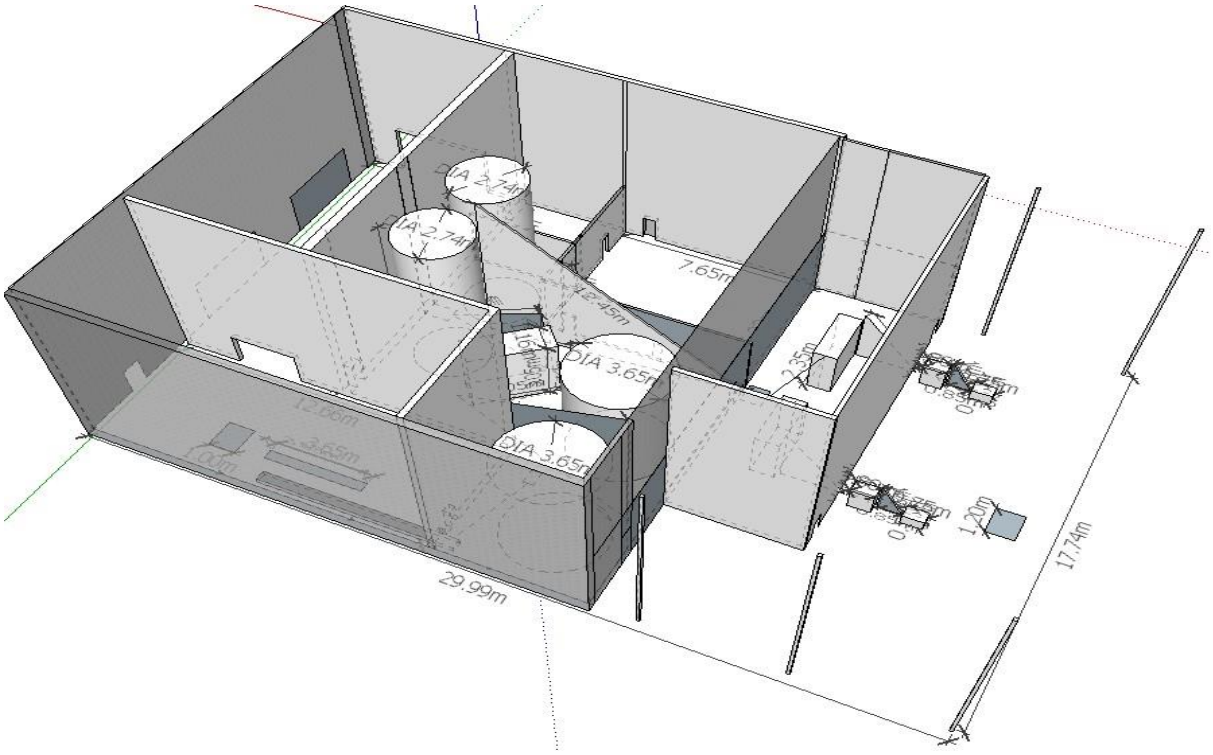
Environmental Impact and Social Assessment

For

the proposed Bio-Control Product (Aflasafe) Plant at Makun, Obafemi Owode LGA, Ogun State



Prepared by

Harvestfield Agrohao Industries Ltd
1, Isheri road, Olowora, Omole Phase 2,
Ikeja, Lagos State

