of the theories of origin is that the Hausa once lived in a location

on the banks of Lake Chad but had to move westward when the water level in the lake receded. The third theory is that the Hausa were nomads in the Sahara Desert. Some who have put forth this theory believe they have a link to Ethiopia. Scholars who have accepted this link base their belief on the shared worship of the sun god by both groups before the advent of Islam and Christianity to the groups.
The Fulani ancestors are believed to be nomads who migrated from the Senegambia region to their present areas in Northern Nigeria. Most of the areas they occupy in Nigeria were obtained by conquest. Kankiya is one of the settlements of the Hausa and Fulani in Katsina State.

Language
Hausa is the major language spoken in Kankiya. Linguistically, Hausa language belongs to the West Chadic branch of the Afro-Asiatic language family and it is related to Arabic, Hebrew, Berber, Amharic and Somali. It is the most widely spoken Sub-Saharan language, and it is spoken inparts of Nigeria, Burkina Faso, Cameroon, Chad, Cote d'Ivoire, Ghana, Niger and Sudan. It is spoken in Nigeria as a first language by an estimated 18.5 million people. The Hausa dialect spoken in Kankiya belongs to the Western Hausa dialect. Variants in this dialect group include Sokoto, Katsina, Gobirawa, Adarawa, Kebbawa and Zamfarawa. Other dialect groups are Eastern Hause spoken in Kano, Katagum and Hadejia, and Northern Hausa which includes Arewa and Arawa, (Enthnologue and Irene Thompson, 2015).

Fulani which is the next major indigenous language in Kankiya belongs to the Atlantic branch of the Niger-Congo language family. Speakers call themselves Fulbe, but the Hausa call them Fulani which has become the name by which they are commonly referred to in Nigeria. The language is spoken in parts of Nigeria, Cameroon, Chad and Sudan, (Enthnologue).

Traditional Administrative Structures
At the apex of the traditional administration structure in Kankiya is the District Head of Kankiya. Kankiya is a part of Katsina Emirate and the District Head is part of the Emirate Council. He is appointed by the Emir of Katsina and he is answerable to the Emir. The District Head is assisted in his administration of Kankiyaby 11 Village Heads, representing the 11 villages that make up Kankiya. The Village Heads are directly responsible for administering their respective villages and maintaining law and order in their various domains. The District Head and Village Heads also use the advice of community elders in performing their duties.

A number of local community based organizations (CBOs) are operational among residents. They are set up to perform economic developmental and welfare functions among residents, and they assist in managing interests of residents. Major CBOs in Kankiya include KungiyarMarayuKankiya, KungiyarTaimakonMarayu, Kungiyar S/BirniZango and KungiyarManoma Ta.

Religious Beliefs and Practices
Kankiyaresidents are predominantly Muslims. A few of them, mostly among civil/public servants who may not be indigenous residents are Christians.The major mosques in Kankiya include MasalachiHakimiGari, Masalachi'nLayiKankiya, Masalachi'nKanti, Masalachi'nSabuwar-Abuja and Masachi'nSabuwar-Abuja Sabo.

Figure 4.23: The Newest Major Mosque in Kankiya

Festivals celebrated among residents include 'Shayi' which is a ceremony of the circumcision of young males. 'Sauka' is a ceremony marking graduation of children from Quranic School. There is also 'Bikinshanruwammace' which is a celebration marking the harvest of crops from the farms. The most celebrated festivals are those of Id-el-Fitri, Id-el-Kabir and Ed-el-Mahlud which are generally referred to as Sallah celebrations.

There are no food taboos in the community and no animal is considered sacred, however, as a largely Muslim society they do not rear pigs or eat pock, and they also do not consume alcoholic beverages. They also do not eat the donkey, it is reared for use to carry things to and fro the farms. The society generally prohibits practices that are perceived to be harmful to human coexistence. These practices include desecration of places of worship, committing suicide, having sexual intercourse with a married woman who is not one's wife and cannibalism. Residents generally abide by these restrictions.

Archaeological Features and Reserved Places
Kankiya has unexplored sites of potential archaeological value. It is an area that is currently farmland. Local sources know the place as 'Mangorori Unguwarkanawa Kankiya'. It said to be a deserted settlement that is more than 200 years old. Formal archaeological excavations and studies have not been conducted on this site. The community has a cemetery which is currently in use. It is a reserved area, established. These sites of historical significance will not be impacted by the proposed project.

Life Style and Social Indulgent Practices of Residents
Indulgent practices and vices assessed in Kankiya include drinking of alcohol, cigarette smoking and use of hard drugs, prostitution, teenage pregnancy and child labour. The use of spirits and alcoholic beverages is generally considered offensive among Muslims and it is not a common practice among Kankiya residents. Some adult residents, mostly males, smoke cigarettes. Cigarette smoking is fairly common and most smokers started in their teenage.

It was noted that children assist their parents and guardians in various ways including on their farms, selling in shops and the markets, hawking, running domestic errands or doing household chores. A lot of these occur off school hours and during holidays and neither attract wages nor stop the children from attending school. However, there are some children who do these services and who do not attend school.

Conflict Management.
Conflicts do not always have violent outcomes. Various conflicts occur daily within the study area. Most of these are resolved without violence. The traditional resolution method employed in managing conflicts emphasizes arbitration and representation, as all parties to

any dispute are required to be present as their matter is discussed and determined. The main organs involved in conflict resolution include Village Heads and District Heads. Decisions of these organs are accepted by the disputing parties.

Besides the traditional methods, there are also the courts including Sharia Courts, Magistrate Courts and High Courts. Disputing parties can always resort to any of these. Kankiya community usually does not bar anyone from using them or interfere in anyone's decision to resort to them.

Participation of Women and Youth in Development

There are women and youth groups in Kankiya that are recognized as essential arms of the social structure and traditional administrative structure. Although they do not seat in the traditional council and, therefore, do not participate directly in communal decision making, they serve to advise the council and mobilize their members towards community development. They also play very important roles in conflict resolution and in attending to welfare needs among their members. Apart from their advisory role, the youth participate in ensuring community security, and maintaining a clean environment.

4.11.11 settlement Pattern and Housing Characteristics

Settlement Pattern

Kankiya is a community of 11 villages. These are: Gachi, Ka Wari, Kafin Soli, Kauyenmaina, Fakuwa, Kafindangi, Tafashiya, Nassarawa, Gyaza, Galadinma A and B, and Magam. Each of these villages has hamlets. Houses in the community are clustered. The settlement pattern is nuclear, but it has a scattered settlement pattern at the outskirts of the town. It is a small town in a rural setting. The town and housing are not panned. The houses are not built in any given pattern. Spacing of houses is not fixed but most houses built within five to eight metres of the other. A factor that has greatly influenced settlement pattern and size in Kankiya is availability of land. Lands have been available for development, for residential and commercial purposes.

Types of Houses.

Common types of living houses in the study area include bungalows, flats and tenement (rooming/terraced) houses, (**Table 4.22).** Bungalows and flats are more common than tenement buildings. Bungalows account for 49.6% and flats 31.9%. Tenement houses and duplexes account for 12.6% and 5.9%, respectively.

Figure 4.24: Some Types of Houses in the Study Area

The number of bedrooms in the houses range from two to five, while the modal is four and the mean is three. An average of two household members sleep in one room in the houses surveyed. At this rate the houses are not congested. Many of the houses are designed with the traditional concept where kitchens, toilets and baths are located outside the house. A fenced courtyard encloses these facilities and conveniences.

Table 4.21: Types of Houses in the Study Area.

House Types	Frequency	
	(No.)	(%)
Bungalows	67	49.6
Tenement Houses	17	12.6
Flats	43	31.9
Duplexes	8	5.9
Total	135	100.0

Source: FNL Survey, 2015.

Materials Used for Housing Construction

Materials used in construction of walls for living houses in Kankiya are mud blocks, bricks and cement block, **Table 4.22**. As at the time of field survey, laterite was being mined from the project site for block-making. Materials used for roofs are predominantly corrugated iron sheets (zinc). A few houses are roofed with other materials including aluminium, slate and thatch. Most houses, about 56%, are built with walls made of mud blocks. Houses built with bricks and cement blocks are 23% and 21.5%, respectively. Corrugated iron sheets are used for the roofs 77.8% of houses while slate is used in 14.8%, thatch in 5.2% and aluminium in 2.2%. Most of the houses are floored with cement. Generally, materials used in building walls of houses in the study area may not be modern but they are solid and durable. Apart from thatch, the other roofing materials are also durable.

Figure 4.25: Laterite Mined at the Project Site and Used for Block-Making

Table 4.22: House Construction Materials the Study Area

Construction Materials	Frequency	
	(No.)	(%)
<u>Walling Materials</u>		
Cement Blocks	29	21.5
Brick	31	23.0
Mud Blocks	75	55.5
Total	135	100.0
<u>Roofing Materials</u>		
Corrugated Iron Sheet (zinc)	105	77.8
Aluminum	3	2.2
Slate	20	14.8
Thatch	7	5.2
Total	135	100.0

Source: FNL Survey, 2015.

Sources of Energy Used in Households for Cooking and Lighting in the Study Area

Firewood is the predominant source of fuel used by households to cook their meals, **Table 4.23**. The use of firewood accounts for about 93.3%. Kerosene is used by a few households, 6.7%. Lighting in households in the study area is primarily provided by public electricity. The houses are connected to the national grid. However, most households have made provisions for alternative sources of electricity because of frequent outages on the public grid. In 39.6% of houses, kerosene lamps are used to provide alternative lighting and in 1.4% private electricity generating sets are used.

Table 4.23: Types of Fuel Used for Cooking and Lighting in Households in the Study Area.

Types of Fuel	Frequency	
	(No.)	(%)
Fuel Used for Cooking		
Firewood	125	93.3
Kerosene	9	6.7
Total	134	100.0
Source of Energy for Lighting		
Kerosene	53	39.6
Public Electricity	79	59.0
Private Electricity Generator	2	1.4
Total	134	100.0

Source: FNL Survey, 2015.

4.11.12 Natural Resources and the Economy of Kankiya

Natural Resources Exploited in the Study Area

Natural resources in Kankiya are inclusive of lands, grass lands and water bodies. The lands are quite extensive and they provide space and materials (like sand and clay) for farm lands, the physical development of the community, especially in housing and infrastructural development. The lands also provide the sand and clay used for housing and road construction. The land mass has been put to various uses. The vegetation does not support much of forests, but the growth of grasses and shrubs. The grass lands are useful grazing grounds for herdsmen in the area. The grasses and shrubs are also useful in the construction of thatches for construction of houses and granaries, especially in the villages and suburbs.

The water bodies are inclusive of Inchimami River and Kankiya dam. Inchimami River or Koroma as often referred to locally is the main natural drainage in Kankiya. Kankiya dam is a small man made earth dam from where water is used for irrigation of farm lands and for grazing of livestock. These resources have been exploited by generations of residents, and have kept and sustained human habitation over the years.

Land Ownership, Tenure and Use

Traditionally, lands in Kankiya are communally owned and managed. Within the traditional setting, families have acquired lands on which they have developed their private properties. Individuals, whether indigenous residents or not, can also buy land from the community and own such land. Such land is put to any use as desired by the owner(s). Rights over lands within a family are handed down from one generation to another. Women can buy and own land. Any intentions to obtain land for corporate or industrial use should be initiated through the traditional leadership in the community, which is in the best position to offer proper guidance concerning ownership.

Residents were conscious of a gradual decrease in communal lands over the years. They also indicated their perception of the factors responsible for this loss in communal lands. Land loss has been mostly attributed to encroachment by the state government and environmental factors, especially wind and water erosion. Both factors are estimated to have accounted for between 30% and 50% of communal lands that have been lost over the years.

Over the years, lands in the community have been used for farming, grazing of livestock, housing and infrastructural development. Residents gave an indication of the various uses to which community lands have been put and also estimated current proportions of land use, **Table 4.24**. It is estimated that government acquisition of land for construction of public facilities including education and health facilities, and roads has amounted to.

Table 4.24: Land Use Structure in Kankiya.

Land Use Structure	Frequency (%)
Agricultural	60.0
Industrial	2.0.
Residential	20.0
Institutional (Infrastructure)	18.0
Total	**100.0**

Source: FNL Survey, 2015

Environmental Challenges

The main environmental challenge in the community is erosion. Two kinds of erosion are commonly experienced in the community; these are wind erosion and water erosion. Wind erosion occurs mostly when strong North East trade winds blowing across the study area sweep away dried and loose top soil. This is a common phenomenon during the dry and dusty harmattan months, especially between November and March. Water erosion occurs when it rains. Torrential rains cause fast flowing run off which also wash off much top soil.

Figure 4.26: Water Erosion in the Study Area

Erosion is aided in the area by the lack of dense foliage ordinarily provided by grasses, weeds, shrubs and trees. Without much vegetation cover, the grounds are dried up being exposed to heat making it easy for the winds during harmattan and water during the rainy season, to carry away soil.

Employment Status of Households

Employment has been defined in this study to include all forms of paid work, whether done on a full time or part time basis. Unemployment on the other hand has been defined as being ready and looking for work and not being able to secure one in the last six months preceding this study. The definitions of employment and unemployment only considered those aged 15-64 years who were not full time students. Thirty two households in the community, 22.7%, indicated that they had one or more unemployed members. Unemployment is most pronounced in the study area during the dry season when the crops have been harvested and the farms are left fallow awaiting another cropping season. In NBS (2011) estimates of the level of unemployment among different groups in rural Nigeria, the rate of unemployment among the uneducated (those who have never attended school) was 22.8%. Among those who have attained only primary school education it was 22.7%. Among those who have obtained JSS and SSS certificates it was 36.9% and 22.5%, respectively.

Unemployment was 38.2% among 15-24 year olds and 24.1% among 25-44 year olds. For those aged 45-59 years and 60-64 years the rates were 19.6% and 22.1%, respectively. The sex distribution of unemployment in rural Nigeria was 25.1% among males and 26.1% among females. These statistics suggest that the highest rate of unemployment in the study area would occur among females aged between 15 and 24 years whose only qualification is Junior Secondary School Certificate. Residents in this category most times do not have any skills that can enhance employment.

Livelihood Activities.
Employed members of households in Kankiya are involved in different livelihood activities. Livelihood activities identified in households during the study included farming and gathering of firewood, grazing of livestock, hunting, trading and artisanship practices. Others are sundry activities like employment in the civil/public services, providing local transportation services and contracting, **Figure 4.27**. Farming accounts for over 50.0% of the livelihood of households in Kankiya. Some practitioners own farms which they cultivate directly every farming season. Others have farm lands that they hire labour to cultivate. Most people in the latter group work full time at other livelihood activities like employment in the civil/public services. Crop farming is most common. Residents farm with traditional and rudimentary equipment like cattle driven ploughs, hoes, cutlasses and machetes. The use of fertilizers and herbicides is common among farmers. Farmers generally complained of lack of access to fertilizers because they are not usually available and when available they the cost is such that farmers cannot afford as much as they need. Farmers have had access to improved seedlings. Commonly grown crops include grains like guinea corn, millet and maize. Others are vegetables like carrot, okra and cabbage, among others. Farmers still practice shifting cultivation and bush fallow systems which entail leaving farmlands fallow for between three years and five years, depending on pressure on available farmlands.

Grazing is a traditional livelihood activity of the Fulani. Some have their livestock at home and take then out or hire people to do so on a daily bases. Others are nomads who live out in the fields with their animals. Nomads usually move with availability of the right kind of grass and fodder for their livestock. Their stay in any particular location is not time specific. The livestock are inclusive of cattle, sheep, goats and some donkeys. Hunting is still a recognized means of livelihood, although many residents not employed in the activity. Hunters use daneguns, traps and cutlasses.

Artisanship services are provided by private small scale enterprises in the study area. Some of them are able to employ a few workers and some through apprenticeship programmes have trained others. Such artisanship practices in Kankiya include tailoring, auto mechanic workshops, welding workshops and furniture/cabinet making. Others are electrical and electronic installations and repairs, masonry and block making.

Trading is a significant livelihood activity in the study area. The market at Galadima, which operates daily, provides outlet for buying and selling. Apart from the market there is some retail trading along roads and streets. This type of selling is conducted from a variety of places. Some can only afford to sell a few things like confectioneries, fruits and others from table tops set up beside their houses while several trade from rented shops where they stock a variety of goods including electrical and electronic goods, cloths and leather products. There are also those who hawk fruits and food.

Some residents work in the public and civil services. These are inclusive of health workers, teachers and those who work with Kankiya LGA and its agencies. Some residents are involved in contracting providing sundry administrative services, especially at the local government headquarters and transportation, among others.

Some residents practice more than one livelihood activity. Engaging in multiple livelihood activities provides household members complementary sources of income. In many cases, however, it is an indication that each of the activities only provides subsistence income.

Incomes from these livelihood activities vary very significantly. Among farmers, monthly incomes of between ₦10, 000 and ₦50, 000 were estimated from FGDs, KIIs and questionnaire responses. However, a monthly modal income of ₦20, 000 was estimated.

Among traders the estimated monthly income range was ₦5, 000 to ₦30, 000 and the modal was ₦25, 000. Similarly, among artisans a range of between ₦10, 000 and ₦20, 000 with a modal of ₦15, 000 was established. Employees in the civil/public services experience a wider range in their monthly incomes, determined by their seniority and grade levels.

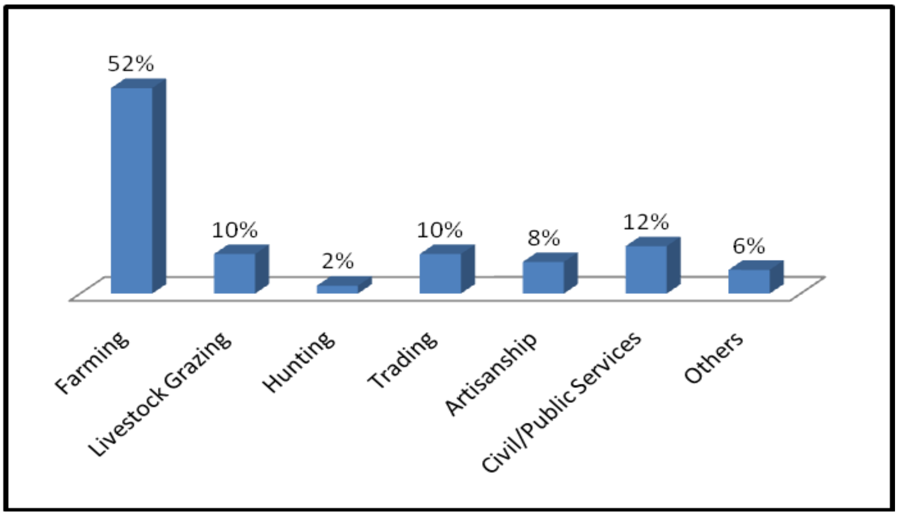


Figure 4.27: Livelihood Activities in Kankiya.

Income Levels of Households in Kankiya

The nominal income levels of households in Kankiya are presented in **Table 4.25**. The modal household income range is between ₦10, 100 and ₦20, 000, while the mean household income (obtained by dividing total income by total respondents) is ₦33, 809.

Given the mean household income value of ₦33, 809, mean household size of 5.1 in Kankiya LGA and assuming a Naira to United States of America (USA) dollar exchange rate of ₦180:1USD and 30 days in a month, a household member will earn ₦221 or 1.2 USD daily. Using midpoint of the modal income range (i.e. ₦15, 050 which is midpoint of the range ₦10, 100-₦20, 000), the average household member will earn about ₦98.4 or 0.5USD daily. By the first analysis, the average household member earns more than 1USD per day which is above poverty income and by the second it is less, which is below poverty income. The National Bureau of Statistics (NBS) calculated the poverty profile of Nigeria (NBS, 2010), and using the poverty wage of 1USD per person per day concluded that 61.2% across Nigeria live below the poverty line. Given that the modal value represents the most frequently occurring household income group, it implies that a majority of household members in Kankiya live below the poverty line.

Table 4.25: Household Income Levels in Kankiya.

Income Levels (₦)	Income Mid-Point (₦)	Frequency/Respondents		Total	
		(No.)	(%)	(₦'000)	(%)
Less than 1,000	500	-	-	-	-
1,000-5,000	2,500	5	3.6	12.5	0.1
5,100-10,000	7,550	27	19.4	203.9	0.94
10,100-20,000	15,050	39	28.1	587.0	1.25
20,100-35,000	27,550	28	20.1	771.4	26.29
35,100-50,000	42,550	17	12.2	723.4	24.71
50,100-100,000	75,050	14	10.1	1050.7	21.8
Above 100,000	150,000	9	6.5	1350.0	24.89
Total	-	139	100.0	4698.9	100.0

Source: FNL Survey, 2015.

Household Expenditure Patterns.

Households in Kankiya indicated that about 80% of their monthly incomes are spent on household needs including food, health care, education, transportation, clothing and utilities,

Figure 4.28. Most households indicated that purchase of food constitutes a very significant part of their monthly expenditure. The regular items on the menu of households like rice, vegetables, beans and meat are bought. In spite of the availability of free public primary schools in Katsina State, households spend on school materials. Apart from that, some households pay various sums to train their wards in private schools.

Households spend part of their monthly incomes on health care, purchase of cloths, transportation of their members to and from work, school and other places. They also pay for utilities, especially electricity and fuels to operate kerosene lamps and stoves.

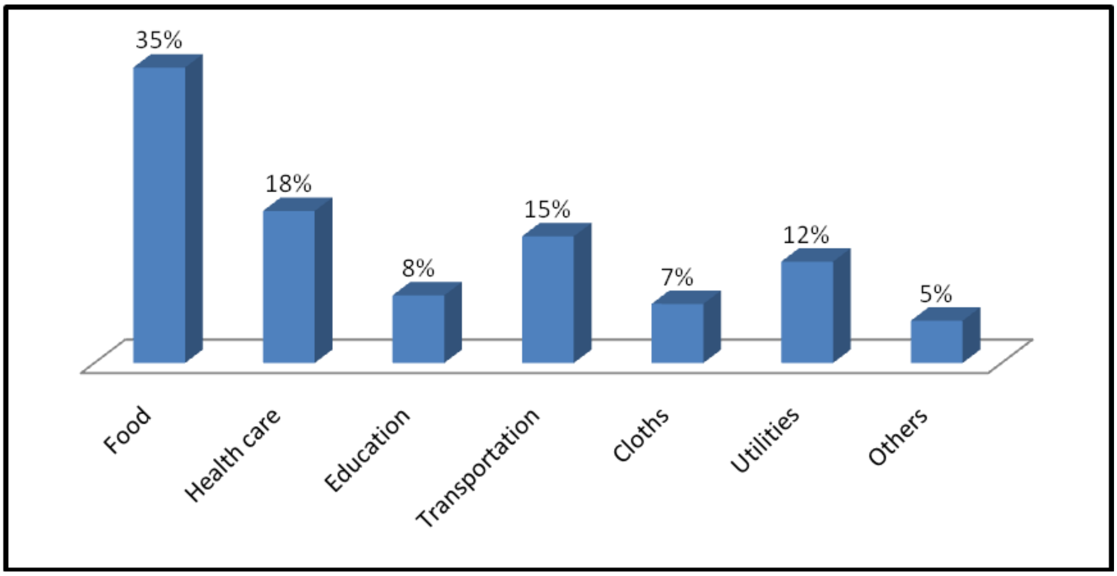


Figure4.28: Expenditure Pattern of Households in Kankiya.

4.11.13 Health Characteristics

Status of Available Health Facilities

Orthodox health care services are provided at Kankiya by a General Hospital, a Comprehensive Health Centre and three private clinics. There are also drug stores (chemists). The drug stores are unevenly distributed and their number could not be confirmed during the study. Some residents use herbal care which is not usually provided as a livelihood. Many locals know herbs, tree barks and roots within the environment, for instance dogonyaro and lemon grass, which are believed to bring relief to certain ailments.

The General Hospital and Comprehensive Health Centre offer out-patient, ante-natal, post-natal, immunization and medical laboratory services. They provide health education by conducting enlightenment campaigns and talks to members of the community, especially during ante-natal sessions. There are also programmes for family planning and for management of HIV/AIDS patients. Health workers at the facilities estimate that about 70% of women of child bearing age in the community are aware of one family planning method or another although the response rate is quite low, estimated at 10%. Immunization services are provided weekly and the antigens dispensed include BCG, HBV, OPV, Yellow Fever, Measles, Vitamin A and Penta 1, 2, 3. Antenatal care and general medical services are provided 24 hours daily. Generally, an average of 10 patients is seen daily at the Comprehensive Health Centre and 30 at the General Hospital.

Health Conditions of Household Members

Households indicated how often their members felt sick enough to seek help in the four weeks before the study, **Table 4.26**. The responses tend to suggest that household members do not take ill frequently as in 45.7% of households no member felt sick enough to seek any help,in 37.0% of households some members sought help once or twice and in 17.3% help was sought three or four times.

Households' use of mosquito bite and malaria preventive measures was used as an indicator of health conditions. Responses, **Table 4.27,** show that 77.2% of households use insecticide treated mosquito nets when they sleep, 15.8% use ordinary nets and 7.0% do not use any preventive measures. The responses indicate an awareness of the need to prevent mosquito bites in the community.

Immunization services are provided at the Comprehensive Health Centre and the General Hospital, and also by the LGA during mass immunization programmes. Health workers estimated that about 70% of children under five years in the community have received immunization against one or more of the common childhood diseases.

Table 4.26: Number of Times a Household Member Required Medical Attention in Four Weeks.