Submitted to

Federal Ministry of Environment

Environment House, Mabushi, Abuja, Nigeria

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LIST OF ABBREVIATIONS

µg	Microgram
µm	Micrometer
µS/cm	MicroSiemens per centimeter
AAS	Atomic Absorption Spectrophotometer
AC	Alternating Current
acfh	Actual Cubic Feet per Hour
Ag	Silver
AIDS	Acquired Immune Deficiency Syndrome
Al	Aluminum
ALARP	As Low As Reasonably Practical
AML	Approved Manufacturers List
ANSI	American National Standard Institute
APHA	American Public Health Association
APM	Afrika Managers Limited
As	Arsenic
ASCE	American Society for Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
B	Boron
Ba	Barium
BAT	Best Available Technology
BOD	Biological Oxygen Demand
Br	Bromine
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
Btu	British Thermal Units
°C	Celsius
Ca	Calcium
$CaCO_3$	Calcium Carbonate
CBD	Convention on Biological Diversity
CBO	Community Based Organization
cc	Cubic Centimeter
Cd	Cadmium
CDC	Community Development Department
CFC	Chlorofluorocarbon
CFR	Code of Federal Regulations
CFU	Colony Forming Unit
CH_4	Methane
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
Cl^-	Chloride
cm	Centimeters

Cmol (+) Kg^{-1}	Centimoles of Positive Charge per Kilogram
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
Cr	Chromium
CSR	Corporate Social Responsibility
Cu	Copper
dB	Decibels
dBA	Decibels weighted to 'A' scale
DC	Direct Current
DD	Data Deficient
DGPS	Digital Global Positioning System
DIN	Deutsche Industrie-Norm (German Industrial Standard)
DNV	Det Norske Veritas
DO	Dissolved Oxygen
DPR	Department of Petroleum Resources
DPS	Dynamic Positioning System
E	East
EA	Environmental Audit
EAP	Environmental Action Plan
EBS	Environmental Baseline Survey
EC	Electrical Conductivity
EER	Environmental Evaluation Report
EEZ	Exclusive Economic Zone
EG&S	Environmental Guidelines and Standards
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMS	Environmental Management System
EPA	Environmental Protection Agency
ERP	Emergency Response Plan
ESIA	Environmental and Social Impact Assessment
ESS	Emergency Support System
ETP	Effluent Treatment Plant
F	Fahrenheit
FAO	Food and Agriculture Organisation
FBE	Fusion Bonded Epoxy
Fe	Iron
FEED	Front End Engineering Design
FEPA	Federal Environmental Protection Agency
FGD	Focus Group Discussion
FMEnv	Federal Ministry of the Environment
FOS	Federal Office of Statistics

Ft	Feet
G	Gram
Gal	Gallon
Gg	Gigagram
GHG	Greenhouse Gas
H_2CO_3	Carbonic Acid
H_2S	Hydrogen Sulfide
ha	Hectare
HCO_3	Hydrogen Carbonate
Hg	Mercury
HH	Household
HIV	Human Immunodeficiency Virus
HP	High Pressure
HP	High Power
hp	Horsepower
hr	Hour
HRH	His Royal Highness
HSE	Health, Safety, and Environmental
HSEMP	Health, Safety, and Environmental Management Plan
HSEMS	Health, Safety, and Environmental Management System
HV	High Voltage
HVAC	Heating Ventilation Air Conditioning
I/C	Interconnect
I/O	Input and Output
IDSR	Integrated Disease Surveillance and Response
IFC	International Finance Corporation
II&R	Incident Investigation and Reporting
in	Inches
ISO	International Standard Organization
ITCZ	Inter-tropical Convergence Zone
IUCN	International Union for Conservation of Nature and Natural Resources
JHA	Job Hazard Analysis
K	Potassium
kg	Kilogram
khz	Kilohertz
km	Kilometers
km^2	Kilometer Squared
kW	Kilowatt
kWh	Kilowatt Hour
L	Liter
LASEPA	Lagos State Environmental Protection Agency
lb	Pound

lbs/MWh	Pounds per Megawatt Hour
LCDA	Local Council Development Area
LEL	Lower Explosive Limit
LFL	Lower Flammability Limit
LGAs	Local Government Areas
Li	Lithium
LP	Low Pressure
LV	Low Voltage
m	Meter
m^2	Square Meter
m^3	Cubic Meter
mEq	Milliequivalent
Mg	Magnesium
mg	Milligram
MIS	Management Information System
mL	Milliliter
mm	Millimeter
MMS	Maintenance Management System
Mn	Manganese
MoU	Memorandum of Understanding
MP	Medium Pressure
Ms	Millisecond
MSDS	Material Safety Data Sheet
MTons	Million tons
MV	Medium Voltage
MVA	Motor Vehicle Accidents
MW	Megawatts
MWh	Mega Watt Hour
N	Nitrogen
Na	Sodium
NaCl	Sodium Chloride
NAFDAC	National Agency for Food and Drug Administration and Control
NESREA	National Environmental Standards and Regulations Enforcement Agency
NCE	Nigeria Certificate in Education
NGO	Non-Government Organizations
NH_3	Ammonia
Ni	Nickel
nm	Nanometer
NO_2	Nitrite
NO_3	Nitrate
NOx	Nitrous Oxides
NPA	Nigerian Ports Authority

OC	Organic Carbon
O&M	Operations and Maintenance
OGEPA	Ogun State Environmental Protection Agency
OSC	On-the-Scene-Co-coordinator
OSHA	Occupational Safety and Health Administration
OTJ	Off-the-job
P	Phosphorus
PAH	Polycyclic Aromatic Hydrocarbons
PAI	Pesticides Active Ingredients
Pb	Lead
PCBs	Poly Chlorinated Biphenyls
PCS	Process Control System
PO_4	Phosphate
ppb	Parts Per Billion
PPE	Personal Protective Equipment
ppm	Parts Per Million
PSI	Pounds per square inch
PSM	Process Safety Management
PSV	Pressure Safety Valve
PVC	Polyvinyl chloride
QA	Quality Assurance
QC	Quality Control
RAP	Resettlement Action Plan
RCF	Refractory Ceramic Fibers
RIV	Relative Importance Values
S	South
s	Seconds
Scf	Standard cubic foot
scf/m	Standard Cubic Foot per Minute.
SDV	Shut Down Valve
sec	Seconds
Si	Silicon
SIA	Social Impact Assessment
SO_2	Sulfur Dioxide
SO_4	Sulfate
SO_X	Sulfur Oxides
SOP	Standard Operating Procedure
SSCE	Senior Secondary School Certificate Examination
SSS	Safety Shutdown System
STD	Sexually Transmitted Disease
STU	Sewage Treatment Unit
SWA	Stop Work Authority

TEG	Tri-ethylene Glycol
THC	Total Hydrocarbons
TLV	Threshold Limit Value
tn	Ton
TOC	Total Organic Carbon
TOM	Total Organic Matter
TOR	Terms of Reference
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
UES	Uniform Effluent Standards
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNO	United Nations Organization
UPS	Uninterruptible Power Supply
USEPA	United States Environment Protection Agency
V	Vanadium
V	Volt
VAC	Volts Alternating Current
VDC	Volts Direct Current
VOC	Volatile Organic Compound
WHO	World Health Organization
WMP	Waste Management Plan
yr	Year
Zn	Zinc

ACKNOWLEDGEMENT

Harvestfield Agrohao Industries Limited wishes to acknowledge and thank the Federal Ministry of Environment, Ogun State Ministry of Environment and State Environmental Protection Agency, host communities, NGOs, CBOs and other concerned stakeholders and persons, for their cooperation, assistance and support during the period of this study. Profound appreciation goes to those who provided aid in technical and project planning matters to produce the Environmental Impact Assessment (EIA) Report for the proposed Bio-Control Product (Aflasafe) Plant at Makun, Obafemi Owode LGA, Ogun State.