Number of Times Healthcare was Sought	Frequency	
	(No.)	(%)
None	37	45.7
1-2 Times	30	37.0
3-4 Times	14	17.3
5 Times	-	-
More than 5 Times	-	-
Total	81	100.0

Source: FNL Survey, 2015.

Table 4.27: Use of Malaria (Mosquito Bite) Preventive Measures in Households.

Preventive Measure	Frequency	
	(No.)	(%)
None	7	7.0
Ordinary Mosquito Nets	16	15.8
Insecticide Treated Mosquito Nets	78	77.2
Preventive Drugs	-	-
Total	101	100.0

Source: FNL Survey, 2015.

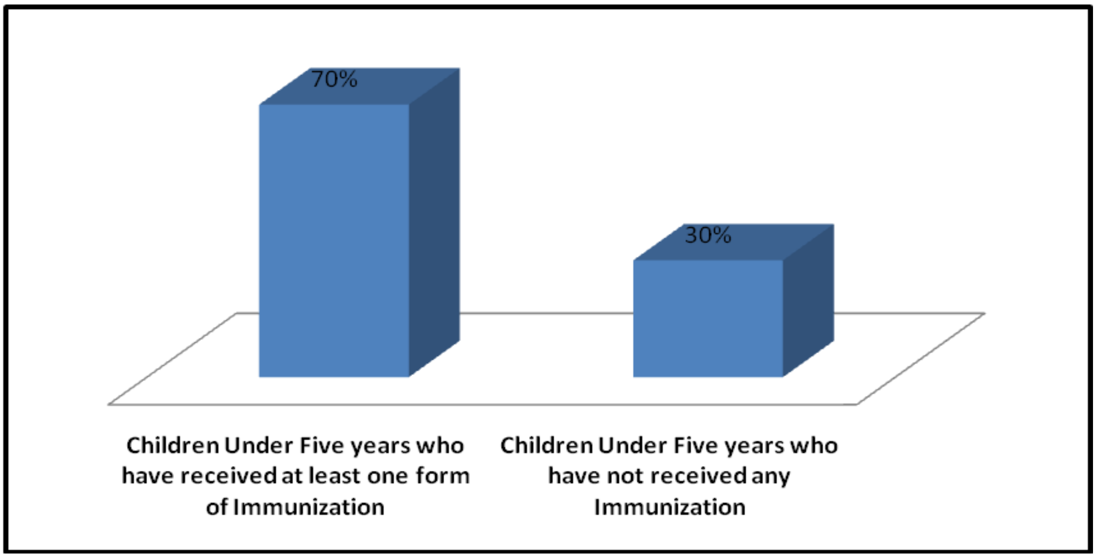


Figure 4.29: Immunization Coverage of Children Under Five Years in Kankiya.

Prevalent Health Condition and Diseases

Diseases frequently reported by households were discussed at FGDs with residents and KIIs with health workers in the community. The most commonly reported diseases and ailments, in order from the most frequent are malaria, respiratory tract infections, diarrheal diseases, ulcer and hemorrhage (pile). Other cases occasionally reported include insect bites, rashes, burns and trauma from accidents. The General Hospital has also treated patients for hypertension, diabetes, STIs, impaired vision and dental problems.

According to data gathered during the field surveys, the prevailing health conditions of members of Kankiya community are presented below:

Infant Mortality Rate (IMR) …………….. 114/1,000 Live Birth
U5MR ………….. 269/1,000 Live Birth
MMR ……………. 1,000/100,000 L Birth
Total Fertility Rate ……. 7
HIV sero prevalence …… 3%
Life expectancy………. 55 years
Low birth weight…….. 31.1%
No. of health facilities …….. 5

Nutritional status of U5
Wasting …… 17.3%
Under weight …… 35%
Stunting ……… 36.9%
Vitamin A supplementation …… 70%
Iodization of salt …… 99%

Use of Health Care Services
The use of health care services (orthodox and traditional) when household members take ill showed that many households use the services of orthodox facilities, however, some practice self-medication. Household where their members visit orthodox health facilities when they take ill are 48.8%. In 44.0% of households members buy drugs from drug stores which are not necessarily prescribed by a medical doctor. Only about 7% indicated that their members use herbal medicine when they take ill.

Table 4.28: Places Often Visited When Household Members Take Ill.

Places Visited	**Frequency**	
	(No.)	**(%)**
Hospital/Clinic/Health Centre	61	48.8
Drug Store	55	44.0
Traditional/Herbal Medicine	9	7.2
Total	125	100.0

Source: FNL Survey, 2015.

Water and Sanitation
Water sources used by households in Kankiya are basically the public pipe borne water, wells and water boreholes, **Table 4.29**. Available national statistics indicate that in Katsina State generally, 7.7% of the population obtains water for domestic use from public pipe borne water supply while 23.8% get water from boreholes 58.8% from wells, 3.4% from streams and 5.3% from vendors/water tankers (Annual Abstract of Statistics, 2010). The situation in Kankiya is that largest proportion of households, 75.4% obtain water for domestic use from wells, followed by 19.5% from the public pipe borne supply and 5.1% from public and private boreholes. These sources of water are not treated and, therefore, may not be safe for consumption.

Figure 4.30: Sources of Water in the Study Area

All the households sampled dispose their refuse by dumping in street corners, open drains and bushes. There is no public arrangement for general collection and disposal of refuse. Sewage disposal methods in households in Kankiya include pit toilets, water closet and bush. State level data indicate that 0.9% use water closet toilets and 99.1% use pit Katsina State, (Annual Abstract of Statistics, 2010). In households in Kankiya, **Table 4.29**, 87.4% of households use pit toilets (covered and open), 4.2% use water closet toilets and 8.4% defecate in the bushes. Refuse and sewage disposal practices that are common in households in the community are not modern and healthy.

Table 4.29: Sources of Water to Households and Sewage Disposal Methods in Kankiya.

Attributes	**Frequency**	
	(No.)	**(%)**
<u>Sources of Water to Households</u>		
Pipe borne water	23	19.5
Private/Commercial water bore holes	6	5.1
Wells	89	75.4
Total	118	100.0
<u>Disposal of Household Sewage</u>		
Covered Pit toilets	50	42.0
Open Pit Toilets	54	45.4
Water closet	5	4.2
Bush	10	8.4
Total	85	100.0

Source: FNL Survey, 2015.

Nutrition.

Most households (65.0%) in Kankiya indicated they are able to provide three or more meals daily and 35.0% indicated that they are able to provide at least two meals daily. Feeding the household is not a difficulty most likely because the local economy is agrarian and households grow significant portions of their food. The meals consist mainly of carbohydrates. Commonly available sources of protein are beef, milk and milk products, and poultry products. Fruits are not a regular part of daily meals. The NBS (Annual Abstract of Statistics, 2010) reports that in the North-West geopolitical region, where Kankiya belongs, children who are less than 5 years and who are underweight are 43 per 1000, against the national average of 29 per 1000. The estimate of women who are too thin (BMI < 18.5) in the region is 20 per 1000 while the national average is 15 per 1000 and women who are overweight (BMI > 25) are 15 per 1000 and the national average is 21 per 1000.

The estimates for underweight in children under 5 years and among women are worse in the region than the national average while the estimate is better in the case of women who are overweight.

Disease Vectors in Kankiya Community.

Disease vectors identified in the area are presented in **Table 4.30**. The most common is mosquitoes which transmits plasmodium responsible for causing malaria in humans. Others are house flies, tsetse flies and rats. The physical environment around the community, the bushes and open domestic waste dumps, provide the necessary breeding grounds for these disease vectors.

Table 4.30: Identifies Disease Vectors in Kankiya.

Disease Vector(s)	Common Habitat	Parasite(s) Transmitted and Disease(s) Caused
Mosquito (anopheles and culex).	Stagnant water, swamps, bushes.	Plasmodium causes malaria.
House fly and Latrine fly (muscadomestica and fanniacanicularis).	Toilets, refuse heaps and dumps.	Diarrheal diseases.
Tsetse fly (glossino species).	Bushes.	Trypanosome causes sleeping sickness.
Rats.	A variety of places including houses (especially where fish is smoked, bushes, drains, swamps).	A variety of diseases including laser fever, although there was no report of laser fever in the period before and after the study.

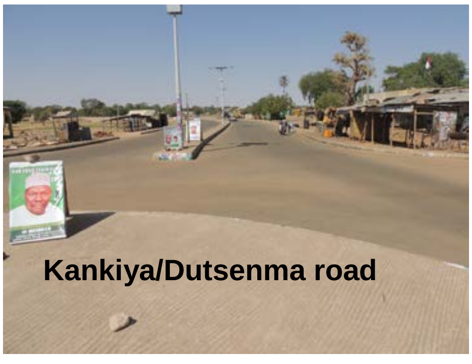
Source: FNL Survey, 2015.

4.11.14 Infrastructural Development

The Infrastructural Framework

The infrastructural framework in the study area is made up of physical and social amenities. A list of these facilities is presented in **Table 4.31**.

Table 4.31: Existing Infrastructure in Kankiya.

Infrastructure	Description
Roads. 	Kankiya has tarred access roads. These roads are Kano Katsina highway, Kankiya/Dutsama road and Kankiya-Ingama road. Apart from these, there are tarred and untarred internal link roads and streets.  

Infrastructure	Description
Communication/Telecommunication.	Telecommunication services provided by MTN, Airtel, Globacom and Etisalat are available in Kankiya.  **Telecom masts in the study area**
Electricity.	The community is supplied public electricity from the national grid. There is a PHCN sub-station at Kankiya, located on Kankiya-Ingama Road.  
Water.	Water is obtained for domestic use from public and private water boreholes, public pipe borne water supply and open wells. Kankiya dam and Inchimami River provide water for irrigation and livestock.

Infrastructure	Description
Health Institutions.	There is a General Hospital, a Comprehensive Health Centre and three private clinics in Kankiya.  Pilot Health Centre in Kankiya
Educational Institutions.	The education infrastructure includes functional public primary and secondary schools, a technical school and a School of Health Technology.  School Of Health Technology, Kankiya
Hotels/Guest Houses	The main hospitality facility is the Attakawa Guest House.
Market.	There is daily market in the community, at Galadima A and B.
Judiciary Service	These are provided by Sharia Courts, Magistrate Courts and High Courts.

Source: FNL Survey, 2015.

Functional State of Existing Infrastructural Network

The road network comprises of tarred and earth access and internal link roads. Kankiya is accessed on the Kano Katsina highway, Kankiya-Dutsama road and Kankiya-Ingama road. These are all tarred and motor able roads. Apart from the access roads there is a network of motorable internal roads and streets which facilitate movement within the community. Some of these are tarred but most are earth roads.

Telecommunication services provided by the major GSM service providers in Nigeria, namely MTN, Airtel, Globacom and Etisalate, are available in the community. Residents are able to communicate freely within Katsina State and Nigeria on these services.

There is functional public electricity in the community. It is supplied electricity from the national grid. Residents, however, experience frequent electricity outages. The electricity supply infrastructure includes a PHCN sub-station located on Kankiya-Ingama Road. Households get their water supply from public and private water boreholes, several open public and private artisanal water wells, and public pipe borne water supply system. Kankiya dam and Inchimami River provide water for irrigation and feeding livestock. Kankiya dam is a small earth dam and Inchimami River is often referred to locally as Korama.

Orthodox health facilities in Kankiya include a General Hospital, a Comprehensive Health Centre and three private clinics. The General Hospital is managed by Katsina State Government while the Comprehensive Health Centre is managed by Kankiya Local Government. The private clinics are namely Lafia Ta Fi Kudi, LafiaJari Clinics and Maternity Hospital and M. D. Clinics and Maternity Hospital. All these facilities provide out-patient, ante-natal, post-natal, immunization and medical laboratory services.

The education infrastructure includes public and private primary schools, public secondary schools, a technical school and a school of health technology. These are Nuhu Primary School, Hassan Usman Primary School, Sada Primary School, Suleiman Primary School, Kiddies International Nursery and Primary School, and Al Bashira Nursery and Primary. At secondary level the schools include Government Girls Secondary School (Junior and Senior schools), Government Day Secondary School (junior school), Government Secondary School Kanti, Al Bustan School and Community Arabic and Science Secondary School. There is a technical school (Business and Apprenticeship Training Centre), a private school (Hassan Sada Model Quranic School), and a tertiary institution (Katsina School of Health Technology). Some of the public school buildings and classrooms, in both the primary and secondary schools, need to be renovated. This especially affects roofs, doors and windows in the classrooms. There is also a general need for additional utilities like toilets for pupils and teachers, private water supply and electric fans for the classrooms. Desks and chairs provided for both pupils and their teachers need to be repaired, and in some cases replaced. The schools also do not have enough teaching aids and instructional materials for teachers' use.

There is daily market in the community, located at Galadima A and B. The market provides outlet for traders. It has built up open and lock-up stalls. Judiciary services in Kankiya LGA are provided by Sharia Courts, Magistrate Courts and High Courts.

Public Transportation

The main means of transportation available to Household members in Kankiya is land based. Residents trek for short distances within the community usually distances less than three kilometers. For longer distances they use private and commercial motorcycles, tricycles and motor cars. Donkeys and camels are often used to carry produce from the farms. Commuters pay ₦50 per person per drop, by motorcycle, tricycle and car.

Methods of Land Acquisition

The method of land acquisition in Kankiya is as stipulated by the Landuse Act of Nigeria places the ownership, management and control of land in each state of the federation in the Governor. Land is therefore allocated with his authority for commercial, agricultural and other purposes. Anybody desiring to acquire any available land, (land not sold out to any private owner), must go through the Katsina State Ministry of lands. Such land, if available to the public, will be applied for. Afterwards, the land will be surveyed by a government-recognised surveyor, and a survey plan developed for the land. When the process is completed, the buyer pays the amount of money stipulated by the government, and a Certificate of Occupancy is issued to the buyer who then becomes the owner.

Anybody desiring to purchase a piece of land from a private owner in Kankiya, shall approach the owner and make his intention known to the owner. If the owner is willing, and agrees to sell, the intending buyer shall engage a government-recognised surveyor to survey the land. The surveyor then develops a fresh survey plan for the land which shall be government-approved. The buyer then reaches an agreement with the seller, pay the agreed amount, document the agreement which will be endorsed by both parties and their witnesses. When the process is completed, the buyer takes ownership of the Certificate of Occupancy for the land.

4.11.15 Socio-Economic and Health Sensitivities and Vulnerable Groups

Changes in sensitive components of the environment can have big and long lasting effects. The socio-economic sensitivities of the Kankiya area are presented in **Table 4.32**. Some of the socio-economic sensitivities potentially associated with the proposed project include having to safeguard traditional lands, household income levels; creating opportunities for employment and contracting, and having access to amenities.

Table 4.32: Socio-Economic and Health Sensitivities in Kankiya

Socio-Economic Component	Sensitivity and Benefits
Land	Family and communal lands which are significant cultural and economic assets will be acquired for the proposed project. Thiswill represent a permanent loss to certain households and the community.
Traditional Livelihood Activities	The primary livelihood activity in households across the communities (farming) will be affected because land acquisition will reduce land availability for cultivation. These will no longer be available for pursuit of livelihood activities.
Household Income Levels	Household income levels will be affected. • Those who lose livelihood activities will likely experience reduction in their income. • Those who are employed on the project will earn incomes higher than they would earn from their traditional livelihood activities, and therefore, will experience an increase in their incomes.
Employment and Contracting	The project will provide opportunities for employment and contracting to the indigenous and local resident.
Access to Amenities	The project could affect access to amenities in two ways. • Reduced access due to increased number of users and possible damage of the available public amenities. Expected in the short run. • Possible increase in amenities if private bodies provide amenities as part of their social responsibility and if State and Local Governments provide as a result of the growing demand. Expected in the long run.
Maintaining Ethnic Balance	Workers and others would reside in the community therefore increasing the proportion of non-indigenous local residents.
Health Status of residents	Some of the construction and other workers on the proposed project will be sourced from outside the community. These and job seekers who may be attracted by the project may have health issues that can impact local residents.

Vulnerable Groups in the Study Area

The sensitivity analysis identified groups potentially vulnerable to the envisaged impacts of the proposed project. Their vulnerability would derive from a number of different factors, including inability to cope with potential changes in the society and economy as a result of the proposed project. A key vulnerable group in this regard would be the youths. For the male, particularly teenagers in school, there is the tendency to abscond or drop out of school to seek casual employment at the project site. Availability of employment and payment of wages could lure some away from school. The presence of construction workers, many of who would likely be young people would encourage the thought and feeling of independence among youth in the community. Among itinerant construction workers and job seekers could be some miscreants. These may interact with youth in the community and tend to influence them negatively. The youth generally, but particularly those in school and those that may not be able to secure employment during project construction activities, would be quite vulnerable. The elderly, those aged 65 years and above, would constitute another vulnerable group. Proportion of the elderly in Kankiya LGA is 2.7% of the population and the elderly usually require special attention which would include provision of healthcare and welfare services. This potentially makes them vulnerable to changes in the socio-economic environment. Among residents of the community there are the uneducated and unskilled. They derived their livelihood entirely from exploiting the environment, especially in farming and gathering firewood, grazing of livestock and hunting in the proposed project site. Their vulnerability lies in their rigid dependence on exploiting their immediate environment for sustenance. Anything that would affect the environment would also affect their livelihood, and without skills they may not readily identify any alternatives.

4.11.16 Environmental Baseline Situations In Kankiya.

A summary of some socio-economic environmental baseline conditions in Kankiya, their implications and required outcomes is presented in **Table 4.33.**

Table 4.33: Socio-Economic and Health Environmental Baseline Outcomes and Suggested Interventions.

Socio-Economic and Health Baseline Situations in Kankiya	Associated Sectors and Conditions.	Socio-economic and Health Outcome.	Required/Suggested Intervention.	Monitoring Indicators.
Poor Infrastructural Framework.	**Water**-lack/limited access to safe potable water. **Education**-lack of facilities and materials. **Health**-lack of equipment. Inadequate staffing. **Electricity** – inadequate supply of public electricity	Incidence of diarrheal and other forms of water borne diseases; Poor diagnoses and inadequate health intervention; Incidence of avoidable deaths. Poor academic performance; poor school attendance; increased unemployment and miscreant behaviour.	Provision of facilities to produce and deliver safe potable water to homes. Improved staffing and provision of equipment (laboratories, libraries, diagnostic equipment) in education and health facilities. Refurbishment of public electricity distribution facilities.	Number of treated bore holes provided in the communities. Number of subject areas that are adequately staffed in the public schools. Increased school attendance. Functional laboratories. Functional public library. Availability of diagnostic equipment and staff at the Primary Health Centre. Hours of electricity available to households daily.
Domestic Waste and Sewage Management.	**Housing-Poor design, no provisions for**	Pollution of the physical environment as	Regulate and enforce use of water closets or covered pit toilets in	Number of properly designed

Socio-Economic and Health Baseline Situations in Kankiya	Associated Sectors and Conditions.	Socio-economic and Health Outcome.	Required/Suggested Intervention.	Monitoring Indicators.
	modern toilets and refuse management processes.	sewage and waste are discharged into the environment; health problems for humans.	houses, by LGA. Institution of environmentally friendly refuse management processes.	houses approved and construction monitored by LGA.
Gender inequality	**Public Administration-traditional practices that inhibit women's participation in communal decision making.**	Limited opportunities for women.	Without requiring a change in composition of traditional decision making bodies, women can be made to take up more prominent communal responsibilities.	Number of women playing prominent roles in CBOs.
Human Capital Development.	**Technical Education**-lack of facilities. **Micro Finance**-Poor access to credit; non availability of venture capital. **Employment**-existence of high unemployment in households.	Inadequate technical manpower; limited employment opportunities; low investments; stifling of entrepreneurial ability; low household incomes.	Introduce, equip and staff technical education. Enlighten business persons about the need for financial services in growing the business. Identify and eliminate bottle necks in the lending process.	Reduced unemployment; increased utilization of credit by entrepreneurs.

4.11.17 Community Perceptions, Concerns and Expectations about the Project

Residents generally perceived that the project will bring about industrialization and development in Kankiya. They welcomed the project with some concerns. Their perception and concerns about the project were expressed at FGDs and KIIs. They also identified some needs of the community at these sessions. The concerns and expectations are presented below.

Concerns

Concerns raised by residents included the following;

- Weather the project may become abandoned.
- Would the project be completed early?
- Improper maintenance of facility and the likelihood of causing fatal accidents in the community.
- Improper education and equipping of workers on the project which may lead to accidents.
- Pollution problems from gases and chemicals that will be used in the facility. They believe that it will be harmful to residents living near the facility; therefore, they should be relocated.
- Insecurity issues could arise because of workers and job seekers that will be attracted to the community.
- There will be a reduction in currently available grazing land.

Expectations

Various expectations were expressed by residents including;

- Adequate compensation for owners of the land acquired for the project.

- Regular and adequate electricity supply to Kankiya.
- Employment opportunities for residents of the community.
- Empowerment of residents through contract awards.
- Social benefits in interacting with people from other places.
- Urbanization and industrial development of Kankiya.

CHAPTER FIVE

IMPACT ASSESSMENT

CHAPTER FIVE

POTENTIAL AND ASSOCIATED IMPACTS ASSESSEMT

5.1 General

The key objective of an ESIA is to predict changes (adverse or beneficial, whole or partial) in the ecological and socio-economic environment resulting from a proposed development project or activity as well as recommend mitigation measures to minimise, eliminate or offset those aspects that will adversely impact on the environment.

This chapter therefore presents the findings from the overall assessment of the potential and associated environmental impacts of the proposed utility scale solar PV based power plant to be installed and operated in Kankiya area of Katsina State. It includes consideration of potential impacts related to abnormal occurrences in addition to those that might result from normal operations. The rationale used in this impacts evaluation is drawn from FMEnv sectoral guidelines and the World Bank Guidelines/ IFC performance standards. The assessment process was as follows:

- Identification of the various potential impacts using interaction matrix to show the relationship/ interaction between the project environmental components and planned project activities.
- A screening of potential impacts associated with each phase of the project is performed using a Risk Assessment Matrix; and
- A detailed evaluation of the individual impact producing factors that comprise each aspect of the project phases is then performed. The significances of the potential impacts are quantified using the same rationale as for the screening.

The assessment approach generally involved matching the various activities of the different stages of the proposed project (as described in chapter 3 of this report) with the components of the existing environment. Consequently, the possible changes (and extent of changes) in the environment as a result of the interactions have been identified/evaluated, hence mitigation measures proffered in order to reduce, offset or ameliorate such changes.

The potential/ associated adverse and beneficial impacts of the proposed power plant project on the existing environment were identified at this stage of the ESIA. The EIA Procedural Guidelines and the World Bank Environmental Assessment Source Book, ISO 14001 approach and the Hazard and Effect Management Process (HEMP) among other references were used in the identification process. The Risk Assessment Matrix (RAM) has been employed in determining risks posed by the identified potential/associated impacts of the project in order to proffer appropriate mitigation measures. In predicting impacts, the experiential/practical ‘worst case scenario’ approach has been applied to determine the extreme effects of project activities on environmental components, while ‘consensus of opinions’ has been made use of to determine the importance of affected environmental components. The impact evaluation results make up the pedestal for developing the EMP of the proposed project.

Evaluation of the identified impacts were carried out and compared using specific criterion such as legal/ regulatory requirements, magnitude of impact, risk posed by impact, public perception and importance of affected environmental component. Results of identification and evaluation are presented in this chapter of the report.

5.2 Impact Assessment Methodology

The pathway followed in the identification/assessment and evaluation of the potential and associated impacts of the proposed project is illustrated in the **Figure 6.1** below.

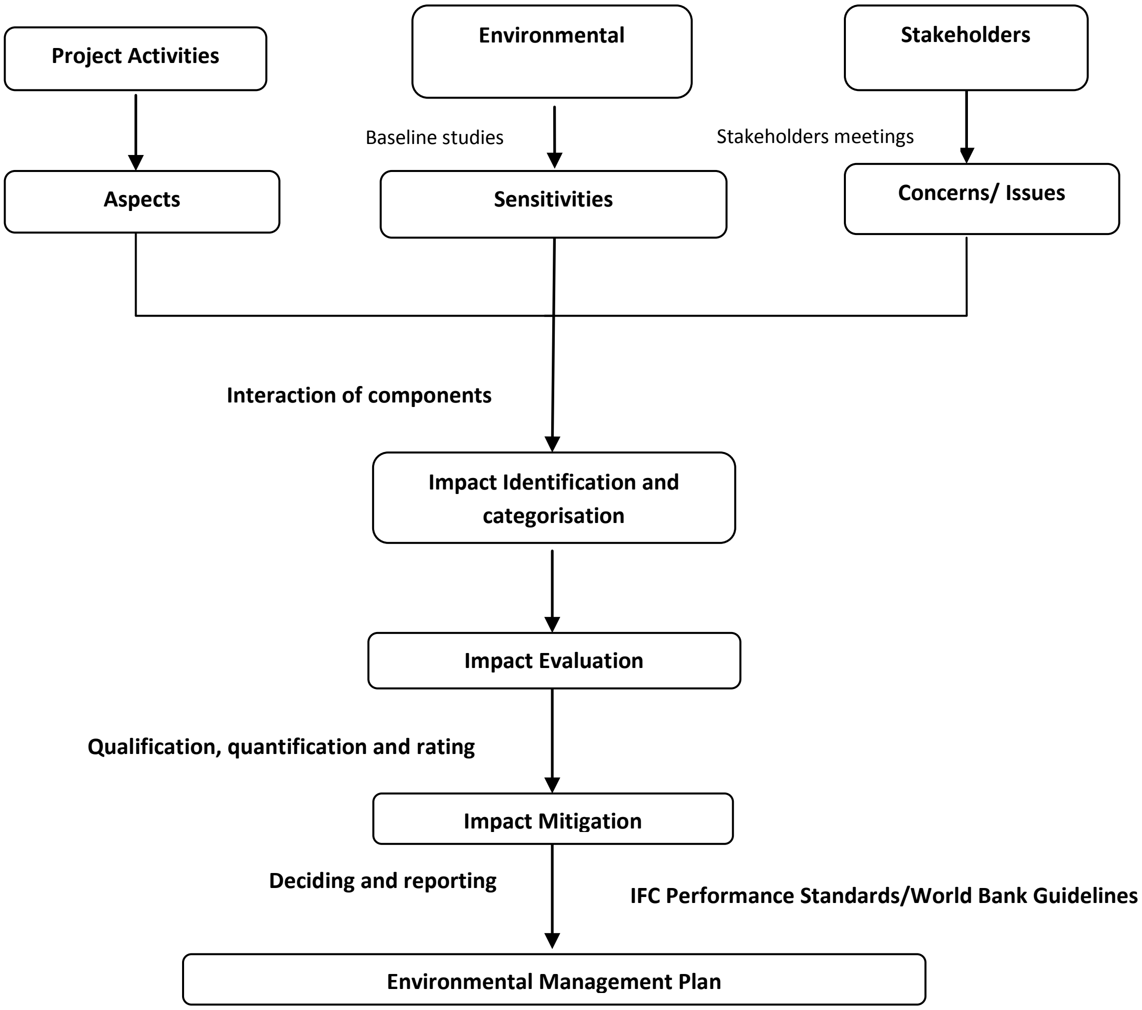


Figure 5.1: Impact Assessment and Management Flowchart

5.3 Project Phases and Activities

A number of project activities would be carried out in phases. These planned activities are what would impact on the environmental components positively or negatively. The utility scale PV-based power plant project activities are grouped into four phases as follows:

Pre-Construction phase: Involves activities such as award of contract, project design and planning, consultation, recruitment, site preparation and transportation of the utility scale PV-based power plant components to site.

Construction phase: It involves activities such as mobilisation of men and equipment to site, digging, trenching, bulldozing, grading, soil compaction; and installation of temporary camp and power plant components. This phase is usually a short term one.

Commissioning phase: It involves the integrated application of a set of engineering techniques and procedures to check, inspect and test every operational component of the project, from individual functions, such as instruments and equipment, up to complex amalgamations such as modules, subsystems and systems..

Operational phase: This is usually 'long term', involving activities from post construction to pre-decommissioning. It commences once the power plant has been commissioned for use. Activities include use of natural resources (water for domestic uses and cleaning of solar modules), plant and equipment operations, routine maintenance of equipment and plant.

Decommissioning/ abandonment phase: It begins once the power plant use is discontinued or project life span has come to an end.

It should be noted that impacts can occur at any time; during these phases mentioned above i.e. pre-construction, construction and operational phases of the project. Some impacts may however occur in some or all phases of the project.

5.4 Impact Identification

The first step in identifying impacts associated with the project is the development of an interaction matrix which shows the relationship/ interaction between the project environmental components and planned project activities.

Table 5.1: Project Activities – Environmental and Social Interaction Matrix

Project Activities	Pre-construction Phase			Construction & Installation										Operation / Maintenance							Decommissioning		
Environmental Components ↓	Mobilisation of Power Plant Components and Personnel	Recruitment/ Community Engagement	Site Preparation (access clearing & camping)	Onsite Fabrication and Carpentry Works	Plant Foundation Construction (piling, trenching etc)	Plant Installation Activities	Waste Management	Fuel / Hazardous Material Handling	Painting and Coating (i.e. use of aerosols)	Logistics (support, supply & servicing)	Fires / Explosions	Depletion of Natural Resources (i.e. ground water use)	Incidents /Accidents	Commissioning/ Testing	Power Generation	Plant Maintenance/ Servicing	Depletion of Natural Resources (water for plant use)	Waste Management	Logistics (support, supply & servicing)	Incidents and Accidents	Mobilisation of Personnel and Equipment	Power Plant Decommissioning	Abandonment /Restoration
Air Quality and Noise																							
Particulates																							
NO_X, SO_X, CO_X, etc																							
Gaseous hydrocarbons																							
Noise disturbance																							
Vibration																							
Water Quality																							
Surface water physico-chemistry																							
Groundwater physico-chemistry																							
Aquatic Ecology																							
Plankton																							
Fishes																							
Macro-benthos																							
Terrestrial Ecology																							
Fresh water swamps																							
Mangrove swamps																							
Rainforests																							
Sahel Savannah forests																							
Avifauna																							
Mammals																							
Sediment Quality																							
Physico-chemistry																							
Seabed disturbance																							

Table 5.1: Project Activities – Environmental and Social Interaction Matrix – cont'd

Project Activities	Pre-construction Phase		Construction & Installation											Operation / Maintenance							Decommissioning		
Environmental Components ↓	Mobilisation of Power Plant Components and Personnel	Recruitment/ Community Engagement	Site Preparation (access clearing & camping)	Onsite Fabrication and Carpentry Works	Plant Foundation Construction (piling, trenching etc)	Plant Installation Activities	Waste Management	Fuel / Hazardous Material Handling	Painting and Coating (i.e. use of aerosols)	Logistics (support, supply & servicing)	Fires/ Explosions	Depletion of Natural Resources (i.e. ground water use)	Incidents /Accidents	Commissioning/ Testing	Power Generation	Plant Maintenance/ Servicing	Depletion of Natural Resources (water for plant use)	Waste Management	Logistics (support, supply & servicing)	Incidents and Accidents	Mobilisation of Personnel and Equipment	Power Plant Decommissioning	Abandonment / Restoration
Soil Quality																							
Physico-chemistry	■		■		■	■	■	■		■	■							■	■		■		■
Topography/ natural drainage	■		■		■	■	■	■		■								■	■		■		■
Public Perceptions																							
Aesthetic quality	■		■			■	■	■										■			■	■	■
Stakeholder participation	■	■					■						■	■				■		■	■	■	■
Socio-Economics/ Human Health																							
Employment opportunities	■	■		■	■	■			■	■					■	■			■		■	■	■
Public health/safety	■			■			■	■	■		■							■			■		
Landuse			■		■	■																	■
Farmlands			■				■											■					
Macro & micro economics		■								■					■	■			■				
Worker safety/ Occupational health	■		■	■	■	■			■	■	■		■	■	■	■			■	■	■	■	■
Traffic on local roads	■									■			■						■		■		
Conflict and agitation from host community	■	■								■				■					■		■		

Key

■	Activity interacts with ecological or human component
	Activity does not interacts with ecological or human component

5.5 Impact Characterization

Based on the interaction matrix developed above, impacts at various phases of the project are further characterized using the checklist approach. This involves categorizing impacts (i.e. potential and associated) based on the terms as presented in **Table 5.2**.

Direct Impacts	These are impacts resulting directly (direct cause-effect consequence) from the power plant project activities
Indirect Impacts	These are impacts that are at least one step removed from the PV-based solar power plant project activities. They do not follow directly from the project activities.
Adverse Impacts	Adverse impacts are those that would produce negative effects on the biophysical and/or socio-economic environment.
Beneficial Impacts	These are impacts that would produce positive effects on the biophysical and /or socio-economic environment.
Reversible Impacts	These are impacts where environmental/social components can recover over time
Irreversible Impacts	These are such that the impacted component cannot be returned to its original state even after adequate mitigation measures are applied
Cumulative Impacts	These are impacts resulting from interaction between the project activities and other activities, taking place simultaneously
Long term	Those predicted adverse impacts which remain after mitigating measures have been applied (period of about 5 years)
Short term	Impacts that are removed after mitigating measures have been applied (period of about 6 months)

Table 5.2: NSF PV-Based Solar Power Plant Impacts Categorisation

Project Activities	Associated and Potential Impacts	Direct	Indirect	Adverse	Beneficial	Reversible	Irreversible	Cumulative	Long term	Short term
Pre-construction Phase										
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Employment opportunities arising from recruitment of workers	■			■	■			■	■
	Business opportunities for local contractors through sub contracting activities	■	■		■	■			■	■
	Skill acquisition and enhancements to locals and future workforce	■	■		■		■		■	
	Improvement in quality of life for adequately compensated individuals	■			■				■	
	Conflicts/ community agitations over employment issues (quotas and methods)	■	■	■		■	■		■	■
	Issues/ dispute on memorandum of understanding with project proponent	■		■		■			■	■
	Influx of people (migrant workers, sub-contractors and suppliers) and increased pressure on existing social infrastructure		■	■		■		■	■	■
	Increase in social vices (like theft, prostitution) resulting from increased number of people in the area		■	■		■				■
	Community agitations over land disputes, wrong stakeholder identification, leadership tussles, etc	■		■		■			■	■
	Loss of vegetation covers and forest products (fuel wood, timber, medicinal plants) due to site clearing and preparation activities	■		■			■			■
	Increased risks of accidents leading to injury/ death and loss of asset during mobilisation		■	■		■	■			■
	Risks of armed robbery attack and hostage taking leading to injury/ death of personnel		■	■		■			■	■
	Nuisance (noise and vibrations) from movement of heavy duty equipment and vehicles affecting site workers and wildlife	■		■		■				■
	Dust particles and vehicular emissions from increased movement	■		■		■		■		■
	Generation of wastes such as scrap metal, wood, sand, concrete, paper, domestic waste etc	■		■		■		■		■

Key

■	Activity interacts with ecological or human component
	Activity does not interacts with ecological or human component

Table 5.2: NSF PV-Based Solar Power Plant Impacts Categorisation cnt'd.

Project Activities	Associated and Potential Impacts	Direct	Indirect	Adverse	Beneficial	Reversible	Irreversible	Cumulative	Long term	Short term
Construction and Installation Phase										
• Plant foundation works • Piling, trenching, etc • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Risks of injury/ death and loss of assets resulting from accidents associated with road transportation to and from construction site	■		■		■	■			■
	Workplace accidents leading to injury or fatalities from burns, cuts, bruises, trips, falls from objects at height	■		■		■	■			■
	Employment of local labour and skills acquisition for workers taking advantage of new opportunities	■			■		■		■	■
	Increased cash flow and stimulation of local economies within the host community	■			■	■	■		■	■
	Increased revenue opportunities for local population due to presence of non-resident workers and travelers	■			■	■	■		■	■
	Generation of dust and particles from heavy duty equipment usage	■		■		■			■	■
	Flora/ habitat loss and disturbance from vegetation clearing and earthworks within the power plant site	■		■		■	■		■	■
	Fauna (birds, mammals etc) disturbance and displacement as a result of migration away from construction activity areas	■		■		■	■			■
	Soil/ groundwater contamination resulting from accidental leakages and spills of hazardous substances (diesel, petrol, cleaning agents, lubricants, hydraulic oil)	■		■		■	■	■		■
	Light traffic diversion and congestion along Kankiya – Katsina A9 road during installation and construction phase		■	■		■				■
	Increased risks of accidents leading to injury/ death and loss of asset during mobilisation		■	■		■	■			■
	Potential collapse of power plant structures as a result of unsuitable geotechnical conditions	■		■		■				■
	Hazards from construction of base camp, and electric evacuation lines	■		■		■	■			■
	Cement dust and toxic fumes inhalation by onsite workers during foundation works and welding of plant components	■		■		■	■	■		■
	Risk of electrocution and burns during welding	■		■			■			■
	Noise nuisance (including impulsive noise) from construction activities (e.g. piling, digging) resulting to temporary migration of mammals and rodents	■		■		■	■			■
	Loss of aesthetic quality as a result of alterations to normal landforms from construction activities	■		■			■		■	■
	Risks of fire/ explosions resulting from accidental ignition of onsite petrol/ diesel storage tanks	■		■			■			■
	Generation of wastes from construction activities such as scrap metal, wood, sand, concrete, paper, domestic waste, used oil etc	■		■		■	■	■		■

Key

■	Activity interacts with ecological or human component
	Activity does not interacts with ecological or human component

Table 5.2: NSF PV-Based Solar Power Plant Impacts Categorisation cnt'd.

Project Activities	Associated and Potential Impacts	Direct	Indirect	Adverse	Beneficial	Reversible	Irreversible	Cumulative	Long term	Short term
Commissioning and Operational Phases										
• Testing and commissioning • Power generation • PV-Based utility scale Solar Power plant maintenance and servicing	Generation and addition of electricity supply to the national grid									
	Increased business opportunities and quality of life (small, medium, large scale) due to enhanced power delivery									
	Improvement in air quality due to reduced emission from privately owned diesel or petrol generators									
	Reduced demand on petrol and diesel used for household power generation									
	Injuries/ fatalities of personnel due to incidents/ accidents from operating the power plant									
	Soil/ groundwater contamination from accidental petrol /engine oil spill during refueling of vehicle									
	Workplace accidents/ incidents (cuts, trip, falls etc) leading to injury/ death of personnel during operations									
	Acquisition of skills by individuals to be employed to operate the plant									
	Depletion of groundwater resources for washing solar modules, and domestic use									
Decommission Phase										
• Mobilisation of personnel and equipment • Power plant decommissioning • Abandonment / restoration	Loss of employment, business opportunities and decreased economic activity									
	Reduced power generation to national grid and low power supply									
	Risks of injuries/ death to locals (i.e. farmers and hunters) from possible collision with abandoned structures									
	Risk of accident and injury to workers during demolition of structures									
	Increased dust and vehicular emissions from decommissioning activities									
	Traffic obstruction on major roads from movement of vehicles during decommissioned process									
	Availability of land for alternative uses									
	Loss of site aesthetic qualities due to abandoned and dilapidated structures									

Key

(shaded)	Activity interacts with ecological or human component
	Activity does not interacts with ecological or human component

5.6 Impact Screening and Evaluation

The environmental aspects of the proposed project were taken out from the planned project activities description (**Chapter 3**). These aspects were then matched with the existing baseline description of the project environment (**Chapter 4**) and used to develop a checklist of potential and associated impacts of the proposed project.

Evaluation process is based on professional judgment and use of clearly defined criteria (legal/ risk, frequency of occurrence, importance and public concern) to determine the significances or otherwise of the impacts. The modified ISO 14001 method was used in this evaluation. Criteria and weighing scale adopted for the evaluation are described below.

Legal/Regulatory Requirements (L)

Here, the proposed project activities that resulted in impacts were weighed against existing legal / regulatory provisions to determine the requirement or otherwise for permits prior to the execution of such activities. Such legal/regulatory requirements were identified from the laws/guidelines, which have been reviewed in the opening chapter of this report as well as those guidelines in the source references relating to the proposed project activity. The weighting scale used was as follows:

Legal/Regulatory Requirements Criterion

Condition	Rating
No legal / regulatory requirement for carrying out project activity	**Low**
Legal / regulatory requirement exist for carrying out activity	**Medium**
A permit is required prior to carrying out project activity which may result in impact on the environment	**High**

Importance of Environmental Component (I)

The importance of target environmental component in respect of identified potential impact was also determined and rated as “high”, “medium” or “low”. The ratings were based on consensus of opinions among consulted experts including project engineers and other stakeholders in the proposed project. The importance criterion is summarised below.

Importance Criterion

Importance	Attribute - Environmental
High	•Highly undesirable outcome (e.g., impairment of endangered, protected habitat, species) •Detrimental, extended flora and fauna behavioural change (breeding, spawning, moulting) •Major reduction or disruption in value, function or service of impacted resource •Impact during environmentally sensitive period •Continuous non-compliance with international best practices
Medium	•Negative outcome •Measurable reduction or disruption in value, function or service of impacted resource •Potential for non compliance with international best practices
Low	•Imperceptible outcome •Insignificant alteration in value, function or service of impacted resource •Within compliance, no controls required

Risk Posed by Impact (R)

The criteria used to categorize the risk posed by the impacts of the proposed project address both the consequence severity and probability or likelihood of occurrence. In determining the likelihood of occurrence reference was made to historical records of accidents/incidents in electric power production and distribution operations within Nigeria. The consequence criterion considers the environmental and socio-economic (workers/public health and safety) attributes of the study area as shown below.

Consequence Criterion

Consequence	**Severity Rating**	**Attribute – Environmental**	**Attribute – Workers / Public Health and Safety**
Negligible	1	Minor / Little or No Response Needed	Slight injury (no medical /first aid treatment required)
Minor	2	Moderate / Limited Response of Short Duration	Minor injury (no lost time) No impact on public
Moderate	3	Serious / Significant Resource Commitment	Major injury (lost time) Limited impact on public
Major	4	Major/Extended Duration/Full Scale Response	Single fatality Multiple major injuries Serious impact on public
Severe	5	Multiple Occurrences/Elongated Duration/Larger Scale Response	Multiple fatalities

These consequence criteria are combined with the probability of occurrence to evaluate and categorise the risks posed by impacts into "high", "medium", and "low" risk as summarised below and in **Figure 5.2**.

Risk Rating

Risk Rating	**Attribute -** Environmental, Human Health, Safety and Reputation
Low	This means that no further mitigation may be required
Medium	This means that the impact can be mitigated with additional controls and modifications
High	This means that the impact requires avoidance or major control/mitigation

Severity			Likelihood of Occurrence				
			A	B	C	D	E
			No known occurrence in Urban development/construction industry (>1,000 years)	Has occurred in Urban development (1,000 – 100 years)	Incident has occurred in Urban development / construction industry (100 – 10 years)	Happens several times/year in Urban development/construction industry (10 - 1 (years)	Happens several times/year in Urban development /construction industry (10 - 1 (years)
	1	Negligible	1A	1B	1C	1D	1E
	2	Minor	2A	2B	2C	2D	2E
	3	Moderate	3A	3B	3C	3D	3E
	4	Major	4A	4B	4C	4D	4E
	5	Severe	5A	5B	5C	5D	5E

Low Risk		Medium Risk		High Risk	

Figure 5.2: Matrix Used for Assessing Risks Posed by Impacts

Frequency of Impacts Occurrence (F)

Evaluation of the frequency of occurrence of each impact was also carried out. Frequency of occurrence was rated as "high", "medium" or "low" based on the historical records of accidents/incidents, consultation with experts and professional judgment. The frequency criterion is summarised below.

Frequency Criterion

Frequency	Attribute – Environmental, Socio-economic, Human Health and Safety
High	• Major degradation in quality in terms of scale (>1% of study area or habitat within the study area), appearance, duration (beyond duration of project) • Irreversible or only slowly recoverable (change lasting more than 1 year) degradation of environmental ecosystem level (population, abundance, diversity, productivity) • High frequency of impact (occur continuously and almost throughout the project execution period) • Geographic extent of impact (e.g. encompassing areas beyond study area)
Medium	• Degradation in quality in terms of scale (>0.1% of study area, habitat), appearance, duration (a few months) • Slow reversibility (change lasting a few months before recovery), lasting residual impact • Potential for cumulative impact • Intermittent frequency of impact (occur in only a few occasions during the project execution period) • Limited geographic extent of impact (large area within NSF utility scale PV-based solar power plant site)
Low	• Minor degradation in quality in terms of scale (<0.1% of study area, habitat, very localized), appearance, duration (a few days to a month) • Effect within range of naturally occurring impacts, changes, dynamics • Rapid reversibility (change lasting only a few weeks before recovery), no lasting residual impact of significance • No potential for significant cumulative impact • Low frequency of impact (occur in just about one occasion during the project execution period) • Only very localized geographic extent of impact (e.g. not more than a few meters from impact source point)

Definition of Sensitivity (S)

The sensitivity of the receiving environment is integrated into the analysis by determining a sensitivity score for each impact. The notion of sensitivity takes into consideration numerous factors including, population numbers, biodiversity, presence of protected or rare species, economic importance, capacity to recover and also the percentage of the ecosystem or resource affected compared with regional, national and international ecosystems and resources.

The sensitivity is scored on a scale of 1 to 4, where 1 is for low sensitivity and 4 for high sensitivity. The scoring is established qualitatively. General principles for defining the sensitivity value are provided in the Table below:

Table 5.3: General Principles for Scoring Sensitivity

Score	Guide
1	The species/ecosystems affected are widespread both within project regional territory and nationally. There are no species considered to be rare, endangered or protected.
2	The species/ecosystems affected are not widespread within regional habitats, but are widespread within Nigeria. There are no species considered to be rare, endangered or protected.
3	The species/ecosystems affected are rare or protected within Nigerian territory, but are widespread outside Nigerian boundaries.
4	The species/ecosystems affected are rare, endangered or protected at an international level.

Definition of Significance (Q)

The significance of the impact is scored by multiplying the score for intensity by the score for sensitivity. The significance of the impacts is qualified by:

Positive impact: impact favourable or which can be a benefit to the environment;
Negative impact: impact causing environmental nuisance or degradation
Direct impact: impact caused by studied activity, which has a scale of effect in the same time and in the same place as studied activity
Indirect impact: the consequences of the impact are distant in space and in time from the studied activity
Long-term Impact: the consequences of the impact last at least 3 years
Short-term Impact: the consequence of the impact is instantaneous or last less than 3 years

5.7 Result of Impact Assessment

The overall significance of potential impacts (taking into cognisance the evaluation criteria as well as product of likelihood and consequence) of the proposed project were thus assigned as those impacts to which the following conditions apply.

- **Major significance** =Impacts for which (L+R+F+I+P) is ≥15 with a consequence / likelihood rating of: 3E, 4D, 4E, 5C, 5D and 5E.

- **Medium significance** = Impacts for which (L+R+F+I+P) is between 10 - 14 with a consequence / likelihood rating of: 2D, 2E, 3C, 3D, 4B, 4C, 5A, 5B.

- **Minor significance** = Impacts for which (L+R+F+I+P) is ≤9 with a consequence / likelihood rating of: 1A, 1B, 1C, 1D, 1E, 2A, 2B, 2C, 3A, 3B, 4A.

Table 5.4 summarizes the potential impacts on the physical, biological and socioeconomic environments caused by the proposed project.