EXECUTIVE SUMMARY

ES 1.0 Introduction

Harvestfield Agrohao Industries Limited is an Agriculture and Agro-Allied company duly registered in Nigeria. The company has a factory office at Km 40, Lagos Ibadan Expressway while the Head office is at Isheri Road, Omole Phase II, Lagos. One of Nigeria's leading agro-chemical companies with a mission to become the major driver of Agrochemical, Bio-control agents, spraying equipment, seed and public Health business in Nigeria, employing the best brains and offering quality products for **CROP PROTECTION (** Chemicals – Fungicides, Pesticides, Herbicides, Bio-Control –Aflasafe, Bio-Stimulants – Nodumax), **SEEDS (**Vegetables, Grains {Rice, Maize}), **PUBLIC HEALTH (**Insecticide Treated Nets, Fumigants, Rodenticides), **AGRICULTURAL EQUIPMENT (**Agro-Chemical Sprayers, PPE).

Harvestfield Industries Limited proposed to construct Aflasafe Bio-control Plant for the production of Aflatoxin safe-products into the Nigerian market for use by farmers. The factory will be constructed on four acres of land within Ogun Property Investment Corporation (OPIC) Industrial Estate, Makun, along Lagos -Ibadan Express Road, Ogun State.

Aflasafe commercialization in Nigeria is being driven by Harvestfield Industries Limited. The engagement started in 2017, with a non-exclusive distributorship agreement with IITA's Business Incubation Platform (BIP). The one-year agreement provided HIL opportunity to test the market potential and entry strategy for Aflasafe. With the signing of a TTLA with IITA in 2018, HIL strengthened its position as the appointed and exclusive manufacturer and distributor of Aflasafe in Nigeria.

In compliance with the requirements of the *Environmental Impact Assessment (EIA) Act Cap E12, LFN 2004* of Federal Ministry of Environment (FMEnv) Harvestfield through her consultant, Spatial Ecosystems Limited (SPEC), accredited by Federal Ministry of Environment (FMEnv) and National Environmental Standards and Regulations Enforcement Agency (NESREA), wishes to carry out an Environmental and Social Impact Assessment of the proposed Aflasafe Bio-control Plant. The ESIA presents the baseline environmental condition of the receiving environment, identified associated and potential impacts of the proposed development and recommended control techniques/mitigation measures to manage the impacts.

The assessment was carried out to amongst other things:

- ✓ determine the baseline (biophysical, social and health) conditions of proposed project environment;

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

The ESIA scope of work includes:

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

The ESIA Methodology includes:

1) Project scoping exercise
2) Site verification
3) Desktop literature survey
4) Stakeholder consultation
5) Baseline field data gathering

6) Project impact assessment and development of mitigation measures
7) Development of Environmental Management Plan
8) ESIA submission and
9) Post ESIA impact mitigation monitoring

The proposed project is affected by a number of national, state and international legislation which have been considered by the ESIA. Some of the legislation are as follows:

- Ogun State Environmental Protection Agency (OGEPA)
- Ogun State Urban and Physical Planning
- National Policy on Environment (1989, Revised 1999). Issued by Federal Environmental Protection Agency (FEPA)
- Environmental Impact Assessment (EIA) Act CAP E12, LFN 2004
- Land Use Act L5 LFN 2004
- Forestry Law CAP 55, 1994
- Workmen Compensation Act, 1987
- Abandonment Guidelines 1995
- National Environmental Standards and Regulations Enforcement Agency (Establishment) Act (2007)
- National Agency for Food and Drug Administration and Control (NAFDAC) Act Cap NI LFN 2004
- Harmful Wastes CAP HI LFN 2004
- UNFCCC, Paris agreement of 2016 [The agreement was signed on 22 September, 2016 and ratified by Nigeria on 16th May, 2017]
- Polluters Pays Principle (Adopted by Nigeria in 1999)
- World Bank Guidelines on Environmental Assessment
- Nagoya Protocol of 2010
- Kyoto Protocol of 2004
- The IFC Performance Standards

EX 2.0 Project Justification

Maize and groundnuts are significant sources of human food, animal feed and income in sub-Saharan Africa. Maize is Africa's most important food crop grown on nearly 30 million hectares of land and supporting over 300 million people on the continent. It is an important income generating food staple in Nigeria and its importance has been increasing over the years. Nigeria is the largest maize and groundnut producer in West Africa. However, maize and groundnuts are particularly prone to aflatoxin contamination. Chronic aflatoxin ingestion has been linked to liver cancer, immune-

system suppression, growth retardation, and more rapid progression of HIV/AID. Aflasafe is a safe natural solution to the problem of aflatoxin. It works from the plot to your plate to stop contamination from reaching dangerous levels and keep foods like maize and groundnuts safe to eat.