Table 5.4: Identified Potential and Associated Impacts of the Proposed Solar PV Based Power Plant Project

Project Activities	Associated and Potential Impact	Impact Significance Evaluation					Significance Ranking
		Legal Requirement	*Risk*	*Frequency*	*Importance*	*Perception*	
Pre-Construction Phase							
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Employment opportunities arising from recruitment of workers	-	-	-	-	-	Beneficial
	Business opportunities for local contractors through sub contracting activities	-	-	-	-	-	Beneficial
	Skill acquisition and enhancements to locals and future workforce	-	-	-	-	-	Beneficial
	Improvement in quality of life for adequately compensated individuals	-	-	-	-	-	Beneficial
	Conflicts/ community agitations over employment issues (quotas and methods)	High (5)	Med (3)	Med (3)	High (5)	High (5)	Major (21)
	Issues/ dispute on memorandum of understanding with project proponent	High (5)	Med (3)	Med (3)	High (5)	High (5)	Major (21)
	Influx of people (migrant workers, sub-contractors and suppliers) and increased pressure on existing social infrastructure	Med (3)	Low (0)	Med (3)	Low (0)	High (5)	Medium (11)
	Increase in social vices (like theft, prostitution) resulting from increased number of people in the area	Low (0)	High (5)	Low (0)	Med (3)	Med (3)	Medium (112)
	Community agitations over land disputes, wrong stakeholder identification, leadership tussles, etc	High (5)	High (5)	Med (3)	High (5)	High (5)	Major (23)
	Loss of vegetation covers and forest products (fuel wood, timber, medicinal plants) due to site clearing and preparation activities	Med (3)	Low (0)	Low (0)	Med (3)	Low (0)	Minor (7)
	Increased risks of accidents leading to injury/ death and loss of asset during mobilisation	High (5)	Med (3)	Low (0)	High (5)	High (5)	Major (18)
	Risks of armed robbery attack and hostage taking leading to injury/ death of personnel	Low (0)	High (5)	Low (0)	Med (3)	Med (3)	Medium (11)

Table 5.4: Identified Potential and Associated Impacts of the Proposed Solar PV Based Power Plant Project (Cont'd)

Project Activities	Associated and Potential Impact	Impact Significance Evaluation					Significance Ranking
		Legal Requirement	Risk	Frequency	Importance	Perception	
Pre- Construction Phase							
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Nuisance (noise and vibrations) from movement of heavy duty equipment and vehicles affecting site workers and wildlife	High (5)	Low (0)	Med (3)	Med (3)	Low (0)	Medium (11)
	Dust particles and vehicular emissions from increased movement	Med (3)	Low (0)	Med (3)	Med (3)	Med (3)	Medium (12)
	Generation of wastes such as scrap metal, wood, sand, concrete, paper, domestic waste etc.	High (5)	Med (3)	High (5)	Med (3)	Med (3)	Major (19)
Construction and Installation Phase							
• Plant foundation works • Piling, trenching, etc • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Risks of injury/ death and loss of assets resulting from accidents associated with road transportation to and from construction site	Med (3)	Med (3)	Low (0)	High (5)	High (5)	Major (16)
	Workplace accidents leading to injury or fatalities from burns, cuts, bruises, trips, falls from objects at height	High (5)	Med (3)	Med (3)	High (5)	High (5)	Major (21)
	Employment of local labour and skills acquisition for workers taking advantage of new opportunities	-	-	-	-	-	Beneficial
	Increased cash flow and stimulation of local economies within the host community	-	-	-	-	-	Beneficial
	Increased revenue opportunities for local population due to presence of non-resident workers and travelers	-	-	-	-	-	Beneficial
	Generation of dust and particles from heavy duty equipment usage	Med (3)	Med (3)	Med (3)	Med (3)	Low (0)	Medium (12)

Table 5.4: Identified Potential and Associated Impacts of the Proposed Solar PV Based Power Plant Project (Cont'd)

Project Activities	Associated and Potential Impact	Impact Significance Evaluation					*Significance Ranking*
		Legal Requirement	Risk	Frequency	Importance	Perception	
Construction and Installation Phase							
• Plant foundation works • Piling, trenching, etc • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Flora/ habitat loss and disturbance from vegetation clearing and earthworks within the utility scale PV-based solar power plant site	Med (3)	Low (0)	Low (0)	Med (3)	Low (0)	Minor (6)
	Fauna (birds, mammals etc) disturbance and displacement as a result of migration away from construction activity areas	Med (3)	Low (0)	Med (3)	Med (3)	Med (3)	Medium (12)
	Soil/ groundwater contamination resulting from accidental leakages and spills of hazardous substances (diesel, petrol, cleaning agents, lubricants, hydraulic oil)	High (5)	High (5)	Med (3)	Med (3)	Low (0)	Major (16)
	Light traffic diversion and congestion along Kankiya – Katsina A9 road during installation and construction phase	Low (0)	Low (0)	Med (3)	Low (0)	Med (3)	Minor (6)
	Increased risks of accidents leading to injury/ death and loss of asset during mobilisation	Med (3)	Med (3)	Low (0)	High (5)	High (5)	Major (16)
	Potential collapse of power plant structures as a result of unsuitable geotechnical conditions	High (5)	Med (3)	Low (0)	High (5)	Med (3)	Major (16)
	Hazards from construction of base camp, and electric evacuation lines	Med (3)	Med (3)	Low (0)	High (5)	High (5)	Major (16)
	Cement dust and toxic fumes inhalation by onsite workers during foundation works and welding of plant components	High (5)	High (5)	Med (3)	High (5)	High (5)	Major (23)
	Risk of electrocution and burns during welding	High (5)	Med (3)	Low (0)	High (5)	Med (3)	Major (16)
	Noise nuisance (including impulsive noise) from construction activities (e.g. piling, digging) resulting to temporary migration of mammals and rodents	High (5)	Low (0)	Med (3)	Med (3)	Low (0)	Medium (11)
	Loss of aesthetic quality as a result of alterations to normal landforms from construction activities	Med (3)	Low (0)	Low (0)	Low (0)	Med (3)	Minor (6)

Table 5.4: Identified Potential and Associated Impacts of the Proposed Solar PV Based Power Plant Project (Cont'd)

Project Activities	Associated and Potential Impact	Impact Significance Evaluation					Significance Ranking
		Legal Requirement	Risk	Frequency	Importance	Perception	
Construction and Installation Phase							
• Plant foundation works • Piling, trenching, etc • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Risks of fire/ explosions resulting from accidental ignition of onsite petrol/ diesel storage tanks	High (5)	High (5)	Med (3)	High (5)	Med (3)	Major (21)
	Generation of wastes from construction activities such as scrap metal, wood, sand, concrete, paper, domestic waste, used oil etc	High (5)	Med (3)	High (5)	Med (3)	Med (3)	Major (19)
Commissioning and Operational Phases							
• Testing and commissioning • Power generation • Power plant maintenance and servicing	Generation and addition of electricity supply to the national grid	-	-	-	-	-	Beneficial
	Increased business opportunities and quality of life (small, medium, large scale) due to enhanced power delivery	-	-	-	-	-	Beneficial
	Improvement in air quality due to reduced emission from privately owned diesel or petrol generators	-	-	-	-	-	Beneficial
	Reduced demand on petrol and diesel used for household power generation	-	-	-	-	-	Beneficial
	Injuries/ fatalities of personnel due to incidents/ accidents from operating the power plant	High (5)	Med (3)	Med (3)	High (5)	High (5)	Major (21)
	Soil/ groundwater contamination from accidental petrol /engine oil spill during refueling of vehicle	High (5)	Risk (5)	Med (3)	Med (3)	Low (0)	Major (16)

Table 5.4: Identified Potential and Associated Impacts of the Proposed Solar PV Based Power Plant Project (Cont'd)

Project Activities	Associated and Potential Impact	Impact Significance Evaluation: Legal Requirement	Risk	Frequency	Importance	Perception	*Significance Ranking*
Commissioning and Operational Phases							
• Testing and commissioning • Power generation • Power plant maintenance and servicing	Workplace accidents/ incidents (cuts, trip, falls etc) leading to injuries such as / Injuries that arise during operation of solar panel cell such as heat burns /death of personnel during operations	High (5)	Med (3)	Med (3)	High (5)	High (5)	Major (21)
	Acquisition of skills by individuals to be employed to operate the plant	-	-	-	-	-	Beneficial
	Depletion of groundwater resources for cooling plants	Med (3)	Low (0)	Med (3)	Med (3)	Med (3)	Medium (12)
Decommission Phase							
• Mobilisation of personnel and equipment • Power plant decommissioning • Abandonment / restoration	Loss of employment, business opportunities and decreased economic activity	Low (0)	Med (3)	Low (0)	Med (3)	High (5)	Medium (11)
	Generation of waste from decommissioning activities	High (5)	Med (3)	High (5)	Med (3)	Med (3)	Major (19)
	Reduced power generation to national grid and low power supply	Low (0)	Med (3)	Low (0)	High (5)	High (5)	Medium (13)
	Risks of injuries/ death to locals from collision with abandoned structures	Low (0)	Low (0)	Low (0)	Med (3)	Med (3)	Minor (6)
	Risk of accident and injury to workers during demolition of structures	High (5)	Med (3)	Med (3)	High (5)	High (5)	Major (21)
	Increased dust and vehicular emissions from decommissioning activities	Med (3)	Low (0)	Med (3)	Med (3)	Low (0)	Medium (9)
	Traffic obstruction on major roads from movement of vehicles during decommissioned process	Low (0)	Low (0)	Med (3)	Low (0)	Med (3)	Minor (6)
	Availability of land for alternative uses	-	-	-	-	-	Beneficial
	Loss of site aesthetic qualities due to abandoned and dilapidated structures	Med (3)	Low (0)	Low (0)	Med (3)	Med (3)	Minor (9)

5.8 Impact Discussion

Photovoltaic (PV) are seen to be generally of benign environmental impacts, generating no noise or chemical pollutants during use. It is one of the most viable renewable energy technologies for use in an urban environment, replacing existing building cladding materials. It is also an attractive option for use in scenic areas and National Parks, where the avoidance of pylons and wires is a major advantage

The identified, evaluated and ranked impacts are further discussed in this section. The impacts mentioned in the preceding sections for the proposed NSF utility scale PV-based solar power plant project are grouped into two:

- Beneficial impacts, and
- Adverse impacts.

The impacts are then discussed in line with the two major project phases; construction (merged with pre-construction phase) and operational phase (includes maintenance and decommissioning). Discussions made here are intended to provide an insight into the significance or otherwise of identified impacts.

5.8.1 Beneficial Impacts

The proposed project as mentioned in **chapter two, section 2.2** is to be executed with the aim of adding electricity to the national grid for supply to households and commercial establishments. The benefits expected from the power plant grouped into the two project phases are as follows:

Construction Phase

The project benefits to stakeholders during pre-construction, construction and installation phases are as follows:

- stimulate economic growth through local contractor participation in providing construction materials, equipment and services;
- ensure social development through job creation (both direct and indirect);
- increased economic activities in Kankiya community from influx of workers and visitors to the project site;

Operational Phase

Benefits accrued from project during operations include:

- power plant to provide additional 125 MWp electricity power upon completion to the national grid;
- provide reliable power supply to reduce dependant on private power generators used by individuals and corporate bodies;
- reduced fuel consumption resulting in improved air quality;
- reduction in noise from power generators for households and industries resulting in improved air quality;
- reduce thermal and air pollution associated with the use of private power generators, and fossil fuel power plants;
- demonstrate Federal Government’s commitment to improved electricity supply;
- source of income to the government through royalties and tax revenue generation;
- income for NSF from sale of power generated;
- stimulates economic growth, development and job creation (both direct and indirect), thereby also promoting secondary social development/ services such as healthcare and hospitals service delivery, etc;
- meets other goals of the Katsina State Government (e.g. small-medium enterprise promotion, etc);

- support technology development through technical assistance and training for Nigerians as part of overall strategy of institutionalizing local content in Nigeria's Energy Sector;
- generation of income from temporary jobs during the construction phase;
- revenue from locally placed orders for goods and services, including contracts for the provision of building materials and services, maintenance repairs and equipment servicing, and the establishment of supply contracts (e.g. security, waste disposal, catering, laundry).

5.8.2 Adverse Impacts

The potential adverse impacts from project activities are grouped into the following subjects and discussed further according to the different applicable phases.

- Land use
- Impacts from equipment, personnel and plant material movement;
- Impacts from service vehicles emissions;
- Impacts from noise and vibration;
- Impacts on flora and fauna species;
- Impacts from waste generation;
- Impact on groundwater and soil quality;
- Impact on traffic;
- Visual/ aesthetic impact;
- Social economic impacts;
- Health impacts; and
- Impacts from work place hazards.

Land Use Impact

The occupied surface mainly determines the impact of large-scale PV installations on ecosystem quality. Consequently, land consuming alternatives such as mobile installations with dual-axis trackers will show relatively large impacts on ecosystem quality compared to fixed-mounting solutions, if considering the same modules technology. The environmental impacts of large-scale PV installations are the result of the interplay between a number of distinct parameters (e.g. energy production, supports mass and nature, electric equipments, etc.), whose related influence may counterbalance each other.

The impact of land use on natural ecosystems is dependent upon specific factors such as the topography of the landscape, the area of land covered by the PV system, the type of the land, the distance from areas of natural beauty or sensitive ecosystems, and the biodiversity. The impacts and the modification on the landscape are likely to come up during construction stage by construction activities, such as earth movements and by transport movements. Furthermore, an application of a PV system in once-cultivable land, as is the case in Kankiya, is possible to damnify soil productive areas. The ‘‘sentimental bind’’ of the cultivator and his cultivable land is likely to be the reason of several social disagreements and displeasure.

A typical ground-mounted PV configuration occupies more land than just the PV module area. Enough land is needed for access and maintenance as well as to avoid shading. The developer in Kankiya will flatten the landscape and erect fences around major solar plants. Security options that avoid fencing, such as security cameras or establishing wildlife corridors throughout a farm, can allow wildlife to move freely. These options help reduce the impacts of security options to the surrounding ecosystem (Kammen et al., 2010).

Soil erosion rates for PV solar farms (ground-mounted) depend largely on the type of ground cover. PV projects that are sustainably developed and that use soil conservation techniques, such as elevated PV modules with grass cover underfoot, can reduce soil erosion to negligible rates

Land use for renewable energy sources, such as PV, is distinct in that renewable energy sources use land statically (passively), whereas conventional fuel sources use resources extracted from the land during their operation and maintenance phase. Another benefit of PV power plants is that they can be located on marginal lands and brownfields. They can also be used on higher-quality lands in conjunction with grazing livestock and crops (Fthenakis and Kim, 2009).

Impacts from Equipment, Personnel and Plant Material Movement
In executing the proposed utility scale PV-based power plant project, a great deal of haulage/ movement would be undertaken all through the phases of the project by the NSF and stakeholders. Movements would include:

- Transportation of equipment and personnel during construction and operational phases; and
- Movement of plant components to project site for construction and installation.

Construction Phase
As part of the construction phase, personnel and materials would be transported to site daily. Transportation could be from NSF arrangement or visitors to the site. Vehicles to be deployed for construction purposes would include saloon, SUVs and heavy-duty vehicles (such as trucks, bulldozers, excavators, caterpillars etc).

Movement of vehicles during this phase is important and cannot be avoided as such would impact significantly on the environment as well as on people living within the area in the following ways:

- Vehicular emission of pollutant gases (such as CO, SO_2 and NO_2) from vehicle exhaust;
- Contribution to global gas warming and ozone layer depletion from pollutant gases emitted from vehicles;
- Increased traffic and road blocks from movement of heavy duty truck within Kankiya roads en-route project site;
- Potential accident to personnel and asset from vehicle movement during construction; and
- Dust emission arising from construction activities at the project site. Although, the potential for dust nuisance is unlikely at locations beyond 200m from the source except in the most extreme wind conditions.

NSF intends to commence construction phase by first quarter, 2016 and complete it by third quarter, 2017. This implies that the above mentioned impacts are likely to occur for about 21 months. The impact from equipment, personnel and plant material movement on surrounding receptors is therefore considered to be of **major significance** prior to mitigation and steps will be taken to minimise the effects (see **chapter six**).

Operational Phase
At operational phase there are unlikely to be any significant emissions of gases, dust or odour. This is because there will be relatively few vehicle movements associated with the operation of the facility (except for staff and visitor’s movement). As a result, impacts associated with movement of equipment personnel and plant material during operations would be significantly reduced.

Impacts from Power Plant Air Emission
Emissions of air pollutants would occur from a wide variety of activities during the project development phases. Air emissions are categorized based on the origin or source of the emission (i.e. point sources, fugitive sources and mobile sources) and further, by process

such as combustion and material storage. Air emissions may be in form of combustion gases; NO_x, SO_2 and CO from diesel engines (graders, trenchers, excavators, etc).

Construction Phase

At installation and construction phases of the project, the potential sources of emissions would include dust, particulate matter (PM), emissions from heavy trucks and earthmoving equipment that will be operated on the site. Exhaust emissions during material transportation, stockpiling and equipment transfer during construction activities. These emissions will be localised to the construction site area and will be short-term, the extent of impact would therefore be **moderate and its significance low**.

Operational Phase

Use of solar energy release no CO_2, SO_2, or NO_2 gases and don't contribute to global warming. Over its estimated life a photovoltaic module will produce much more electricity then used in its production and a 100 W module will prevent the emission of over two tons of CO_2. There are no emissions associated with the operational or use phase of PV modules. The modules are enclosed and sealed within two glass modules, and therefore there are no expected emissions while the modules are in use.

Decommissioning activities may also generate emission of fugitive dust caused by a combination movement of air materials, machinery contact with soil, and exposure of bare soil and soil piles to wind. A secondary source of emissions may include exhaust from diesel engines of equipment used for dismantling.

Also, Sulphur hexafluoride, a potent greenhouse gas is contained in transformers used in power generation. Upon decommissioning, measures should be taken such that this gas is not released to the atmosphere, but be domesticated for other use (if possible).

Impacts from Noise and Vibration

Construction Phase

The primary short-term noise and vibration impacts are associated with construction and decommissioning activities. **Table 5.5** below presents noise levels of some construction equipment/ machinery that may likely to be used during construction.

Table 5.5: Typical Noise Levels of Construction Equipment

Equipment	Noise Level (dB(A)) from 50ft of Source
Cranes	83
Backhoes	80
Loaders	84
Dozers	85
Scrappers	89
Trenchers	97
Grader	85
Compactor	82
Concrete mixer	85
Jack Hammer	88
Saw	76
Shovel	82
Truck	88

Source: Workers Compensation Board Report, 2000

At a distance of 50 feets (equivalent to 15 meters), the above noise level from use of machinery is expected.

During site preparation and construction activities, work equipment will result in increased noise level and vibration in the area, although noise would not cause a major disturbance to the local inhabitants as Kankiya community is about 2.5 km away from the project site. However workers at the site, nearby nomadic settlers, and facilities closeby would be impacted.

Also, there would be increased noise level during site construction activities from movement of heavy trucks, earth moving equipment and other machinery, welding, etc. Noise may cause a major disturbance to fauna species such as birds and mammals in the area. These would move further into the forest to avoid the disturbance.

Heavy construction equipment is the principal source of noise and vibration during construction activity, and the pattern would constantly change as construction progresses. For the most part, construction activity occurs during daytime hours when higher sound levels are generally more tolerable. In addition, any adverse noise impacts due to construction activities would be short term. There may also be some increases during transportation of materials, site preparation activities such as vegetation clearance and trench digging.

Operational Phase
Photovoltaic systems make no noise and cause no pollution in operation. Solar energy is clean, silent, and freely available. The only significant source of noise that may arise at this phase, will be from vehicular activity.

Impact on Flora and Fauna Species
As discussed in **Chapter Four**, a number of diverse assemblages of organisms exist within the study area. Organisms observed in the area include mammals, birds, reptiles etc. Vegetation types include fresh water rainforest and pockets of mangrove. The project activities would have an impact on the flora and fauna population of the area.

The project would require the removal of clearing of vegetation to accommodate the power plant and ancillary structures. The resulting effect would be the loss of flora species in the site as well as migration of fauna species that make use of the plants for food and shelter further away into the forest. There would also be loss of forest products (fuel wood, timber, medicinal plants) due to site clearing and preparation.

As the solar park is managed responsibly, it can create new habitats for endangered animals and plants. NSF intends to follow the following environmental protection practices as applicable in Kankiya:

- Provide dedicated buffer area for endangered species;
- Consideration of the local environment and compensatory measures;
- Involvement of local experts on ecological planning;
- Avoidance of soil sealing (no more than 1% of the surface);
- Proper crop selection to ensure the preservation of local genetic diversity;
- Avoidance of negative effects from fencing;
- Development of a proper monitoring program.
- Avoidance of pesticides and fertilizers,
- Use of goats, sheep for grazing to reduce site maintenance activities, and
- Risk assessments on the Conservation of Wild Birds

The proposed project site covers an area of approximately 200 hectares of secondary vegetation. The main species of vegetation observed were woody trees, shrubs, herbs and grasses. The grasses were observed to be used as food by goats, sheep, cattle's owned by nomadic herdsman within the project site. It should however be noted that these herdsmen move from place to place. The loss of vegetation species would mean loss of grazing resource, although a large expanse of land still exists for use beyond the site.

Apart from clearing activities, noise from vehicle and heavy duty machinery use would cause noise and vibration which would scare fauna species away and further into the forest as was earlier mentioned. Generally, the impacts on flora and fauna species are termed **minor significant**.

Impacts from Waste Generation

Wastes from the project are grouped into solid wastes, liquid (wastewater) and air emissions. Solid wastes would include; wood, metals, food remains, glass, and refuse etc. Liquid wastes include sewage, waste chemicals and oily water, while gaseous air pollutants ($NO_{x,}$ SO_x and CO) would be from exhausts of vehicles. It should be noted however that during their normal operation PV systems emit no gaseous or liquid pollutants, and no radioactive substances.

Solid Waste

Solid wastes generated can be hazardous or non-hazardous in nature. Improper handling of these wastes or their discharge into the surrounding environment without proper treatment would increase the level of micro-organisms (bacteria, viruses and fungi) that could be pathogenic to staff working in the area or to aquatic organisms. NSF intends to manage wastes by a combination of source reduction, waste minimisation, and recycling.

Liquid Wastes

Liquid wastes (wastewater) discharges contain a variety of substances that can cause pollution and they include detergents, oil and grease, organic compounds, hydrocarbons, nutrients, etc. Untreated greywater (sewage) from the plant facility during operation are known to contain strains of fecal coliform bacteria several times greater than is typically found in treated domestic sewage. Greywater has the potential to cause adverse environmental effects because of concentrations levels of nutrients and other oxygen-demanding materials it contains. Greywater discharge from this PV-based solar power plant project will not be large scale.

Gaseous Emissions

Air pollutant gases contribute to global emission load leading to global warming and increased green house effect. The use of aerosols during painting or spraying of plant components would also lead to the release of chloroflouro carbons (CFCs), also a chief contributor to global warming.

Exhaust emissions from vehicles and plant stacks are considered to be a significant source of air pollution as mentioned earlier. The health effect of these air pollutants are presented below in **Table 5.6**. Direct and long exposure of air pollutants to workers may be potentially detrimental.

Table 5.6: Health Effect of Major Pollutants

Pollutants	Sources	Most Relevant Effects
Carbon Monoxide (CO)	Incomplete combustion of fuels or from gas turbines during plant operation	• Impairment of mental function in high concentration • Death at high levels of exposure • Aggravation of some heart diseases (angina)
Nitrogen oxide (NO_x)	Vehicle exhaust from gas turbines during plant operation	• Aggravation of respiratory illness • Reduced visibility • Formation of acid rain
Volatile Organic Compound (VOC)	Incomplete combustion of fuels of from vehicles	• Reduced lung function • Aggravation of respiratory and cardio respiratory diseases • Increased cough and chest discomfort • Reduced visibility • Cancer and premature death
Sulphur oxide (SO_x)	Combustion of sulfur-containing fossil fuels	• Aggravation of respiratory diseases (asthma, emphysema) • Reduced lung function • Irritation of eyes • Reduced visibility

Source: California Air Resources Board, 2002

Impact of waste discharge and gaseous emission on the environment are major significant especially when not properly managed. They could cause problem to human health. In **Chapter Six**, mitigation measures for the management of anticipated waste to prevent indiscriminate discharge or dumping are discussed.

Oil Spill and Diesel/ Lube Oil Leakage
Also to be considered is the possibility of oil spill and diesel/ lube oil leakage from vehicle, storage containers especially during the construction phase. A major oil spill may not be possible but the possibility of oil spilling or leaking during transportation, loading and offloading is very high. Spill over time and not managed properly could accumulate and become an issue. It could lead to loss in aesthetic quality and a factor to fire incident.

Impact from waste generation is **medium to major significance** and should be treated with great priority.

Impact on Groundwater and Soil Quality
The operational phase of the project is not expected to have significant effect or bearing on the water aquifer of the area and soil over time. Water for drinking and domestic use will be sourced from the ground using constructed boreholes, and from Katsina State Water Board. There is no threat that over time the recharge rate of the water level beneath the soil may be disrupted. Although water depth observed for the area is relatively low ranging (more than 5 meters).

Also diesel and oil leakage from vehicle movement, stored oil, maintenance and workshops for vehicles are likely to sip into the soil if not handled properly and may find its way groundwater where they become nuisance. The possibility of this occurring is rather low, hence has been ranked **minor significant**.

Impact on Traffic
It is envisaged that movement of personnel and equipment along the local road (Kankiya road) leading to the site would increase once the project commences. The road within the community is slightly busy during the day and as such may lead to intermittent traffic build up which may not last long with proper coordination.

The more common access to the proposed power plant is by road. This primary route connection is crucial to transportation because it is how residents, goods and materials would be moved about in the area. Construction activities may result in a significant increase in movement of vehicles for the transport of construction materials and equipment increasing the risk of traffic-related accidents and injuries to workers and the local community.

The road network consists of a tarred link road to Kankiya community, and internal link roads and lanes. A number of construction vehicles will be required to travel to the site with construction material and earth-moving equipment. Traffic slowdown and 'hold-ups' negatively affect air quality. Similarly, the quality of life of impacted persons may be reduced due to anxiety, frustration and anger over traffic disruptions. However, this traffic will be limited to frequent journeys over the construction period only, and anticipated impact to terrestrial traffic will occur as a result of this additional vehicle movement in the vicinity of the development area.

During the operation phase of the project, traffic around the project area may also be increased due to migration of people to the area. The impacts increase as in the construction phase would likely exist and potentially be extended during the project's operation phase.

Visual/ Aesthetic Impact

The project development will no doubt bring about change in visual look of the project site. If the structures are architecturally well-designed it could be aesthetically pleasing. On the other hand, if the project is partially developed and then abandoned, its visual impression could be negative. Project abandonment may also lead to resentment and frustration from community inhabitants and as such should not be considered.

Social Economic Impacts

Direct Beneficial Impact

The major beneficial impact arising from the construction, installation and operation of the power plant is the number of jobs it would provide as has been discussed earlier. It is estimated that 500 workers (skilled and unskilled) would be engaged during the construction phase of the project. Personnel with required skills would be employed and possibly trained further while unskilled personnel would be available for capacity increase.

The modal household income range is between N10, 100 and N20, 000, while the mean household income (obtained by dividing total income by total respondents) is N33, 809. It is expected that the project would subsequently add to increase income levels of individual to be engaged by NSF.

On a national scale, the actualisation of this project would mean addition of electricity to the national grid and subsequent improvement in quality of life for Nigerians.

Indirect Impact

The project would also mean change in the quality of life for workers who are to be employed and source of income to contractors in the host communities who would seize the opportunity to provide services and goods to NSF or its workers.

A key aspect of NSF activity in the area is to ensure continuous consultation with community members in order to avoid the following:

- Bitterness and hatred towards the government and/or for NSF;
- Lack of trust or confidence in future endeavours;
- Trespassing of community sacred or no-go areas;
- Increased social vices such as armed robbery, theft etc due to individuals not being recognised; and
- Youth restiveness and disturbance etc.

Issues such as job creation, settlement of conflict etc between NSF and the communities would be settled through the grievance mechanism to be activated. The project will not result in any disruption or disturbance of other economic activities beyond those positive elements that are associated with the addition of power and job creation that will be directly and indirectly beneficial to the populace. No negative impacts on employment or economic activities are predicted to occur.

It should also be recognised that once operation commences, another group of individuals would emerge. There are those who would want to cash in on the workers. These groups are the commercial sex workers, miscreants, hoodlums etc. They may be camped outside the facility or stationed within the community and ready to interact with NSF personnel. Interactions of this nature often lead to increased rate of STDs and other communicable diseases in the area, theft and conflict.

NSF will develop a community relations and engagement plan that identifies fair strategies of engagement for all communities.

Impacts on Economic Activities

Environmental impacts of the project can vary in their severity and time scale, be direct or indirect and can differ according to phase of development with which they are associated. A range of economic impacts which can result from the construction and operation of the proposed project are discussed under the following headings:

- Demographic impacts;
- Impacts on social infrastructure;
- Impacts on natural resources;
- Impacts on lifestyle;
- Impacts on cultural property; and
- Social equity of impacts.

Demographic Impacts

Demographic impacts are those impacts which cause a change in the size or make-up of a population. The principal demographic factor which the power plant project is likely to affect is migration. The project would generate inward migration of employees as well as attract other industrial development to the area in the hope of taking advantage of economic opportunities and power supply.

Seeing that the project activity is of a long duration it can result in permanent demographic impacts. For example, job seekers may move to the project location where construction activity is being undertaken, but not return to their places of origin when the activity has ceased.

Demographic change can affect different stakeholders in different ways. With migration of people (presumably more males than females especially during construction phase) into the project area, issues such as marital infidelity, pregnancies and abortions, sexually transmitted diseases, etc (with consequent health concerns) may arise.

Impacts on Social Infrastructure

The social characteristics of the community would be determined in part by the nature of, and access to, social infrastructure. This includes items such as:

- Health care facilities;
- Educational facilities;
- Transport and roads;
- Waste collection, treatment and disposal facilities;
- Housing;
- Water supply;
- Recreational facilities;
- Public safety (fire, police, etc); and
- Power supply.

The negative impacts on social infrastructure are usually associated with demographic changes. Existing infrastructure in the power plant study area may only be able to serve the local population. Infrastructure facilities in the area are in various functional states and may be strained by an influx of people resulting in further social or health impacts. For example, demand on health or waste management facilities could be greater than the proportional increase in the population as a result of other social impacts such as socio-economic impacts and impacts on lifestyle. The proposed project is expected to have some very positive impact on the economy, which include:

Employment: As discussed earlier, the project would entail some construction, from land clearing to erection of physical structures. All of these would necessitate the hiring of skilled and unskilled hands which, if properly managed would benefit the community. Several community residents may have worked at skilled and unskilled jobs in the construction of existing structures in the area. There is, therefore a pool of experienced labour in the community.

Rentals: Currently, some residents earn income from letting out their premises as residences and as business premises. It is envisaged that the project would attract itinerant workers, and other group of people seeking business opportunities, and some of these would take up residence in the community, or possibly open up offices. Rent would be paid for these premises which in turn would constitute incomes.

Increased Economic Activities: Employment and rentals would imply more income, increased purchasing power, and increased economic activities as residents spend their incomes on local goods and services.

Water Supply

All the water need of the power plant facility for domestic use as well as for fire protection would be from groundwater bore holes. To ensure adequate supply of water both for average and peak day demands as well as during an emergency, an appropriate margin of safety would be adopted and adhered to. The margin of safety (MOS) is defined as the dimensionless ratio of available supply over demand. This would especially become critical in the event of fire and other hazards.

Sewerage System

The project would have a sewerage collection system and treatment facility for the secondary treatment of waste. Human waste from all the development would be collected and treated in a designated sewage treatment plant in compliance with the FMEnv requirements prior to discharge. Given that sewage would be treated before discharge, negative impact of sewage on recipient environment would be minimal.

Housing

The project would substantially induce population growth around the project area and surrounding environs. NOVA Power might consider building residential facilities for its staff as the power plant project becomes fully operational.

The project's development would be conducted in phases and in an orderly approach. This would minimise infrastructure costs and ensure growth occurs in a contiguous manner. Also, since the project would support industrial development for several years, it is expected that population growth would be spread out over those years.

Public Services

The proposed power plant would result in increased demand for fire services within the project area. Development of the plant would lead to the construction and operation of new industrial uses which will require fire services. It may be necessary to consider incorporating personnel, equipment and facilities pertaining to fire service that covers the entire project area so as to cater adequately to any needs of the projected population.

The proposed project would result in increased demand for security within the project area. The proposed project would lead to influx of industrial activities (directly and indirectly) will therefore require maximum security. The facility construction and operation would require increased police services for the entire project area due to expected increase in population. Envisaged adverse economic impact would include

Impacts on Natural Resources

Impact on access to and use of natural resources is the area of greatest interface between environmental and social impacts. As stated in Chapter 4, some indigene people source laterite from the project site for making blocks for construction of local houses. Acquisition of the land, construction and operation of the utility scale PV-based solar power plant will automatically restrict the people's access to laterite. Other impacts in this sense may include:

- Accidental contamination of groundwater used for drinking water or watering animals;

- Reduction of land available for settlement purposes

Impacts on Lifestyle
The project could impact on many aspects of the residents' quality of life. These can affect individuals, stakeholders and the community as a whole. Issues which contribute to the quality of life include: lifestyle, the solidity of a community, patterns and structures of community life, attitudes and behavior and perceptions of risks within the population. Impacts on the quality of life could range from the physical impacts of an activity (e.g. land take), effects on the access to land, contamination of natural resources, and other social impacts, e.g. changes in population level and characteristics.

At a psychological level, individuals and particular stakeholders may feel a lack of empowerment resulting from the presence of the power outfit. Concerns exist among residents of the project area of perceived risks associated with the activity and fear of the change to the quality of life resulting from the project. These and other influences, such as the arrival of project workers, or migrants, could contribute to emotional stress, isolation, insecurity and consequent increases in the levels of crime, and other social problems. Alternatively, the project's development could generate a greater feeling of security as a result of improved economic and social opportunities, e.g. jobs, improved health care, educational facilities and power supply.

The structure and relationships within a community are often subject to change. The presence of the project could influence the spread and direction of this change. Changes in the socio-economic status of particular stakeholders resulting from the project's activities can influence power structures. People who move into the project area, can influence existing relationships and create new ones. The influence of "external values" can affect relationships within the family (marital, parents and children) and the community. Competition for the use of resources or social infrastructure can contribute to resentment between "newcomers" and existing residents. Such tensions can reduce the level of unity within the community.

The indigenous community could be subject to a range of impacts resulting from external activities. These include:

- The imposition of outside values, languages and customs – increased contact with project workers and migrants can cause the gradual loss of the traditional values and culture of the people. Migration of large numbers of people into the project area (particularly temporarily) has been shown to increase social problems, such as crime, prostitution, alcoholism, and social unrest, particularly when unmitigated;
- Loss of land or the means of subsistence – migration into the project area may cause increased competition for limited resources;
- Discrimination and marginalisation – the indigenes may be perceived as inferior by newly established dominant groups which have migrated to the project area. This could lead to racial discrimination, neglect, fracas and inadequate provision of services such as health care.
- Loss of self-esteem and increased dependency – the above factors contribute to a loss of identity which can result in problems of demoralisation, alcoholism and increased dependency on welfare systems.
-

Impacts on Landscape and Visual Receptors
Landscape and visual impacts that will occur include those related to increased numbers of vehicles movement within the area during the project life cycle, and the introduction of new buildings into the landscape. Construction activities are generally regarded as a visual impact due to the temporary intrusion on observers' views. Given the permanent nature of the activities the impact on landscape is predicted to be significant. The plant facility will have a permanent presence on the visual landscape.

Visual intrusion is highly dependent on the type of the scheme and the surroundings of the PV systems. It is obvious that, if we apply a PV system near an area of natural beauty, the visual impact would be significantly high. In case of modules integrated into the facade of buildings, there may be positive aesthetic impact on modern buildings in comparison to historic buildings or buildings with cultural value.

- Optimal architectural solutions to minimize potential impact on visual amenity and building aesthetics (i.e. PV integration into buildings and other installations). The use of PV as a cladding material for commercial buildings is showing the architectural possibilities of the technology to both the architectural profession and their clients. Advances in the development of multi-functional PV facades, which perform aesthetic and practical functions such as shading and heat extraction, have provided an important stimulus for architectural expression (Hestnes, 1999).
- Proper siting and design of large PV installations.
- Use of colour to assemble the PV modules in large scale systems.

Health Impacts and Risks

As the project progresses, risks to the community may arise from inadvertent or intentional trespassing, including potential contact with hazardous materials, contaminated soils and other environmental media.

Increased incidence of communicable and vector-borne diseases attributable to construction and operational activities represents a potentially serious health threat to project personnel and residents of the community.

In the case of infection, residents and workers would contend with malaria, diarrheal diseases, RTI and STDs. In general, itinerant workers could be transmitters of these and other diseases. As has been commonly experienced in other places, construction work tends to attract commercial sex workers who also are a high risk group in terms of transmitting STDs and HIV/AIDS. The magnitude and duration of work expected at the construction phase is such that this phenomenon could be expected.

Migrant project workers may have little or no resistance to prevalent diseases within the project area. Non-resident workers and their families may be quartered in camps with inappropriate living conditions. Additionally, social interactions between workers and the local community could lead to pregnancies with the attendant complications and problems of illegal abortions or orphanages. Enhancement of socio-economic status and health infrastructure can result in an improvement in public health care system.

Health Risks

The generation of electricity from photovoltaic (PV) solar panels is safe and effective. Because PV systems do not burn fossil fuels they do not produce the toxic air or greenhouse gas emissions associated with conventional fossil fuel fired generation technologies. According to the U.S. Department of Energy, few power-generating technologies have as little environmental impact as photovoltaic solar panels. However, as with all energy sources, there are potential environmental, health and safety hazards associated with the full product life cycle of photovoltaics. Recent news accounts have raised public interest and concerns about those potential hazards.

A substantial body of research has investigated the life cycle impacts of photovoltaics including raw material production, manufacture, use and disposal. While some potentially hazardous materials are utilized in the life cycle of photovoltaic systems, none present a risk different or greater than the risks found routinely in modern society. The most significant environmental, health and safety hazards are associated with the use of hazardous chemicals in the manufacturing phase of the solar cell. Improper disposal of solar panels at the end of their useful life also presents an environmental, health and safety concern. The extraction of raw material inputs, especially the mining of crystalline silica, can also pose an environmental, health and safety. The environmental, health and safety concerns for the lifecycle phase are minimal and limited to rare and infrequent events. With effective regulation, enforcement, and vigilance by manufacturers and operators, any danger to workers, the public and the environment can be minimized. Further, the benefits of photovoltaics tend to far outweigh risks especially when compared to conventional fossil fuel technologies. According to researchers at the Brookhaven National Laboratory, regardless of the specific technology, photovoltaics generate significantly fewer harmful air emissions (at least 89%) per kilowatthour (KWh) than conventional fossil fuel fired technologies.3

Impacts from Work Place Hazards

Accidents or injuries to personnel during the project construction, installation and operation phases can occur if proper HSE awareness or supervisions are not carried out. The impact of such accidents/ injury is very significant; given the nature of the job which requires work team commitment. Injury of a person or group of people can easily bring resentment and possible temporary close of the project. This may lead to capital and time lost. Likely sources of accident and injury associated with the power plant project include:

- Loading and offloading of equipment for installation and construction purposes;
- Over-exertion, ergonomic injuries such as repetitive motion and manual tool handling;
- Paint spraying or removal leading to hazardous inhalation;
- Metal cutting and fabrication works;
- Trip and fall from elevated surfaces, ladders, scaffolds and gangways;
- During routine plant maintenance works:
- During oil and fuel removal and tank cleaning;
- Operations involving cranes, winch, lift;
- Cutting and welding operations that make use of compressed gas; and

During pre-construction, construction/installation, operation and decommissioning activities, there could be occupational health and safety impacts. The following are derived from the IFC/ World Bank Environmental, Health, and Safety (EHS) Guidelines for Construction and Decommissioning (2007):

Over-exertion

Over-exertion, ergonomic injuries and illnesses, such as repetitive motion and manual tool handling, are among the most common causes of injuries.

Slips and Falls

Slips and fall associated with poor housekeeping, such as excessive waste debris, loose construction materials, liquid spills, and uncontrolled use of electrical cords and ropes on the ground, are also among the most frequent cause of lost time accidents at construction and decommissioning sites. Falls from elevation associated with working with ladders, scaffolding, and partially built or demolished structures are among the most common cause of fatal or permanent disabling injury.

Strike by Objects

Construction and demolition activities may pose significant hazards related to the potential fall of materials or tools, as well as ejection of solid particles from abrasive or other types of power tools which can result in injury to the head, eyes, and extremities.

Confined Spaces and Excavations

Examples of confined spaces that may be present in the construction or demolition phase and include: utility vaults, tanks, sewers, pipes, and drainages. Ditches and trenches may also be considered a confined space when access or egress is limited.

External Factors

External factors that could jeopardize the outcome of the power plant project are:

Natural Disasters

Natural disasters such as flooding can cause serious damages leading to injuries/death. To minimise the risk of such natural disasters, the project should comply with recognised safety measures, such as the installation of appropriate drainage structures, etc (African Development Bank: Integrated Environmental and Social Impact Assessment Guidelines, October 2003).

Social Instability

The emergence of communal violence, vandalism, civil war, border raids and boundary disputes are phenomena that generate social instability and can lead to migration, disruption of the food chain, injuries, epidemics and mortality. Social pressure may bring an industry to a halt. Good governance and poverty alleviation policies are means to prevent social instability (African Development Bank: Integrated Environmental and Social Impact Assessment Guidelines, October 2003).

Cumulative Impacts

Cumulative impacts result from activities which may not be significant on their own, but are significant when added to impacts of other similar actives probably occurring simultaneously with the project. There no cumulative impacts expected in the proposed NSF utility scale PV-based solar Power Plant project. There are no power plants located in Kankiya.

CHAPTER SIX

IMPACT MITIGATION MEASURES

CHAPTER SIX

IMPACT MITIGATION MEASURES

6.1 General

This chapter presents the mitigation measures proffered for the associated and potential impacts of the proposed NSF PV based solar power plant project. A comprehensive risk assessment matrix, as indicated in **Figure 6.1**, was used to determine the mitigation requirements for each of the impacts identified. The frequency, severity, sensitivity, scale, longevity, political, economic, legal, reputation/image and communication/complaints were factors taken into consideration during these assessments.

Mitigation measures designed to prevent, reduce or control the adverse impacts of the environmental aspects of the proposed project to as low as reasonably practicable were considered and documented in this chapter of the report.

Severity	Low	Medium	High
High	Formal Control	Physical Control	Avoidance
Medium	Training	Formal Control	Physical Control
Low	Informal Control	Training	Formal Control

Likelihood of Occurrence

Figure 6.1: Matrix for Determination of Mitigation Measures

Subsequently, the specific mitigation measures satisfying the mitigation requirement were established putting the following into consideration:

- available resources and competencies;
- on-site conditions; and
- Public concerns and technology.

The classification of the mitigation requirements (formal control, informal control, physical control, training and avoidance) are presented below.

Formal control
This involves the application of documented policy, process or procedure in mitigating the impacts of the project activities.

Informal Control
This involves the application of sound judgment and best practice in mitigating the impacts of project activities.

Physical control
This involves the application of physical processes or instruments (pegs, flags, sign post etc), not necessarily requiring any special technology, in order to mitigate the impacts of a project.

Avoidance
This involves the modification of plans, designs or schedules in order to prevent the occurrence of an impact or impacts.

Training
This involves personnel awareness in specific / specialized areas.

6.2 Mitigation Measures

The mitigation measures prescribed for identified impacts of the proposed project are presented in **Table 6.1.**

Table 6.1: Mitigation Measures Proffered for Significant Impacts

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation / Enhancement Measures	Residual Ranking
Pre-Construction Phase					
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Employment opportunities arising from recruitment of workers	Formal, informal control	Beneficial	NSF shall: • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented and signed • Make transparent communication on hiring policies amongst local communities	Beneficial
	Business opportunities for local contractors through sub-contracting activities			NSF shall: • Ensure local suppliers and contractors implement local employment and local procurement policies to the benefit of host community • Continually encourage local contractors through the award of contracts, according to their competence levels • Carry out periodic review of jobs, supplies and contract awards • Ensure consultation throughout project life span	
	Skill acquisition and enhancements to locals and future workforce	Formal control and training	Beneficial	NSF shall: • Ensure employed staff are trained to develop local workforce capacity; • Make sure payment, royalties etc are paid to eligible, and benefiting individual as appropriate	Beneficial
	Improvement in quality of life for adequately compensated individuals	Formal and informal control			
	Conflicts/ community agitations arising from dissatisfaction with compensation payment, and employment issues (quotas and methods).	Formal, informal control	Major	NSF shall: • Establish an efficient grievance management mechanism • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented, signed, and implemented in timely manner. • Engage in due consultation with relevant groups within host community at all phases of the project • Ensure that its workers are briefed on the socio-cultural norms and sensitivity of the host communities • Explore ways of encouraging goodwill and friendly relationship between its workers/ service contractors and members of the community • Establish, implement, and publicise grievance management procedure	Minor

Table 6.1: Mitigation Measures Proffered for Significant Impacts – cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation / Enhancement Measures	Residual Ranking
Pre-Construction Phase					
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Influx of people (migrant workers, sub-contractors and suppliers) and increased pressure on existing social infrastructure Increase in social vices (like theft, prostitution) resulting from increased number of people in the area	Informal and avoidance control	Medium	NSF shall: • In the future, promptly construct infrastructural facilities in the area to ease pressure on the existing amenities/ infrastructure • Encourage personnel to participate in community development affairs • Ensure that workers are educated on health issues • Ensure provision of security personnel in the project site	
	Community agitations over land disputes, wrong stakeholder identification, leadership tussles, etc Issues/ dispute on memorandum of understanding with project proponent	Formal and informal control	Major	NSF shall: • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented and signed • Provide opportunities for all groups (women, elders leaders etc) to participate in consultations and ensure that all concerns are duly addressed	Minor
	Increased risks of accidents leading to injury/ death and loss of asset during mobilisation	Formal, training and physical control	Major	NSF shall: • Develop and maintain an effective journey management schedule • Enforce speed limits of 100km/hr (major roads) 40-60km/hr (built-up areas) and 10-30km/hr (construction sites); • Ensure its drivers observe road traffic rules and speed limits • Make sure vehicle drivers undergo and pass competency training on driving, and identification of road signs and traffic codes before mobilisation • Use road signs at strategic points; sirens and public announcements where necessary to warn people of on-coming heavy duty vehicles • Ensure all its vehicles are certified roadworthy and in good maintenance condition • Ensure night trips are avoided	Minor

Table 6.1: Mitigation Measures Proffered for Significant Impacts – cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation / Enhancement Measures	Residual Ranking
Pre-Construction Phase					
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Risks of armed robbery attack and hostage taking leading to injury/ death of personnel	Informal and avoidance control	Medium	NSF shall: • Ensure a detailed security plan is developed and communicated to personnel • Make sure there is open communication with security operative in the area • Possibly assist in equipping law enforcement agencies with personnel and equipment to combat crime	Minor
	Nuisance (noise and vibrations) from movement of heavy duty equipment and vehicles affecting site workers and wildlife	Formal avoidance, training and physical control	Medium	NSF shall: • Installing vibration isolation for mechanical equipment • Use equipment with low noise and vibration capacity • Ensure all personnel wear appropriate PPE such as ear defenders in area of high noise at work site • Conduct HSE awareness trainings routinely	Negligible
	Dust particles and vehicular emissions from increased movement	Formal and avoidance control	Medium	NSF shall: • Ensure site preparation and clearing are conducted in wet season • Maintain all its work equipment at optimal operating conditions • Minimise venting from vehicle and equipment through the use of venturi or impingement scrubbers to control particulate matter emissions	Negligible
	Generation of wastes such as scrap metal, wood, sand, concrete, paper, domestic waste etc	Formal, training and physical control	Major	NSF shall: • Make sure all waste generated are separated at source via appropriate, different colour-coded, secure, leak-proof, well labeled for different types of wastes to enhance efficiency in waste handling and disposal. • Ensure personnel working at site are trained in the handling and management of wastes • Treat and discharge all effluents (wastewater, sewage) in accordance to regulatory requirements and in line with NSF waste management procedure/ plan	Negligible

Table 6.1: Mitigation Measures Proffered for Significant Impacts – cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Construction and Installation Phase					
• Plant foundation works • Piling, trenching, etc • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Risks of injury/ death and loss of assets resulting from accident associated with road transportation to and from construction site	Formal, training and physical control	Major	NSF shall: • Develop and maintain an effective journey management schedule • Ensure its drivers observe road traffic and speed limits • Make sure vehicle drivers undergo and pass competency training on driving, and identification of road signs and traffic codes before mobilisation • Use road signs at strategic points, sirens and public announcements where necessary to warn people of on-coming heavy duty vehicles • Ensure all its vehicles are certified roadworthy and in good maintenance state • Ensure night movement are avoided	Minor
	Workplace accidents leading to injury or fatalities from burns, cuts, bruises, trips, falls from objects at height	Formal control	Major	NSF shall: • Ensure that HSE briefings are conducted prior to work commencement • Ensure personnel wear adequate PPE • Design work area to meet best industrial standards recognizing all ergonomic factors • Encourage employees to maintain good house keeping	Minor
	Employment of local labour and skills acquisition for workers taking advantage of new opportunities Increased cash flow and stimulation of local economies within the host community Increased revenue opportunities for local population due to presence of non-resident workers and travelers	Formal and informal control	Beneficial	To enhance this beneficial impact, NSF shall • Retain some of the skilled and unskilled locals to encourage them in acquiring basic skill for self-sustenance • Encourage local contractors through the award of contracts as appropriate and according to their competence levels • Periodically review local contracts to ascertain the right individuals are used • Create awareness workshop to enlighten beneficiary on ways to invest and use new income	Beneficial

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Construction and Installation Phase					
	Generation of dust and particles from heavy duty equipment usage	Formal and avoidance control	Medium	NSF shall: • Ensure construction activities are conducted in wet season, when impact from dust is low • Maintain all its heavy duty equipment at optimal operating conditions	Negligible
	Fauna (birds, mammals etc) disturbance and displacement as a result of migration away from construction activity areas	Formal, physical and avoidance control	Medium	NSF shall: • Ensure that machinery, vehicles and equipment that produce high levels of noise should be avoided to reduce the overall impact. • Plan work activities to avoid heavy duty movement during peak hours	Minor
	Soil/ groundwater contamination resulting from accidental leakages and spills of hazardous substances (diesel, petrol, cleaning agents, lubricants, hydraulic oil)	Formal, training and physical control	Major	NSF shall: • Ensure that fuel storage facilities are leak-free and have bond wall protection • Ensure that only competent and trained personnel are used in handling fuel and chemicals • Hydrocarbon/chemical spill containment and prevention measures and equipment are functional and effective on site	Minor
	Increased risks of accidents leading to injury/ death and loss of asset during construction	Formal, training and physical control	Major	NSF shall: • Make sure vehicle drivers undergo competency training on driving, and identification of road signs and traffic codes before mobilisation • Use road signs at strategic points, sirens and public announcements where necessary to warn people of on-coming heavy duty vehicles • Ensure all its vehicles are certified roadworthy and in good maintenance state	Minor

Table 6.1: Mitigation Measures Proffered for Significant Impacts – cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Construction and Installation Phase					
• Plant foundation works • Piling, trenching, etc • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Potential collapse of power plant structures as a result of unsuitable geotechnical conditions	Formal and avoidance control	Major	NSF shall: • Carry out a comprehensive geotechnical study of the project site before construction works • Ensure geotechnical report provide all strength values and settlement potential required for adequate foundation design • Make use of experts with requisite experience in plant design and construction	Negligible
	Hazards from construction of base camp and electric evacuation lines	Formal, training and informal control		NSF shall: • Ensure personnel wear appropriate PPE (eye goggles, nose masks etc) • Make use of competent and well trained personnel for construction works	
	Cement dust and toxic fumes inhalation by onsite workers during foundation works and welding of plant components	Formal and training control	Major	NSF shall: • Ensure personnel wear appropriate PPE (eye goggles, nose masks etc) • Make use of competent and well trained personnel for construction works • Ensure periodic medical checks are carried out on personnel	Minor
	Risk of electrocution and burns during welding		Major	NSF shall: • Ensure strict adherence to standard work operations including the use of PPE (nose masks, hand gloves, etc) are maintained as stated in the company's HSE policy • Ensure all electrical and welding equipment are maintained at optimal working conditions • Make sure first aid facility are in place at construction site	
	Noise nuisance (including impulsive noise) from construction activities (e.g. piling, digging) resulting to temporary migration of mammals and rodents	Formal, physical and avoidance control	Medium	NSF shall: • Make sure machinery, vehicles and equipment that produce high levels of noise are avoided • Personnel working with machinery, vehicles and instruments that produce high levels of noise should be supplied with ear plugs and ear muffs • Ensure construction works are avoided at night time	Negligible