The benefit of the project includes:

- Eliminating aflatoxin means getting rid of one of the major causes of cancer in Africa. Liver cancer is the third most common cancer on our continent, and at least 30% of cases are down to aflatoxin. Liver cancer is also incredibly deadly, killing about 95% of its victims, so by stopping it we could save tens of thousands of lives each year.
- It can protect our children from stunting and blighted development due to the damage caused by aflatoxin.
- It can prevent harm to our immune systems. We can never know the exact causes of all sickness, but many diseases are always happy to see aflatoxin since it makes us generally weaker against them. We know that it contributes to HIV/AIDS and malaria, and makes vaccines less powerful.
- We can make sure we are better able to digest food by preventing damage to the intestine, reducing malnutrition and helping us get proper nourishment.

Economic benefits

- Aflasafe is highly cost-effective, reaping rich rewards for farmers and the food industry, and opening up new opportunities for individual businesses and national economies alike.
- Aflasafe is cheap to apply, costing only around USD 12–20 per hectare and fetching a premium on growing markets. Early studies show an excellent return on investment for farmers and other agricultural businesses.
- Aflasafe offers more trade opportunities, opening up export markets with stringent aflatoxin controls, such as the European Union. It is estimated that reducing aflatoxin contamination would add USD 281 million each year to groundnut exports in Nigeria alone.

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

- ✓ **Technical Sustainability:** The proposed project will be technically sustainable, utilizing modern practices and techniques in the plant design and adhering to international and national engineering design and construction standards and

codes of practices that shall be adopted throughout all stages of the proposed project development. In addition, the availability of adequate and qualified manpower for the project execution and operation phases shall also make the project to be technically sustainable.

- ✓ **Economic Sustainability:** Harvestfield Agrohao Industries Limited shall ensure standard business ethics and transparency; preventing corruption, encourage public advocacy and lobbying, transparency in payment of taxes, encouraging human right and security.
- ✓ **Environmental Sustainability:** The proposed plant project shall be environmentally sustainable because Harvestfield Agrohao Industries Limited's activities will continually be guided by its Health, Safety and Environment (HSE) policies and programs.
- ✓ **Social Sustainability:** To ensure social sustainability of the project, Harvestfield Agrohao Industries Limited will ensure:
    1. Robust stakeholder engagement
    2. Establish a grievance mechanism
    3. Corporate Social Responsibility

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

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

- Project options: No project options; Delayed project options; and Go-ahead option
- Project alternatives: Alternative location/site, alternative design/technology, Delivery channels alternative.

Option Three: Go-Ahead Option

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

Alternative 1 : Technology Alternatives

The proposed plant shall strict adherence to international and national terminal engineering design, construction standards and codes of practices which shall be adopted at all stages of the proposed project development to ensure the technical viability of the project. During operational stage, the proposed facility will serve as formulation plant, where local active ingredients are mixed with applicable solvents and packaged with latest technology for the Nigerian market. The technology includes cleaning, sterilisation, inoculation and packaging.

Alternative 2: Sites/ Location Alternatives

Several alternative sites for the Aflasafe facility location were evaluated. Selection of the preferred location for Harvestfield Company's facility was based on the following criteria (amongst others);

a) Transport: Proximity to the major road; Lagos-Ibadan Expressway
b) Sensitive area (Many of the existing environmental resources/values are not of prime importance) The project site: (1) does not contain any valuable ecological resources (either terrestrial or aquatic), (2) does not contain any items of archaeological significance or historical importance, (3) is not subject to floods or seismic disturbances,
c) Availability of already acquired land

Alternative 3: Delivery Channels Alternatives

In delivery of finished products to customers and farmers nationwide, Harvestfield will employ the following channels: Delivery to maize and groundnut farmers through National associations, Agro-dealers, HIL branch networks**.** Harvestfield will at no time deal with people or individuals who are going to monopolise the products.