Table 6.1: Mitigation Measures Proffered for Significant Impacts – cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Construction and Installation Phase					
• Plant foundation works • Piling, trenching, etc • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Risks of fire/ explosions resulting from accidental ignition of onsite petrol/ diesel storage tanks	Formal, training and physical control	Major	NSF shall: • Ensure that fuel storage facilities are leak-free and have bond wall protection • Ensure that only competent and trained personnel are used in handling fuel • Develop oil spill contingency plan for prompt clean up • Use booms and other spill containment equipment to ensure that incidental spills/leaks are promptly and adequately contained to prevent fire ignition • Provide fire prevention and fighting apparatus	Minor
	Generation of wastes from construction activities such as scrap metal, wood, sand, concrete, paper, domestic waste, used oil etc	Formal, training and physical control	Major	NSF shall: • Make sure all waste generated are separated at source via appropriate, different colour-coded, secure, leak-proof, well labeled for different types of wastes to enhance efficiency in waste handling and disposal. • Ensure personnel working at site are trained in the handling and management of wastes • Treat and discharge all effluents (wastewater, sewage) in accordance to regulatory requirements and in line with NSF waste management procedure/ plan	Negligible
Commissioning and Operational Phases					
• Testing and commissioning • Power generation • Power plant maintenance and servicing	Generation and addition of electricity supply to the national grid Increased business opportunities and quality of life (small, medium, large scale) due to enhanced power delivery Improvement in air quality due to reduced emission from privately owned diesel or petrol generators Reduced demand on petrol and diesel used for household power generation	Formal and informal control	Beneficial	To enhance this beneficial impact, NSF shall • Ensure project is actualised and sustained as planned • Make sure power plant is maintained by professionals to allow for its continued existence • Encourage business growth and SME as appropriate in host community • Discourage locals from sabotage through direct education, newspaper publications, etc • Proactively assist with the acquisition of new transformers in the host community to boost electricity supply in the area (if possible)	Beneficial

Table 6.1: Mitigation Measures Proffered for Significant Impacts – cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Commissioning and Operational Phases					
• Testing and commissioning • Power generation • Power plant • Maintenance and servicing	Injuries/ fatalities to personnel due to incidents/ accidents from operating the power plant	Formal, training and physical control	Major	NSF shall: • Make sure vehicle drivers undergo competency training on driving, and identification of road signs and traffic codes • Ensure a dedicated transport system is provide for its personnel to limit number of vehicles • Ensure all its vehicles are certified roadworthy and in good maintenance state • Ensure upon start of operation, sinages are erected across the plant site • Ensure provision of first aid facility in the project location	Minor
	Soil/ groundwater contamination from accidental petrol /engine oil spill during refueling of vehicle	Formal, training and physical control	Major	NSF shall: • Ensure that fuel storage facilities are leak-free and have bond wall protection • Ensure that only competent and trained personnel are used in handling fuel and chemicals • Use booms and other spill containment equipment to ensure that incidental spills/leaks are promptly and adequately contained to prevent fire ignition	Minor
	Workplace accidents/ incidents (cuts, trip, falls etc) leading to injury/ Injuries that arise during operation of solar panel cell such as heat burns /death of personnel during operations	Formal control	Major	NSF shall: • Ensure that HSE briefings are conducted prior to work commencement • Ensure personnel wear adequate PPE while working in the plant • Design work area to meet industrial standards recognizing all ergonomic factors • Encourage employees to maintain good housekeeping within work site at all times • Ensure provision of first aid facility in the project location	Minor
	Depletion of groundwater resources for washing solar modules, and domestic use	Formal control	Medium	NSF shall: • Ensure that discharge water temperature does not exceed ambient surface water temperature • Ensure surface and groundwater levels are monitored to check status • Ensure water pumping and transmission mechanisms are maintained at optimal working conditions	Negligible

Table 6.1: Mitigation Measures Proffered for Significant Impacts – cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Decommission Phase					
• Mobilisation of personnel and equipment • Power plant decommissioning • Abandonment/ restoration	Loss of employment, business opportunities and decreased economic activity	Formal and informal control	Medium	NSF shall ensure: • Plans are developed to integrate disengaged workers from the plant into other projects (if any) • That host communities are informed prior to decommissioning	Minor
	Reduced power generation to national grid and low power supply	Formal control	Medium	NSF shall ensure: • Plans are made for another plant to continue generating electricity	Minor
	Risk of accident and injury to workers during demolition of structures	Formal control	Major	NSF shall: • Ensure that HSE briefings are conducted prior to demolition activities • Ensure personnel wear adequate PPE while carrying out demolition • Encourage employees to maintain good housekeeping within work site • Make sure trees or shrubs are re-grown on project site to restore its original form • Ensure provision of first aid facility in the project location	Minor
	Increased dust and vehicular emissions from decommissioning activities	Formal and physical control	Medium	NSF shall: • Ensure demolition activities are conducted after sprinkling of water to prevent dust build up • Ensure personnel wear adequate PPE (i.e dust mask) while carrying out demolition • Maintain all its vehicles at optimal working conditions	Negligible
	Availability of land for alternative uses	Formal and Informal control	Beneficial	To enhance this impact, NSF shall: • Develop a detailed Decommissioning /Abandonment Plan ensure alignment of all stakeholders (state, local, community) • Clean all excavations to acceptable limits and have then backfilled • Remove all wall fences and structures as advised by the abandonment team • Clean contaminated soils to acceptable limit	Beneficial
	Loss of site aesthetic qualities due to abandoned and dilapidated structures	Formal and Informal control	Medium	Available structures and building not demolished should be used for other beneficial purposes to prevent decay	Negligible

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation Type	Ranking Before Mitigation	Mitigation/ Enhancement Measures	Residual Ranking
Decommission Phase					
• Mobilisation of personnel and equipment • Power plant decommissioning • Abandonment/ restoration	Generation of wastes from construction activities such as scrap metal, wood, sand, concrete, paper, domestic waste, used oil etc	Formal, training and physical control	Major	NSF shall: • Make sure all waste generated are separated at source via appropriate, different colour-coded, secure, leak-proof, well labeled for different types of wastes to enhance efficiency in waste handling and disposal • Ensure personnel working at site are trained in the handling and management of wastes • Treat and discharge all effluents (wastewater, sewage) in accordance to regulatory requirements and in line with NSF waste management procedure/ plan	Negligible

CHAPTER SEVEN

ENVIRONMENTAL, SOCIAL AND MANAGEMENT PLAN

CHAPTER SEVEN

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

7.1 General

This chapter presents the Environmental, Social and Management Plan (ESMP), developed for the proposed NOVA Solar Five Farms Limited (NSF) utility scale PV-based solar power plant Project. The ESMP is essentially a management tool that provides assurance to NSF and regulators that mitigation measures developed for the significant impacts of the proposed project (as documented in **chapter six**), will be implemented throughout the project's life span. It also outlines management strategies for complying with health, safety and environmental issues from the project.

The management of NSF has documented goals and policies as part of this ESMP in order to achieve a conserved, safe and healthy environment. The ESMP provides assurance that a reliable scheme has been put in place to monitor the interaction between the planned operations and the environment throughout the duration of the project. This ESMP was developed in accordance with the general requirements of World Bank and International Finance Corporation Performance Standards, ISO 14001 Environmental Management System (EMS), OHSAS 18001 Health and Safety Management System, Equator Principles as well as other national and international regulatory requirements.

The Environmental Social Management Plan (ESMP) was developed, which would be an environmental management tool to ensure that all mitigation measures are implemented and adhered to during the duration of the power plant operation. The ESMP also enables a rapid rescue/ response if an unforeseen environmental impact occurs. It is found in this chapter of the report.

7.2 ESMP Objectives and Guiding Principles

The main objective of the ESMP is to ensure that all significant impacts of the proposed project are either prevented or reduced to acceptable limits. Specifically, the ESMP will:

- Show that a systematic procedure to ensure that all project activities with regards to the environment are executed and managed in compliance with applicable legislation/ guidelines and relevant NSF policies;
- Ensure that all mitigation/ enhancement measures prescribed in the ESIA document for eliminating or minimising all negative impacts of the project are fully implemented;
- Ensure that appropriate recovery preparedness are in place in the event that control is lost during the implementation of the proposed project;
- Present an effective monitoring plan that would be used for assuring the effectiveness of mitigation measures and for identifying unforeseen impacts arising during the project; and
- Provide a feedback for continual improvement in environmental performance.

These objectives shall be achieved by:

- Ensuring compliance with all stipulated legislation on protection of the environment and with national and local environmental policies;
- Integrating environmental, health, safety, security, and social issues fully into the project development and operational philosophies;
- Promoting environmental, health, safety, security, and socio-economic awareness amongst workers and host community;
- Rationalising and streamlining existing environmental, and social activities to add value to efficiency and effectiveness;
- Ensuring that only environmentally, and socially sound procedures are employed during the different project phases and the associated activities;
- Continuous consultations with the relevant regulatory bodies (Federal Ministry of Environment, Katsina State Ministry of Environment etc.), community leaders (District Head, village heads, group heads, family heads, landlords, etc.), women group,

community based organisations (CBOs), Kankiya L.G.A. and other stakeholders throughout the project lifecycle.

Constructive suggestions by NSF staff and stakeholders shall be assessed and evaluated by the NSF HSE Coordinator and integrated into the ESMP during review process as necessary.

7.3 Project Management and Responsibilities

Country Deputy Director

The Country Deputy Director (CDD) shall be responsible for ensuring that all environmental standards and guidelines throughout the project life cycle are followed and implemented. The CDD is also responsible for environmental operation, including environmental supervision of contractors through the Site Project Manager and HSE Officer. He shall ensure implementation of the environmental management plan during the project phases. The CDD is also responsible for liaising with the relevant stakeholders as well as the local community members through a Community Liaison Officer to be appointed.

Site Project Manager

The overall management of the proposed power project from site preparation through construction, to operation and decommissioning is the sole responsibility of the Site Project Manager (SPM). The SPM supervises all activities during the project and reports to NSF management through the CDD.

Engineering, Procurement and Construction Company

The Engineering, Procurement and Construction (EPC) Company that would eventually be selected would be NSF technical partner, and have deep understanding of the construction, installation and operation of utility scale PV-based solar power plants. They would supervise and ensure the successful execution and commissioning of the project.

Site Health, Safety Environmental Officer

The Site Health, Safety and Environmental (HSE) Officer is to report directly to the SPM. He/ she shall ensure that all safety, health and environmental policies and standards are kept and adhered to during the project execution. As a minimum, the Site HSE officer shall ensure all requirements of the ESMP are met. The designated HSE Officer may, at his/ her discretion, stop any work, activity or process not in accordance with directives of NSF.

Federal Ministry of Environment

The Federal Ministry of Environment (FMEnv) is saddled with the responsibility of enforcing national and international environmental laws which Nigeria subscribed to. As part of this project, the FMEnv would:

- serve as a regulatory oversight body in the implementation of this ESMP;
- in coordination with the Katsina State Ministry of Environment ensure that NSF periodically make available, documentations in form of monthly/quarterly reports or as may be designed in the monitoring plan in **section 7.4.12**;
- require NSF to show evidences of caring out monitoring requirements, etc

NSF shall work closely with the Federal and State Ministry of Environment to ensure that all environmental standards are upheld as agreed. NSF shall conduct her business according to the standards stipulated. The company's implementation organogram defining the general line of authority in NSF is presented overleaf as **Figure 7.1**.

7.4 ESMP Safeguard Guidelines

Mitigation measures are proffered for all significant impacts of the proposed power plant project in order to avoid, minimize or reduce expected impacts to as low as reasonably practicable (ALARP). To ensure these measures are achieved, responsibilities have been assigned for each task as presented in **Table 7.1**.

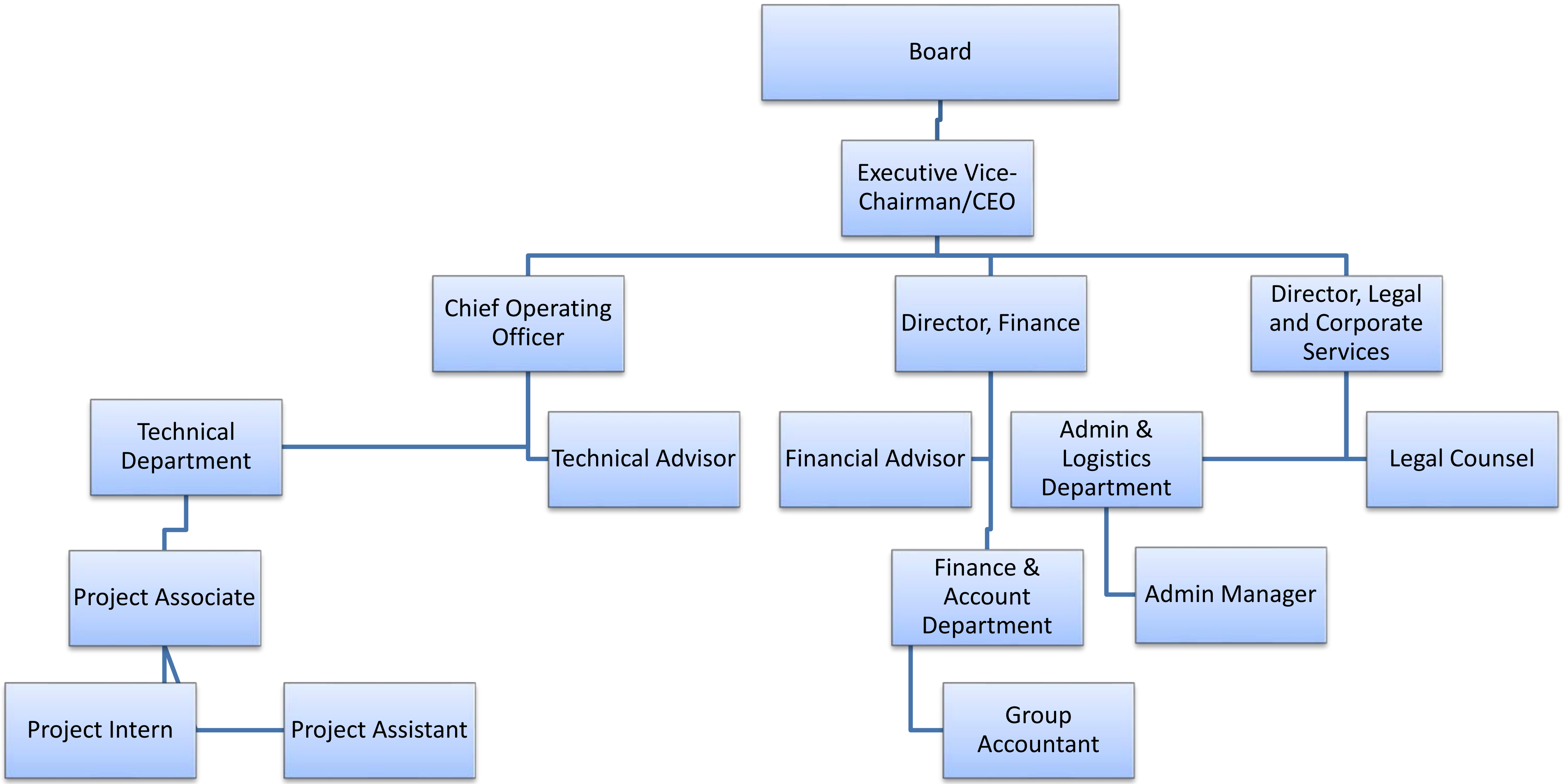


Figure 7.1: NSF Organisational Structure

Table 7.1: ESMP Guidelines for the Proposed PV-based Solar Power Plant Project

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation / Enhancement Measures	Responsible Parties
Pre-Construction Phase			
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Employment opportunities arising from recruitment of workers	NSF shall: • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented, signed, and implemented in timely manner • Make transparent communication on hiring policies amongst local communities	NSF Management/ EPC Manager
	Conflicts/ community agitations over employment issues (quotas and methods)	NSF shall: • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented, signed, and implemented in timely manner • Due consultation of relevant groups within host community at all phases of the project • Ensure that its workers are briefed on the socio-cultural norms and sensitivity of the host communities • Explore ways of encouraging goodwill and friendly relationship between its workers/service contractors and members of the community • Establish and publicise grievance management procedure	NSF Management/ Community Liaison Officer
	Influx of people (migrant workers, sub-contractors and suppliers) and increased pressure on existing social infrastructure	NSF shall: • In the future construct infrastructural facilities in the area to ease pressure on the existing amenities/ infrastructure • Encourage personnel to participate in community development affairs • Ensure that workers are educated on health issues	Site Project Manager/ Community Liaison Officer
	Increase in social vices (like theft, prostitution) resulting from increased number of people in the area		
	Community agitations over land disputes, wrong stakeholder identification, leadership tussles, etc	NSF shall: • Ensure early stakeholders' engagement sessions are held, and all agreed issues properly documented and signed • Transparent communication of hiring policies amongst local communities	NSF Management

Table 7.1: ESMP Guidelines for the Proposed PV-based Solar Power Plant Project- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation / Enhancement Measures	Responsible Parties
Pre-Construction Phase			
• Permitting • Community engagement • Land acquisition • Recruitment • Mobilisation to site • Land preparation and clearing	Increased risks of accidents leading to injury/ death and loss of asset during mobilisation	NSF shall: • Develop and maintain an effective journey management schedule • Enforce speed limits of 100km/hr (major roads) 40-60km/hr (built-up areas) and 10-30km/hr (construction sites); • Make sure vehicle drivers undergo and pass competency training on driving • Use road signs at strategic points, sirens and public announcements where necessary to warn people of on-coming heavy duty vehicles • Ensure all its vehicles are certified roadworthy and in good maintenance condition • Ensure night trips are avoided	Site Project Manager/ Site HSE Officer
	Risks of armed robbery attack and hostage taking leading to injury/ death of personnel	NSF shall: • Ensure a detailed security plan is developed (Appendix 1.2) and communicated to personnel • Make sure there is open communication with security operatives in the area • Possibly assist in equipping law enforcement agencies with personnel and equipment to combat crime	Site Project Manager/ Site Security Officer
	Nuisance (noise and vibrations) from movement of heavy duty equipment and vehicles affecting site workers and wildlife	NSF shall: • Maintain all its work equipment at optimal operating conditions • Make use of equipment with low noise and vibration capacity • Ensure all personnel wear appropriate protective PPE such as ear defenders in area of high noise at work site • Conduct HSE awareness training routinely	Site HSE Officer
	Dust particles and vehicular emissions from increased movement	NSF shall: • Ensure site preparation and clearing are conducted under favourable weather condition when risk of generating dust is minimal. • Maintain all its work equipment at optimal operating conditions • Minimise venting from vehicle and equipment through the use of venturi or impingement scrubbers to control particulate matter emissions	

Table 7.1: ESMP Guidelines for the Proposed PV-based Solar Power Plant Project- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation / Enhancement Measures	Responsible Parties
Construction and Installation Phase			
• Plant foundation works • Piling, trenching, etc • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Generation of wastes such as scrap metal, wood, sand, concrete, paper, domestic waste etc	NSF shall: • Make sure all waste generated are separated at source to enhance efficiency in waste handling and disposal • Ensure personnel working at site are trained in the handling and management of wastes • Treat and discharge all effluents (wastewater, sewage) in accordance with regulatory (FMEnv and DPR) requirements and in line with NSF waste management procedure/ plan	Site HSE Officer
	Risks of injury/ death and loss of assets resulting from accident associated with road transportation to and from construction site	NSF shall: • Develop and maintain an effective journey management schedule • Ensure its drivers observe road traffic and speed limits • Make sure vehicle drivers undergo and pass competency training on driving, and identification of road signs and traffic codes before mobilisation • Ensure all its vehicles are certified roadworthy and in good maintenance state	Site Project Manager/ Site HSE Officer
	Workplace accidents leading to injury or fatalities from burns, cuts, bruises, trips, falls from objects at height	NSF shall: • Ensure that HSE briefings are conducted prior to work commencement • Ensure personnel wear adequate PPE • Design work area to meet best industrial standards recognizing all ergonomic factors • Encourage employees to maintain good house keeping	Site HSE Officer
	Generation of dust and particles from heavy duty equipment usage	NSF shall: • Ensure construction activities are conducted in favourable weather conditions when risk of generating dust is minimal • Maintain all its heavy duty equipment at optimal operating conditions	

Table 7.1: ESMP Guidelines for the Proposed PV-based Solar Power Plant Project- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation / Enhancement Measures	Responsible Parties
Construction and Installation Phase			
• Plant foundation works • Piling, trenching, etc • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Fauna (birds, mammals etc) disturbance and displacement as a result of migration away from construction activity areas	NSF shall: • Ensure that machinery, vehicles and equipment that produce high levels of noise should be avoided to reduce the overall impact. • Personnel working with machinery, vehicles and instruments that produce high levels of noise should be supplied with ear plugs and ear muffs • Plan work activities to avoid heavy duty movement during peak hours	Site HSE Officer
	Soil/ groundwater contamination resulting from accidental leakages and spills of hazardous substances (diesel, petrol, cleaning agents, lubricants, hydraulic oil)	NSF shall: • Ensure that fuel storage facilities are leak-free and have bond wall protection • Ensure that only competent and trained personnel are used in handling fuel and chemicals • Hydrocarbon/chemical spill containment and prevention measures and equipment are functional and effective on site	
	Increased risks of accidents leading to injury/ death and loss of asset during construction	NSF shall: • Make sure vehicle drivers undergo and pass competency training on driving, and identification of road signs and traffic codes before mobilisation • Use road signs at strategic points, sirens and public announcements where necessary to warn people of on-coming heavy duty vehicles • Ensure all its vehicles are certified roadworthy and in good maintenance state	Site Project Manager/ Site HSE Officer
	Potential collapse of power plant structures as a result of unsuitable geotechnical conditions	NSF shall: • Carry out a comprehensive geotechnical study of the project site before construction works • Ensure geotechnical report provide all strength values and settlement potential required for adequate foundation design • Make use of experts with requisite experience in plant design and construction	Site Project Manager/ EPC Manager

Table 7.1: ESMP Guidelines for the Proposed PV-based Solar Power Plant Project- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation / Enhancement Measures	Responsible Parties
Construction and Installation Phase			
• Plant foundation works • Piling, trenching, etc • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Cement dust and toxic fumes inhalation by onsite workers during foundation works and welding of plant components Hazards from construction of base camp, and electric evacuation lines	NSF shall: • Ensure personnel wear appropriate PPE (eye goggles, nose masks etc) • Make use of competent and well trained personnel for construction works • Ensure periodic medical checks are carried out on personnel	Site HSE Officer
	Risk of electrocution and burns during welding	NSF shall: • Ensure strict adherence to standard work operations including the use of PPE (nose masks, hand gloves, etc) are maintained as stated in the company's HSE policy • Ensure all electrical and welding equipment are maintained at optimal working conditions • Make sure first aid facility are in place at construction site	
	Noise nuisance (including impulsive noise) from construction activities (e.g. piling, digging) resulting to temporary migration of mammals and rodents	NSF shall: • Make sure machinery, vehicles and equipment that produce high levels of noise are avoided • Personnel working with machinery, vehicles and instruments that produce high levels of noise should be supplied with ear plugs and ear muffs • Plan work activities to avoid heavy duty movement during peak hours • Ensure construction works are avoided at night time	Site HSE Officer/ EPC Manager
	Risks of fire/ explosions resulting from accidental ignition of onsite petrol/ diesel storage tanks	NSF shall: • Ensure that fuel storage facilities are leak-free and have bund wall facility • Ensure that only competent and trained personnel are used in handling fuel • Develop oil spill contingency plan for prompt clean up • Use booms and other spill containment equipment to ensure that incidental spills/leaks are promptly and adequately contained to prevent fire ignition • Provide fire prevention and fighting apparatus	Site HSE Officer/ EPC Manager

Table 7.1: ESMP Guidelines for the Proposed PV-based Solar Power Plant Project- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation / Enhancement Measures	Responsible Parties
Construction and Installation Phase			
• Plant foundation works • Piling, trenching, etc • Plant component erection • Fabrication, carpentry, painting and coating • Transportation and logistics • Waste generation	Generation of wastes from construction activities such as scrap metal, wood, sand, concrete, paper, domestic waste, used oil etc	NSF shall: • Make sure all waste generated are separated at source to enhance efficiency in waste handling and disposal • Ensure personnel working at site are trained in the handling and management of wastes • Treat and discharge all effluents (wastewater, sewage) in accordance to regulatory (FMEnv and DPR) requirements	Site HSE Officer
Operational Phase			
• Testing and commissioning • Power generation • Power plant • Maintenance and servicing	Injuries/ fatalities to personnel due to incidents/ accidents from operating the power plant	NSF shall: • Make sure vehicle drivers undergo competency training on driving, and identification of road signs and traffic codes • Ensure a dedicated transport system is provide for its personnel to limit number of vehicles • Ensure all its vehicles are certified roadworthy and in good maintenance state	Site HSE Officer

Table 7.1: ESMP Guidelines for the Proposed PV-based Solar Power Plant Project- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation / Enhancement Measures	Responsible Parties
Operational Phase			
• Testing and commissioning • Power generation • Power plant • Maintenance and servicing	Soil/ groundwater contamination from accidental petrol /engine oil spill during refueling of vehicle	NSF shall: • Ensure that fuel storage facilities are leak-free and have bond wall protection • Ensure that only competent and trained personnel are used in handling fuel and chemicals • Use booms and other spill containment equipment to ensure that incidental spills/leaks are promptly and adequately contained to prevent fire ignition	Site HSE Officer
	Workplace accidents/ incidents (cuts, trip, falls etc) leading to injury/ death of personnel during operations	NSF shall: • Ensure that HSE briefings are conducted prior to work commencement • Ensure personnel wear adequate PPE while working in the plant • Design work area to meet industrial standards recognizing all ergonomic factors • Encourage employees to maintain good housekeeping within work site at all times	
	Depletion of groundwater resources for washing solar modules, and domestic use	NSF shall: • Monitor and control the use of water to reduce wastages • Ensure all water pumping and transmission mechanisms are maintained at optimal working conditions • Ensure groundwater levels are monitored to check status	Site HSE Officer

Table 7.1: ESMP Guidelines for the Proposed PV-based Solar Power Plant Project- cont'd

Project Activities / Environmental Aspects	Potential and Associated Impacts	Mitigation / Enhancement Measures	Responsible Parties
Decommission Phase			
• Mobilisation of personnel and equipment • Power plant decommissioning • Abandonment/ restoration	Loss of employment, business opportunities and decreased economic activity	NSF shall ensure: • Plans are developed to integrate disengaged workers from the plant into other projects (if any) • That host communities are informed prior to decommissioning	NSF Management/ Site Project Manager
	Reduced power generation to national grid and low power supply	NSF shall ensure: • Plans are made for another plant to continue generating electricity	NSF Management
	Risk of accident and injury to workers during demolition of structures	NSF shall: • Ensure that HSE briefings are conducted prior to demolition activities • Ensure personnel wear adequate PPE while carrying out demolition • Encourage employees to maintain good housekeeping within work site • Make sure trees or shrubs are re-grown on project site to restore its original form	Site HSE Officer
	Increased dust and vehicular emissions from decommissioning activities	NSF shall: • Ensure demolition activities are conducted after sprinkling of water to prevent dust build up • Ensure personnel wear adequate PPE while carrying out demolition • Maintain all its vehicles at optimal working conditions	

As part of the Environmental, Social and Management Plan for the project, the following guidelines have been developed by NSF to meet both national (FMEnv) and international (World Bank/ IFC) requirements.

7.4.1 Training and Awareness Plan

At the construction phase of the project, the following environmental awareness and trainings programs shall be conducted:

Induction Training

An induction training program shall be a requirement for every construction worker to be engaged in the project and shall be provided by the contractors. The training shall include:

- The proposed tasks for new worker;
- Safe work procedures;
- Use of personal protective equipment;
- Emergency responses and warning notices;
- Personal hygiene and site sanitation;
- Environmental protection ; and
- Hazard recognition and incident reporting.

Weekly Safety and Environmental Forum

There shall be a weekly environmental and safety awareness forum for construction workers during the construction activities at the project site. NSF shall be responsible for coordinating these meetings.

At the operation phase of the project, NSF shall educate all its workers on environment, health, and safety issues using the following means to disseminate information to staff and workers:

- Staff and workers meetings;
- Local area network (intranet)/ the internet; and
- Annual bulletins on NSF operations.

7.4.2 Public Participation/ Involvement Plan

NSF shall welcome suggestions and information from relevant stakeholders, contractors, visitors and the general public, which shall help improve its operations in order to minimize impact on the environment and worker health and safety. The office of the Site Manager/ Community Liaison Officer shall be open to the general public for complaints and suggestions.

Complaints received from the public shall be documented and follow-ups made to ensure that such grievances are addressed accordingly and in line with the NSF grievance redress mechanism. A grievance or compliant register would be developed for this purpose.

Project Grievance Management Mechanism Approach

Grievances are feedback, responds or complaints concerning the way a project is being handled or managed. A grievance mechanism provides a formal and ongoing avenue for stakeholders to engage with the project proponent. Grievance monitoring allows for early warning or signals of any escalating conflicts or disputes. Identifying and responding to grievances supports the development of positive relationships between the proponent and the community, and other stakeholders. A grievance mechanism is not a substitute for a company's community engagement process or vice versa. The two are complementary and should be mutually reinforcing.

An effective grievance management process should include the following components:

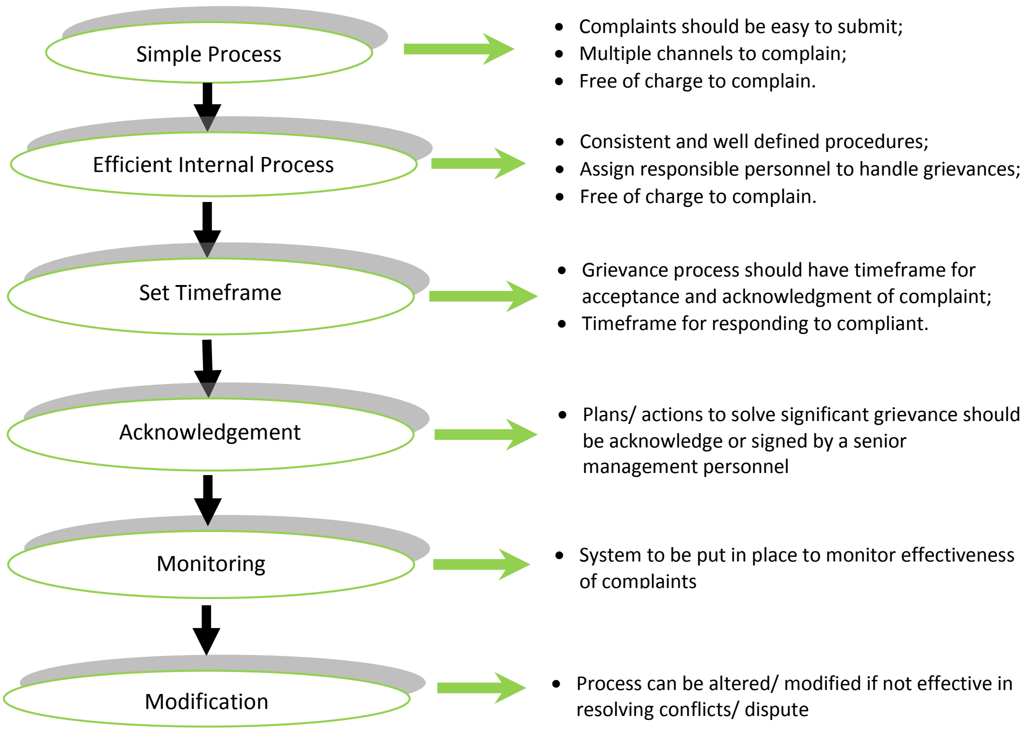


Figure 7.2: Effective Grievance Mechanism Components

According to World Bank Standard (i.e. OP 4.12), it is expected that projects implement a Grievance Mechanism, in order to accommodate any grievances, complaints or concerns that stakeholders may have.

NSF plans to employ a Community Liaison Officer (CLO) who will serve to meet all community liaison responsibilities and related assignment. He shall also ensure the effectiveness in implementation of the grievance mechanism. The grievance mechanism will be advertised and announced to affected stakeholders so that they are aware of their rights to submit comments and how to go about it. The NSF grievance mechanism will be founded on the following principles:

Responsibilities Will Be Adequately Assigned
A responsible person, team or function will be assigned to organise the resolution of grievances. This will enable the system run without undue impediments.

The Process Will Be Accorded Due Importance
It is important for affected communities and other stakeholder groups seeking to have their complaints resolved, to perceive the grievance management process as transparent and fairness. The NSF grievance management process will enhance outcomes and give people satisfaction that their complaints have been heard, even if the outcome is less than optimal. The grievance procedures will be readily understandable, accessible and culturally appropriated by the local population. From the outset, clarification will be made on who is expected to use this procedure The people will be assured that there will be neither costs nor retribution associated with lodging a grievance. The entire process (from how a complaint is received and reviewed, through to how decisions are made and what possibilities may exist for appeal) will be made as transparent as possible through good communication.

The Mechanism Will Be Scaled Needed for the Project

The NSF grievance mechanisms will be designed to fit the context and needs of the 125MWp utility scale PV-based solar power plant project. As much as possible, it will have relatively simple means of addressing complaints, such as through community meetings, community liaison personnel and suggestion boxes allowing for anonymity. It may also need a more formalized process and mechanism, and a higher level of dedicated resources for receiving, recording, tracking, and resolving complaints. The NSF grievance mechanisms will not be taken as a substitute for community engagement process or vice-versa. The two are complementary and will be made mutually reinforcing. Not all grievances shall be handled in the same way. For example, a complaint about a company truck running over chickens in the road may be readily resolved through direct interaction between the complainant and the company's community liaison staff (with a more formal grievance process only as a back-up if staff are not responsive). However, allegations of widespread ground water contamination, for example, may be of such a serious or urgent nature that they require immediate intervention by senior managers and subsequent mediation. In other words, NSF will consider creating different levels of redress within the grievance mechanism that correspond to the scale and seriousness of the complaint.

The Process will be Documented and Publicized

The process will be put in writing and publicized.NSF recognises that the policy or process for addressing complaints cannot be effective if nobody knows about it. Thus the grievance procedures will be put into writing, publicized, and explained to relevant stakeholder groups. The people will be informed on where to go and whom to talk to if they have a complaint, and understand what the process will be for handling it. As with all information, it will be provided in a format and language readily understandable to the local population and/or communicated orally in areas where literacy levels are low. It will not be overly complicated to use nor will it require legal counsel to complete.

Third Parties Will Be Brought In Where Needed

NSF recognises that sometimes ensuring "fairness of process" for affected individuals or groups require certain measures to level the playing field of perceived power. Thus, at a minimum, the host communities will need to have access to information. NSF will facilitate this by providing project-related information in a timely and understandable manner. In cases where significant imbalances in knowledge, power, and influence exist, NSF may wish to reach out to other partners to assist in the process. In terms of advocacy, an NGO might be brought in to assist local communities and advocate on their behalf. Where mediation is desired, academic or other local institutions may be sought out to play an "honest broker" role in mediating between NSF and stakeholder groups. In certain circumstances, NSF may consider providing funding for such third-party advice or facilitation in a way that is acceptable to all parties and does not compromise the integrity of the process

The Process Will Be Made Accessible

Projects that make it easy for people to raise concerns and feel confident that these will be heard and acted upon can reap the benefits of both a good reputation and better community relations. One of the best ways to achieve this is to localize your points of contact. Hire people with the right skills, training, and disposition for community liaison work and get them into the field as quickly as possible. Maintaining a regular presence in the local communities greatly helps to personalize the relationship with the company and engender trust. Talking with a familiar face who comes to the village regularly, or lives nearby, creates an informal atmosphere in which grievances can be aired and sorted out, or referred up the chain of command. This is usually more convenient and less intimidating to people than having to travel distances to the company offices during business hours to file a formal complaint.

Response Time Will Be Defined and Transparency Upheld

NSF will publicly commit to a certain time frame in which all recorded complaints will be responded to (be it 48 hours, one week or 30 days) and ensure this response time is enforced. This will help allay frustration by letting people know when they can expect to be contacted by NSF personnel and/or receive a response to their complaint. Combining this with a transparent process by which stakeholders can understand how decisions are reached will inspire confidence in the NSF system. During critical time periods, such as construction, will be immediate responses to time-sensitive complaints, such as a fence being knocked down by a contractor, for example, and livestock getting out. A related issue is making sure that NSF personnel receiving grievances (typically community relations staff) have the authority to resolve basic complaints themselves, as well as a direct reporting line to senior managers if the issue is more serious or costly to address.

Good Record-Keeping and Feedback
A log book will be kept where necessary, and a sophisticated database will be maintainend where required. Written records of all complaints will be kept as this is critical for effective grievance management. The record shall contain the name of the individual or organization; the date and nature of the complaint; any follow-up actions taken; the final result; and how and when this decision was communicated to the complainant. In some countries, detailed personal information such as passport numbers are required to officially "register" a grievance. This can be intimidating to stakeholders and discourage them from using the mechanism. Thus, overly personal data will therefore be optional and kept confidential unless required to disclose to authorities. In addition to informing the complainant of the outcome (in writing where appropriate), as part of the broader community engagement process NSF will report back periodically to communities and other stakeholder groups as to how the company has been responding to the grievances it has received.

Access to Legal Remedies will not be Impeded
If the project is unable to resolve a complaint, it may be appropriate to enable complainants to have recourse to external experts. These may include public defenders, legal advisors, legal NGOs, or university staff. NSF may find that it can work in collaboration with these third parties and affected communities to find successful resolution of the issues. However, this is not always possible, and situations may arise where complainants will choose to pursue legal recourse. Under these circumstances, NSF will be familiar with the judicial and administrative channels for dispute resolution available in the Katsina State, and Nigeria at large and will not impede access to these mechanisms.

7.4.3 Regulatory Compliance Plan

NSF HSE Officer shall identify and develop a comprehensive checklist of every HSE-related regulation applicable to the proposed project including those contained in this ESIA report. The specific requirements of each of the regulations, standards, or codes shall also be clearly defined in a checklist. Project-specific compliance requirements shall be interpreted and documented into a Regulatory Compliance Plan (RCP), which will be approved by NSF and then incorporated into the detailed project design.

7.4.4 Project Design Guidelines

The specifications to be used for the design, construction, and operations of the proposed utility scale PV-based solar power project are based on applicable regulations, industry standards and codes that are in agreement with standard power and electrical industry practices. Applicable requirements to be incorporated into the project design would be clearly approved national and international project specifications and standards (see **Appendix 3.3** for applicable codes).

7.4.5 Project Execution Guidelines

Vegetation Clearance
All clearance works at the construction site shall be carried out within defined perimeters and only when necessary. Clearing of vegetation shall be kept to the minimum necessary to permit safe operations. Trees felled from site shall be re-utilised for the benefit of the neighboring communities or as otherwise desired by NSF in consultation with the communities. Areas cleared in excess of operational requirements shall be reinstated with

indigenous topsoil and vegetation. A buffer zone or green belt shall be achieved to incorporate environmental conservation practices and improved aesthetic quality at the site.

Foundation Works, Sand Filling and Surfacing
Work within the construction site shall be carried out in such a manner that there is no interference with existing water courses (if any). Work shall be limited to defined operational perimeter.

If existing watercourse (if any) require to be temporarily diverted to enable the works to be carried out, approval for such diversions shall first be obtained from the relevant authorities. The diversion shall be maintained while the work is being carried out and shall be re-instated, including the removal of any obstruction to flow, as soon as practicable after the work is completed. No excavated material or debris shall be discharged into existing watercourses (if any exists).

Use of Public Access Roads
All transportation, construction, installation and surfacing works shall be executed in such a manner that will ensure that interference with the use of public access roads is minimal. However, if operational safety demands the blockade of public roads, then the Site HSE and Community Liaison Officers after due consultation from relevant State Government approving authorities, may approve such operation only when temporary traffic control and diversion arrangements have been provided. Dumping or storage of litter/debris, tools and equipment in public or private roads shall be prohibited. Contractors shall develop road-clearing strategies to ensure that public roads are kept clear, safe, passable and free of traffic.

Hydrological Properties and Drainage Protection
NSF shall ensure that all hydrological characteristics and qualities of the area is maintained at its present status or improved on. During excavation, construction and installation works the contractors shall where necessary ensure that surface water (if any) flows on land areas are controlled and if necessary channeled into temporary discharge pits. Such pits shall be located, designed and constructed in a manner that will minimise the potential threat of erosion. Muddy water and surface runoff from work sites shall be drained into suitable silt traps, bagged and disposed-off with local waste contractors for discharge. The silt trap shall be of adequate size and regularly de-silted. Excessive site clearing shall be avoided and exposed surfaces shall be re-vegetated as soon as practicable to minimise erosion.

In general, NSF intends to carry out the following activities during the project execution phases:

- Schedule project activities to avoid heavy rainfall periods to the extent that is practical;
- Mulching and re-vegetation to stabilise exposed areas;
- Design channels and ditches for post-construction flows;
- Provide adequate drainage systems to minimise and control infiltration;
- Minimise dust from material handling sources by using covers and/or control equipment (i.e. water suppression and bag house)
- Minimise dust from open area sources, including storage piles, by using control measures such as installing enclosures and covers, and increasing moisture content;
- Totally avoid open burning of solid wastes;
- Using impervious surfaces for refueling areas and other fluid transfer areas at plant site;
- Train workers on the correct transfer, handling of fuels, chemicals and response to spills; and
- Provide portable spill containment and cleanup equipment on site and training in the equipment deployment.

7.4.6 Inspection and Maintenance Plan
In order to maintain technical integrity of the facility upon completion, a well-defined

inspection and maintenance management system shall be activated to ensure compliance. NSF's maintenance programme shall deal with establishing processes to develop and sustain necessary maintenance procedures. The system shall identify what procedures are required, classifying procedures to their impact on operating integrity, controlling deviations from procedures, and updating of procedures to capture lessons learned. It will also address training and verifying competency for facility-specific procedures.

The maintenance system will include plans and procedures for:

- Normal maintenance (routine and breakdown maintenance performed by the Maintenance Technicians involved in the project);
- Preventive maintenance (activities carried out at pre-determined intervals);
- Predictive maintenance (as initiated by facility condition monitoring and assessment); and
- Inspection (in accordance with a pre-defined programme and based on statutory and company requirements);

The Site Project Manager will develop a comprehensive Maintenance and Inspection Programme (MIP) for all equipment and machinery before commencement of operations. The programme will cover routine equipment checks; inspection of wastewater discharge units, emissions monitoring; inspection and maintenance of corrosion protection system in serviceable condition; plant component servicing and inspection; and general inspection and maintenance of the turbine generators and diesel tanks; etc. The maintenance and inspection schedule contained in the programme will be designed in line with manufacturer's specifications for each of the equipment and in compliance with specific guidelines as contained in relevant national and international guidelines.

7.4.7 Risk Assessment and Management Plan

Risk assessment and management shall be an integral part of the proposed project's execution. Risks related to project execution and operations shall be identified by a structured approach. Risk assessments shall be planned and conducted in advance of appropriate activities to allow resolution of risk without schedule interruption. Competent personnel shall be included in risk assessments to ensure that risks are correctly identified and assessed.

The responsibility of risk management in the proposed project lies with the EPC contractor. Monitoring by the NSF Management Team will ensure that contractor processes are being implemented fully and effectively.

Workers to be involved in the construction and operational phases of the project will be employed by the EPC contractor; therefore NSF will pay particular attention to applying appropriate contractor control, mitigation and monitoring activities for contractors. NSF expects contractors to have HSE systems in place consistent with Katsina State Government (DSG) guidelines. Personnel working in the area shall work in accordance with job specifications developed by EPC/ NSF. They will have the direct responsibility for executing the work using sound engineering, fabrication, installation, and commercial practices, while maintaining adequate controls. The designs will take into account applicable laws and regulations, and, in the absence of such, generally accepted industry standards. The contractors will develop operating manuals and appropriate documentation regarding the proper operation and maintenance of the power plant facility for approval by NSF. This data will be provided in a timely manner such that facility-specific training can be given to personnel prior to start-up.

7.4.8 Worker Safety and Health Plan

Operations within the work site shall be subject to industry policies and IFC Environmental, Health, and Safety Guidelines. All NSF and contractor staff shall be well informed and trained on the policies and guidelines. Facility will be designed to enhance safety planning.

Contractors shall provide adequate health services as well as first aid services for its workforce. The first aid services shall be extended to visiting personnel and temporary (casual) workers. All construction activities shall be properly managed through careful planning and application of relevant HSE policies including the following:

- Use of permit-to-work;
- Job hazard/ safety analysis and toolbox meetings;
- Use of PPE in designated hazard areas;
- Prohibition on drinking of alcohol during work hours and at work sites and within facilities;
- Prohibition to night trips;
- Regular emergency drills; and
- Prohibition to smoking in fire hazard areas.

Integrity of Workplace Structures
- All structures and installations would be design to enable easy cleaning and repair, and limit the accumulation of hazardous compounds;
- Buildings will be structurally safe, provide appropriate protection against climate change and have acceptable light and noise conditions;
- Facility design would ensure that fire resistant, noise-absorbing materials are used, to extent feasible, on ceilings and walls;
- Floors would be level, even, and non-skid to prevent trips and fall; and

Workspace and Exit
- Space to be provided for each worker would be adequate for safe execution of all activities, including storage of materials and products; and
- All emergency exits route would be unobstructed at all times. Exits would be clearly marked. The number and capacity of emergency exits would be sufficient for safe and orderly evacuation of the people during emergency situations.

Fire Precautions
- NSF shall equip the facility with fire detectors, alarm systems, and fire-fighting equipment. The equipment would be maintained in good working condition and be readily accessible; and
- Provision of manual fire-fighting equipment that is easily accessible and simple to use.

Other requirements to be met by NSF include:
- Water supplied for food preparation or for the purpose of personal hygiene (washing or bathing) would meet national and international drinking water quality standards;
- Equipment and installations requiring servicing, inspection, and/or cleaning would have unobstructed, unrestricted, and ready access;
- Hand, knee and foot railings would be installed on stairs, platforms, permanent and interim floor openings, offices and plant building;
- Ensure that well equipped first-aid is provided at designated areas at site. First-aid stations would be easily accessible throughout the place of work;
- Eye-wash stations and/or emergency showers would be provided close to all workstations as first-aid response;
- Sufficient fresh air (ventilation) would be supplied for indoor and confined work spaces;
- Temperature in office areas would, during service hours, be maintained at a level appropriate for the purpose of the facility;
- Fall prevention and protection measures would be implemented whenever a worker is exposed to the hazard of falling height;

7.4.9 Pollution Control Guidelines

Air Quality Management Plan

In operating equipment, all practical methods and devices available to control, prevent and otherwise minimise atmospheric emissions or the discharge of air contaminants from the power plant shall be utilised. Good engine efficiency of equipment and vehicles shall be maintained. Indiscriminate burning of materials resulting from clearance of trees, bushes and combustible materials shall also not be permitted.

Though the operation of PV-based solar power plants produces no emissions, NSF intends to manage air emissions from all sources during all phases of the project by ensuring:

- Emissions do not result in pollutant concentrations that exceed the FMEnv and WHO ambient quality limits;
- Implementing a leak detection and repair (LDAR) program that controls fugitive emissions by regularly monitoring to detect leaks, and implementing repairs within a predefined period;
- Use of dust control methods, such as covers, water suppression, or increased moisture content for open materials storage piles;
- Use of water suppression for control of loose materials on paved or unpaved road surfaces during construction;
- Vehicle manufacture's recommended engine maintenance programs are implemented;
- Emissions control devices such as catalytic converters, wet scrubber are installed and maintained;
- Fuel switching (e.g. selection of lower sulfur fuels) during fuel combustion to reduce amount of particulate matter emission;

Note: By implementing the above, NSF would ensure air pollutant gases are below the following WHO (IFC) limits during all phases of the project:

- $SPM_{2.5}$= 10µg/m^3 (annual mean), 25µg/m^3 (24 hour mean);
- NO_2 = 40µg/m^3 (annual mean), 200µg/m^3 (1 hour mean); and
- SO_2 = 20µg/m^3 (24 hour mean), 500µg/m^3 (10 minute mean).

Water and Soil Pollution

Pollution of soil/surface water by wastewater shall be prevented by proper management practices. Effluent water from the chemical/ fuel storage and processing facilities shall be collected, transported and treated to FMEnv requirements of 10ppm oil in water. Waste shall be managed using wastewater treatment plant being considered or stored and transferred to disposal center with capability of managing such, before discharge.

All excavation, construction and surfacing activities shall be performed by methods that will prevent pollution of the soil media by accidental spills of contaminants, debris, and other objectionable pollutants. Regular checks shall be conducted on site equipment to minimise minor lube oil and combustible leaks from engines.

Groundwater from boreholes for drinking purposes shall be monitored in line with WHO drinking water quality limits.

Noise Pollution

NSF shall comply with all noise control requirements pertaining to FMEnv and IFC standards. All equipment shall be maintained at optimal working conditions and recommended work practices shall be employed to minimise noise. Ear defenders shall be provided for all workers and any other person present within the vicinity of high noise generating equipment or operations. Noise pollution will be significant mostly during construction phase. If noise level at any time gives rise to public complaint, the issue shall be treated, as public nuisance and NSF will take appropriate measures to resolve the problem. Safe separation distances and buffer zones shall be established between facilities, work sites and neighboring communities to reduce the impact of high noise levels from the facilities.

NSF intends to manage impact from noise by ensuring:

- Equipment with lower sound power levels are used;
- Project execution are done during the day so as to limit noise impact at night;
- Noise control by installing suitable mufflers on engine exhausts;
- Acoustic enclosures are installed for equipment radiating noise;
- Installation of vibration isolation for mechanical equipment;
- Reduced project traffic routing through community areas wherever possible;
- The re-location of noise sources to less sensitive areas within the site to take advantage of distance and shielding
- That noise levels from the facility do not exceed IFC noise limit of 70dB(A); and
- Continuous noise monitoring is carried out to check levels of noise all through the project phases (see **Table 7.2**).

It should be noted that the ambient noise baseline level recorded during the study were in compliance with the FMEnv/ IFC-WHO noise limit as discussed in **chapter 4**.

7.4.10 Emergency Response Plan

NSF and contractors will demonstrate that all potentially significant hazards and potential impacts of the project activities have been identified, the associated risks evaluated and understood, and that controls and recovery measures to effectively manage these risks and impacts are in place before mobilisation to site. NSF will assist the contractors, where necessary, with the provision of an hazard list for guidance.

In case of an emergency during the life span of the power project, the Emergency Response Procedure (ERP) will be activated. Its objectives are:

- To ensure no loss of life;
- To ensure that the environment is protected;
- To ensure that manpower, equipment and funds are available to effectively contain and clean up oil/ chemical spills; and
- To ensure that good record keeping is maintained and accurate information concerning emergencies is disseminated to the workers, public and government.

The ERPs cover the following situations and issues:

- Point and fugitive leakages;
- Isolation of supply points;
- Notification of authorities;
- Fire outbreak/ disasters;
- Safety precautions and environmental protection;
- Repair methods and procedures;
- Emergency repair;
- Contractor arrangements; and
- Re-commissioning and start-up.

NSF and its contractors shall identify all potential emergency situations and develop procedures to use in such scenarios as explosions and/ or fires, medevac, hydrocarbon/ chemical spills, weather related disasters, hostage taking, community disturbance, kidnapping, etc. Emergency drills will be conducted to demonstrate preparedness for response and a schedule of drills and testing of emergency instruments will be prepared by all contractors on the project. Every technical contractor on the proposed project will prepare and submit to NSF for approval a contingency plan for emergency situations and possible incidents beyond the capability of site facilities.

7.4.11 Communication Plan

Effective two-way communication between NSF and contractor staff on HSE and security issues will be maintained. This will include awareness programmes to motivate staff and contractors. HSE and security information and experiences will be shared between NSF and contractors to facilitate improvement in HSE and security performance.

NSF shall ensure its staff at all levels involved in the proposed project become familiar with the importance of compliance with the adopted NSF HSE policies, regulatory compliance plan and security plan and their individual roles and responsibilities in achieving compliance. Each person will be aware of their respective work activity risks and hazards and the controls, mitigation measures and emergency response procedures that have been established. They will also be aware of the potential consequence of departure from agreed operating procedures.
Contractors will set up appropriate procedures and lines of communication to handle HSE and security issues (e.g. direct access to the nearest clinic, direct access to emergency services, etc).

Contractors will be able to communicate easily with their base, work site, their entire workforce and with NSF in an emergency. Appropriate safety programmes and promotion will be employed to effectively promote HSE and create awareness e.g. minutes of meetings, plans and performance targets, HSE performance and news board, posters, bulletins, video, news flash, e-mail, etc.

7.4.12 Environmental Monitoring Plan

All contractors shall be required to monitor their performance with respect to environmental and social performance. The NSF HSE Officer shall also undertake monthly, quarterly and yearly environmental assessment and spot checks throughout the plant project lifecycle. Assessment findings shall be reviewed by the Project Management Team (PMT) and where corrective actions are necessary, specific plans (with designated responsibility and timing) shall be developed to ensure continuous performance improvement.

In addition to assessing operational aspects and monitoring, assessments shall also consider compliance with agreed objectives and targets, and the effectiveness of the ESMP and its implementation programs. The ESMP shall, therefore, be subject to ongoing review and development to ensure that it remains appropriate for all aspects of the project. As is typical with all FMEnv approved projects, the ministry will carry out an assessment before the end of the project to confirm compliance of project activities to the terms and conditions of the ESIA approval.

The objectives of the monitoring programme are to:

- Ensure compliance with regulatory emission and discharge limits;
- Monitor changes in existing physico-chemical, biological and social characteristics of the environment, compared both to the environmental baseline and predicted conditions;
- Ensure continual interactions and flow of information between NSF and the stakeholders;
- Determine whether any detected changes in socio-economic and environmental components are caused by the project or by other forces;
- Determine the effectiveness of the control and mitigation/ enhancement measures and provide a basis for recommending additional measures; and
- Ensure sustenance of accountability and a sense of local ownership throughout the project lifecycle.

The monitoring programme (including data collection) designed for the utility scale PV-based solar power plant project is presented in **Table 7.2** overleaf. The monitoring frequency is subject to review after the first year to determine its effectiveness and possibly include other identified areas of concern.

Table 7.2: Recommended Environmental and Social Monitoring Programme

Indicator Parameters	Impact Category	Monitoring Method	Location	Frequency	Project Phase	Responsibility
Environment Aspects						
Noise Levels	Noise	Point and ambient measurements	Stations measured in this ESIA	Monthly- construction Quarterly- operation	Throughout the project	NSF HSE Officer/ Regulators
Air Pollutants: NO_x , CO_x , SO_x, H_2S, NH_3, C_xH_Y and SPM	Air quality	Point measurement	Sample point location in ESIA	Bi-annually-construction Bi-annually- operation	Throughout the project	NSF HSE Officer/ Regulators
Soil: Characteristics	Soil	Sample collection using soil auger and analyses	Along sample point location in EIA	3years – after commissioning and every 5 years afterwards	Throughout the project	NSF HSE Officer/ Regulators
Groundwater Characteristics	Groundwater	Sample collection and laboratory analyses	From installed boreholes with project site	Quarterly-construction Bi annually –operation (for first three years)	Throughout the project	NSF HSE Officer/ Regulators
Effluent Quality	Waste water quality	Sample collection for laboratory analyses	At sample collection point before evacuation by disposal agency	Quarterly-construction Quarterly-operation	Operational phase	NSF HSE Officer/ Regulators
Social Aspects						
Engagement Issues: (employment, contractors, suppliers)	Socio-economic	Review of MoU, consultation and employment policies	NSF site	Monthly-construction Quarterly-operation	Throughout the project	NSF HSE and CLO Officers
Social Cultural Issues	Socio-economic	Feedback, consultation and review of complaints	NSF Site/ community			
Community health: (prevalent diseases in host community)	Socio-economic/ health	Collection of health statics from clinic and hospitals with the LGA	Community/ LGA	Yearly-construction Yearly-operation	Throughout the project	NSF Management

7.4.13 Waste Management Plan

Waste generated shall be managed in accordance with Federal Ministry of Environment guidelines and NSF waste management procedures. The manner in which wastes are to be handled, stored and disposed is dictated by the nature of the waste. NSF's Waste Management Plan (WMP) takes into consideration the nature of all wastes that will be generated during the lifetime of the project. The following objectives form the basis for the WMP for the proposed project:

- Progressive reduction of wastes with the target to minimise overall emissions/ discharges, which have adverse impact on the environment;
- Meet the environmental requirements of FMEnv and Katsina State Waste Management Law as well as other international bodies (such as IFC/ World Bank) on waste management;
- To establish, implement and maintain waste segregation aimed at enhancing recycling;
- To ensure that NSF and its contractors are responsible for effective waste handling and disposal process;
- To ensure that waste management programme is in line with provisions of the Environmental Management Programme of ISO 14001;

The WMP would be binding on all staff and contractors involved in the proposed project implementation with respect to the:

- Emission or release of air pollutant and fugitive gases;
- Management of spill and untreated liquid effluent from the project site;
- Management of solid wastes from project activities; and
- Generation of noise.

The waste management principles of NSF is designed to ensure that wastes generated are properly handled and disposed of in an environmentally friendly manner by adopting the principle of waste source reduction, recovery and reusing. All wastes, which cannot be reused, are managed and disposed of in accordance with NSF HSE policy and in line with the company's Environmental Management System (EMS).

NSF Waste Management Plan

NSF has developed a Waste Management Plan/ Policy containing procedures to be followed in the management of wastes and discharges from its facility. NSF recognizes that her operations produce waste which must be handled from "cradle to grave". The Waste Management Policy is intended to help staff and the general public comply with Local, State, Federal and International Regulations on waste management.

<u>Waste Handling</u>

For proper handling and disposal, wastes shall be well defined at source and labels transmitted along with the wastes to the final disposal points. NSF personnel and contractors shall record and document all wastes generated in the course of work in a Monthly Waste Report, which shall be used to track/ monitor wastes generated from the plant facility. Basic information that must be provided as a minimum for adequate definition of wastes include:

- Waste type identification;
- Proper waste categorization (domestic, office, industrial and hazardous wastes);
- Waste segregation information; and
- Recommended management practices.

Waste Minimisation
Waste minimisation implies reduction, to the greatest extent possible, the volume of waste materials. The four principles of waste minimisation process are **recycle, reduce, reuse and recover**, and shall be adopted as applicable in this project.

Waste Segregation
Waste segregation and characterisation shall be carried out on wastes that are similar and may be combined to simplify storage, treatment, recycling, and/or effective implementation of appropriate waste disposal methods. Wastes shall be segregated, preferably at source into clearly designated bins at strategic locations within the plant facility. Particular attention shall be given to work area and offices where relatively significant amount of wastes including food packaging would be generated. The Site HSE Officer shall be responsible for the maintenance of the waste segregation scheme.

Waste Disposal
All spoil materials, rubbish and debris shall be cleared regularly from the site and disposed of, at designated areas and facilities as specified in PWM guideline. Instructions on material safety handling sheet shall be strictly adhered to and would form basis for the disposal of hazardous wastes. Wastes in transit shall be accompanied and tracked by Waste Disposal Notes. Waste streams to be generated in the facility would be collected and handled as shown in **Table 7.3**.

Table 7.3: Waste Handling and Disposal Method

Waste Streams	Category	Frequency of Generation	Recommended Practice	Future Practice
Bulbs and mercury tubes	H	Monthly	Segregate and transport well bagged wastes to recycling center in Katsina Town, Katsina State.. Wastes must be clearly labeled	Same
Clinical wastes from first aid treatment	H	Daily	Transport to NSF Retainer Clinic in sealed bags for incineration. Wastes must be clearly labeled	Same
Food wastes/ office sweepings, nylon bags etc	D	Daily	Segregate and store in bags. Disposed-off by NSF's waste disposal agent to be engaged	To be recycled at site
Glass	O	Monthly	Segregate and transport to recycling center in Katsina Town	As currently practiced
Pigging wastes	H	Weekly	Weigh and store in watertight bags placed in drums with lid and transport to the approved dumpsite for incineration	To be incinerated at site
Crude oil/ oily sludge/ fuel filter cartridges	H	Weekly	Transport to collection centre in Katsina Town	As currently practiced
Papers	O	Daily	Segregate (all confidential papers must be separated from non confidential) shred at source and transported to a recycling depot	As currently practiced

Table 7.3: Waste Handling and Disposal Method cnt'd.

Waste Streams	Category	Frequency of Generation	Recommended Practice	Future Practice
Printer, cartridges, computer toners, photocopier toners	O	Weekly	Segregate and transport to recycling canter	As currently practiced
Aerosol cans and spent lubricants	H	Monthly	Collect, segregate and transfer to disposal centre in Katsina for recycling	Same
Oily rags, sorbents; used protective clothing	H	Monthly	Transport to collection centre in Katsina Town	As currently practiced
Refrigerants (HCFC) from fridge and air condition units	O & H	Once spoilt	Safely contain in designated locations for return to manufacturer, or to recycling centre	As currently practiced

Note: O- office wastes, D- domestic wastes, H- hazardous wastes

Specifically, solid wastes are to be collected/ segregated and stored in waste bins placed in strategic locations around the plant facility. The bins would be transferred into well labeled bags which would be evacuated and transferred to waste collection center in Katsina Town, Katsina State. Scrap metals are to be neatly arranged until evacuation. Access to waste storage area would be restricted, except for authorised personnel.

Liquid wastes such as wastewater and used oil are to be transferred into a collecting tank. This would be evacuated once the storage tank is filled up. Sewage is to be collected in a septic tank which would also be evacuated when the need arises. NSF supports no discharge of waste into the environment and as such would ensure that solid and liquid wastes from its facility are transferred to treatment site. NSF key elements of its waste management principles are presented in the flow diagram below.

Accredited Waste Disposal Contractors

Solid waste management in Katsina is handled centrally by The Katsina State Environmental Protection Agency (SEPA). SEPA has created designated refuse collection centers for community storage and evacuation. In addition to the State Environmental Protection Agency (SEPA) that is responsible for managing entire waste of Katsina State, there are also four private waste management agencies that alongside with SEPA manage the solid waste in Urban Katsina. These are:

1. Immaculate Company: Responsible for the provision of household refuse storage facilities to their clients, they also transport the refuse to dispose at collection points. This company is responsible for managing the entire household refuse generated at Barhim Housing Estate, behind Katsina State Secretariat, and some part of Umaru Musa YarâAdua University.
2. Express Environmental Services Operates similar services as Immaculate Company above, but for the Federal College of Education and Diamond Bank branches in urban Katsina.
3. Tri-Dynamic Waste Management Company Operates similar services as Express Environmental Services above for its respective clients. These include: Federal Medical Center and the Administrative Blocks of Umaru Musa YarâAdua University. The company also operates special services such as general cleaning when invited among others.
4. Annur Cleaners operation is mainly special services such as general cleaning, soak-away evacuation, spraying, fumigation, etc. Source: State Environmental Protection Agency, 2011

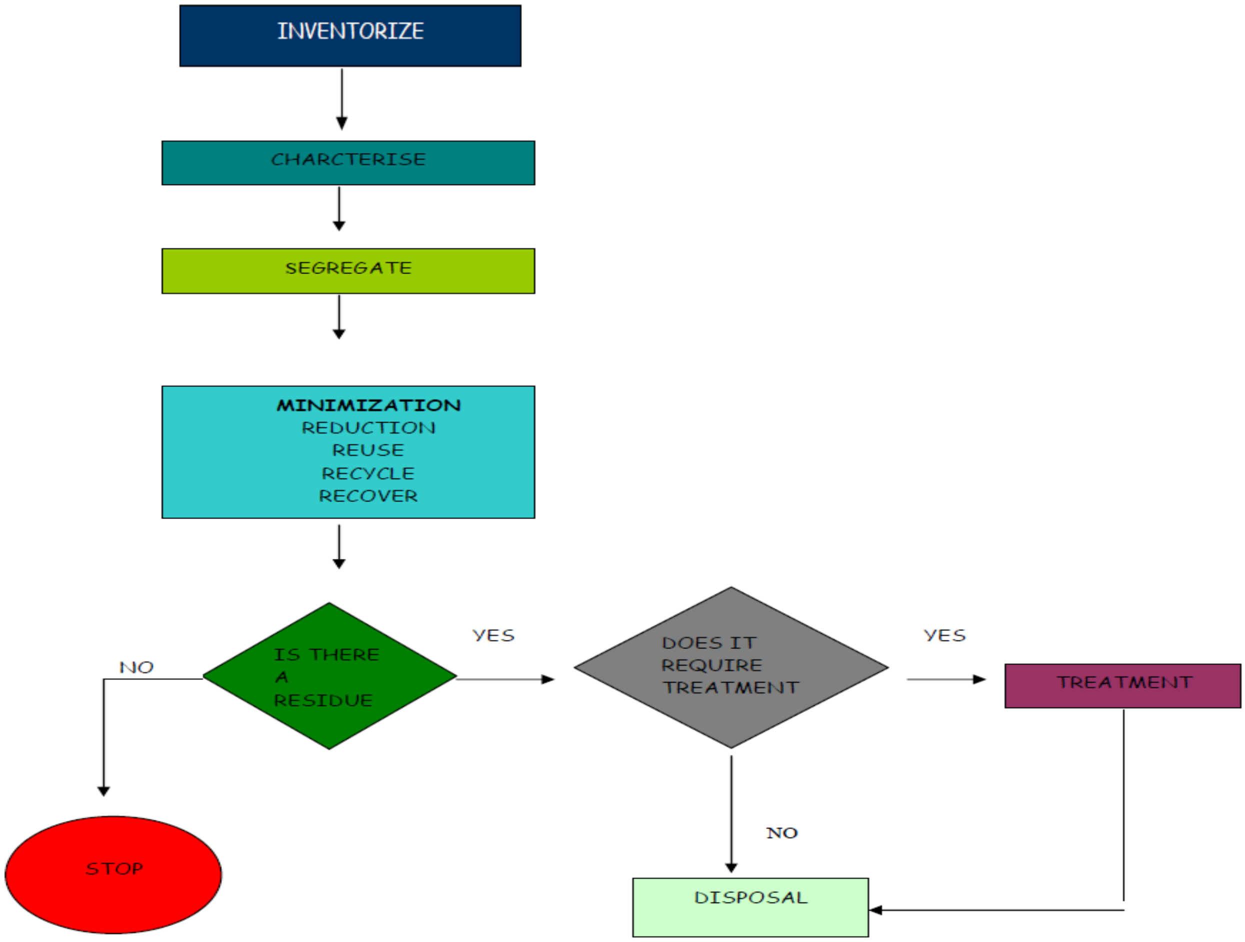


Figure 7.3: NSF Waste Management Principles

Waste management audit for the facility shall be carried out and findings properly documented and followed up. Catering services and camp sites shall maintain acceptable standards of hygiene and good housekeeping. Every employee has a vital role to play in achieving effective environmental protection.

7.4.14 Security Plan

The project team led by the Site Project Manager shall ensure that adequate security arrangements are made to handle security-related issues effectively. The project team will identify, evaluate and manage the risks to personnel and property arising from routine operations, malicious practices, crime, civil disorder or armed conflict.

In addition, each contractor will be required to prepare a Project Site Security Plan and submit it to NSF for review and approval before mobilisation to site. The project team will also organise a security workshop to identify, evaluate and recommend contingency plans for all security risks. A Site Security Officer would be engaged at the site. NSF project security plan is presented in **Appendix 1.2**.

7.4.15 Consultations

NSF recognises the importance of consultations in all phases of the proposed power plant project. This is because it involves soliciting people's views on proposed actions and engaging them in a dialogue. It is characterised by a two-way information flow, from the NSF to people/ stakeholders, authorities, and from people to the NSF. The overall aim of the consultation plan for the proposed project therefore, is addressing the concerns and opinions of the stakeholders with the ultimate view to assuring a smooth project implementation.

While the Federal Government, Katsina State Government and NOVA Solar Five Farms Limited retain decision-making authority, interaction with people and eliciting feedback allows the affected populations to influence the decision-making process by raising issues that should be considered in scoping; project design; mitigation; monitoring and management plans; and the analysis of alternatives. The overall result would be the optimisation of the potentials of the proposed project and maximisation of its benefits.

Consultations, which began during the ESIA process, shall continue throughout the project life cycle and shall be by way of:

- Visits and courtesy calls on the community leaders and other stakeholders to discuss the effectiveness of the addressed social issues on the lives of the people;
- Direct visits to the affected communities to consider (through questionnaires, interviews and visual observations) their opinions on the social acceptability and environmental soundness of the project;
- Organising large public meetings (participatory rural appraisal) to discuss public welfare, clarify misconceptions and address new issues as regards the project;
- Holding workshops and extension courses on resource management (using simply written materials, visual representation, videos and scale models to decode technical languages) and sensitising the indigenous people on the latest impact mitigation techniques; and
- Organising public seminars aimed at identifying new ways of rendering socio-economic assistance for the local people.

7.4.16 NSF Corporate Social Responsibility

The Corporate Social Responsibility (CSR) component of the project is enshrined in the grand bargain with the state that makes the project a Public Private Partnership (PPP). The investor consortium has agreed that the project company structure its transactions (contracts) and operations to:

I. Optimize local content in concentric circles (from the community, then the state, then Nigeria before sourcing from outside Nigeria what is needed for the project).
II. Optimize community participation - by providing a grant of $200,000.00 to be applied to community projects that enhance the community's ability to convert electrical energy into improved living standards
III. Optimize community involvement as first line of asset protection - community participation in the project in I and II provides the basis for the community as the first line of asset defense.

I, II and III will be scoped out in further detail by the project company in close consultation with the community and affected people on the project site. The rationale being that it is the project company that is the entity that owns the assets. Further, it is the project company that will be controlled by the investors and to whom the lenders lend, and ultimately who the community has to manage a relationship with for 25+ years.

The CSR component will involve extensive consultations, mapping and assessments to determine what interventions are desired by the community that the project company can provide resources for (including the proposed $200,000 grant). What issues and opportunities may present themselves at the time the project becomes operational. And the critical focal points within the community that can be engaged to kick-start these conversations.

NSF community assistance project begins with a policy of integrating local content into contracting so that , locals from Kankiya, then Katsina, then Nigeria are provided opportunities to be selected for work on the project during its development, construction and operations and maintenance phases. The local community in Kankiya will have additional support from a grant facility that is bespoke to their desires and needs for economic development using electricity as a vector for socio-economic inclusion in Kankiya.

7.4.17 Environmental Audit and Review

NSF will conduct regular audits in conjunction with applicable regulatory agencies to monitor compliance with its project. The scope shall cover the major project activities including the overall ESMP requirements throughout the life of the project. Contractors' performances towards meeting these requirements will be assessed.

Generally, the audit programme will be conducted in line with the relevant regulatory guidelines. It will be conducted annually during construction and every three (3) years during operations. The findings from these audits will be reported to the Commissioner for Environment and Federal Ministry of Environment, and corrective action plans will be developed and followed-up for performance improvement.

7.4.18 Decommissioning and Abandonment

The design of the facilities shall take due recognition of the need to decommission the power plant and the ancillary facilities at the end of their operational life. The abandonment plan shall take due note of the current national and international legislative requirements for decommissioning and abandonment.

Decommissioning after Construction Phase

Temporary structures (camp, storage yard, offices, etc.) would be installed at the construction phase to support site operations/ activities. Upon actualisation of construction phase, all areas temporarily used will be cleared, cleaned and re-instated.

Decommissioning after Operation Phase

This very last phase of the project is expected to occur after 60 years of usage. The following are activities to be carried out once the plant life span comes to an end:

- Operating processes would be systemically shut down in a safe manner;
- Liquid and solid wastes would be removed for treatment and disposal; and
- fuel storage tanks would be flushed and cleaned to remove oils and gases.

The fate of the emptied and cleaned structures and equipment are then decided by a feasibility study as part of an "Abandonment Assessment" to determine the best environmental and economic solution consistent with Nigerian requirements for decommissioning utility scale PV-based solar power plant facility. The general order of preference of decommissioning options available for redundant structures and equipment are as follows:

- **Re-use:** by sale and/ or transport to another project or company;
- **Re-cycle**: breaking down structures and equipment for raw materials. This is expected to be the fate of majority of metalwork used. The break-up of structures can be done on location or after transport to a breaking or salvage yard, dependent upon ease of transport and safety considerations;
- **Disposal**: some materials not suitable for recycling must be disposed to a licensed waste management facility;
- **Leave in-situ**: in some cases the best environmental and economic option may be to leave material in-situ.

7.5 Cost for ESMP Implementation and Monitoring

Mitigation measures to be adopted for each of the project phases have been presented in Chapter 6 and 7. The EPC Contractor will be directly responsible for financing the implementation of mitigation and monitoring measures from inception to the completion of the power plant project. The cost of impacts mitigation monitoring will be included in the EPC contract value and will be monitored by NSF Management Team.

NSF shall be responsible for auditing the activities of the EPC, and for the associated funding. During operations, NSF will be responsible for financing and managing mitigation measures and monitoring activities in-line with international practices. Part of the conditions for the approval of the ESIA by the Federal Ministry of Environment (FMEnv) is that there will be regulatory monitoring of the approved project impacts mitigations and monitoring measures. The timing and frequency of the monitoring is determined by the FMEnv. FMEnv works closely with the Katsina State Ministry of Environment in monitoring the implementation of the ESIA approval terms and conditions.

Funding of the Impacts Mitigation and Monitoring (IMM) is borne by NSF. In the past, FMEnv will request funding for the monitoring while the project is in progress and the monitoring activity will be carried out after payment of the requested fund. Current practice is that FMEnv now issues a pre-approval letter which includes the cost of IMM and other conditions that has to be fulfilled prior to the issuance of the approval. Meeting the conditions, along with payment of the funds have therefore become prerequisites to the issuance of the ESIA approval. Payment prior to approval also ensures that the funding for monitoring is secured and the activity effected as at when due. The current cost is about ₦500, 000.

CHAPTER EIGHT

CONCLUSION

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CONCLUSION

The Environmental and Social Impact Assessment (ESIA) of the proposed NOVA Solar 5 Farms Limited 125MWp utility scale PV-based solar power Plant project has been carried out to satisfy government, financiers, regulators and stakeholders that proactive environmental actions have been incorporated into project design/ plan.

The study was carried out in line with regulatory requirements for environmental management in Nigeria. One of such regulation is the Nigerian EIA Act Cap E12 LFN 2004, which stipulates that an EIA is compulsory for projects of this magnitude that have potential for significant environmental impacts. Also, the ESIA has been carried out to meet the International Finance Corporation (IFC)/ World Bank standards.

The ESIA process aims at providing detailed information for decision-making and to contribute to environmentally, and socially sound and sustainable development.

Consultations with the host community (Kankiya) and other stakeholders have been carried out and shall continue throughout the project lifecycle. Consultation and engagement meeting ensured that all answers to questions concerning the proposed project were provided to the satisfaction of stakeholders.

Environmental baseline conditions (biophysical and socio-economic) as well as sensitive components of the study area were established through field data gathering/ sampling and complemented with information from literature/ desktop research, maps and information from articles on the area. The established baseline data will serve as future reference and for monitoring purposes.

Climatic information was obtained from Nigerian Meteorological Agency. Results from laboratory analyses of groundwater, and soil were obtained from samples collected from the study area. air/ noise measurements were obtained in-situ at the study area.

Air quality data shows that parameters measured were below both FMEnv and WHO limits as well as equipment detection limits (except for SPM in a station). Noise levels were compliant with regulatory limits for industrial and residential areas. Groundwater, and soil analyses results showed that analysed parameters were consistent across sample stations.

Interactions between the biophysical and socio-economic components of the existing environment and the PV-based solar power plant project environmental aspects were used to identify, characterise and evaluate the potential and associated impacts of the proposed project. Thereafter, mitigation measures/ recommendations to ensure the sustainability of the project based on best industry practices, available technology and HSE considerations were developed for the significant impacts.

An Environmental, Social Management Plan (ESMP) was developed in the course of this study to ensure that procedures for managing adverse impacts of the power plant operations as well as the implementation of the environmental and social commitments made are maintained throughout the duration of the project. The ESMP also contains the environmental monitoring programme that would be used to monitor future changes to the environment from project activities. As a result, NSF would ensure that air pollutants, noise and groundwater are monitored in line with FMEnv and World Bank (IFC) standards.

Finally, it is hoped that all necessary information/ evidence contained in this report is sufficient in the development of an Environmental Impact Statement (EIS) and acquisition of necessary permits for the operation of the utility scale PV-based solar power plant project.

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