In summary, the proposed project plan, including the current locations, is the most optimal. As such, the professional recommendation that can emanate from the foregoing is that the project can proceed as planned, as long as adequate measures are put in place to effectively mitigate/ameliorate the negative environmental and social impacts that may attend the proposed project. The various environmental impacts and the proposed mitigation options for the negative impacts are discussed in subsequent sections of this report.

ES 3.0 Project Description

Aflasafe commercialization in Nigeria is being driven by Harvestfield Industries Limited. The engagement started in 2017, with a non-exclusive distributorship agreement with IITA's Business Incubation Platform (BIP). The one-year agreement provided HIL

opportunity to test the market potential and entry strategy for Aflasafe. With the signing of a TTLA with IITA in 2018, HIL strengthened its position as the appointed and exclusive manufacturer and distributor of Aflasafe in Nigeria. The company has a factory office at Km 40, Lagos Ibadan Expressway while the Head office is at Isheri Road, Omole Phase II, Lagos. Harvestfield Industries Limited proposed to construct Aflasafe Bio-control Plant for the production of Aflatoxin safe-products into the Nigerian market for use by farmers. This would help farmers to effectively controls aflatoxin during crop development and post-harvesting.

Aflasafe uses a few simple elements:

- The active ingredient is a combination of **four friendly strains of the fungus *Aspergillus flavus*** that do not and can never produce aflatoxin. Each country has its own custom mixture, made of highly effective aflatoxin-busting strains that have been collected and tested locally. These spores are cultivated and made into a liquid suspension.
- A seed treater is used to coat the spores onto **ordinary sorghum grains** that have been cleaned and roasted, to kill and sterilise them so they cannot sprout or carry any other nasties. The sorghum acts both as vehicle and as food to support the spores of the friendly strains.
- Blue food coloring is added to distinguish Aflasafe from other sorghum for food or feed use – giving Aflasafe its distinctive blue colour (the exact shade can vary a bit).
- A small amount of **maize starch** (technically referred to as *polymer*) helps the spores to stick to the grain.

All that remains is to package up the Aflasafe into bags, and take samples for quality control testing before it is dispatched to farmers and distributors.
All the machinery used to make Aflasafe, such as the cleaner and roaster for the sorghum, the seed treater, and the packaging equipment, is available off-the-shelf throughout Africa, as it is commonly used by companies such as seed producers and feed manufacturers.

The process of making and producing Aflasafe include the following:

- Intake
- Weighing and Cleaning
- Clean Grain Storage
- Sterilization
- Cooling

- Sterilized Grain Storage
- Inoculation
- Packaging (Weighing and Sealing)
- The project activities

The project activities will broadly cover the following areas:

- Pre-construction activities include: site preparation, engineering design, materials delivery etc.
- Construction activities include: building of the Aflasafe Bio-control Factory structures, construction of office complex, installation of various equipment compressors, power generation equipment etc.), civil works etc.
- Operational activities include:operation of the Aflasafe plant, packaging and supply of same to customer locations etc.
- The decommissioning activities include: Removal of plant components for relocation or sale

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

Solid waste

1. Impurities of Active Ingredient (AI) can generate solid waste as a low percentage which might not be soluble in the solvent or water of the formulation. An estimation of 1 % of total impurity can be produced as hazardous solid waste.
2. Tanks from supply of liquid raw materials, bags from supply of powdery raw materials including will be given back to the suppliers through take back scheme. However, the company has put in incentive measure which meant farmers (product end users) to help the company retrieve the bottles for reuse.

Liquid waste

- ***Industrial Wastewaters*:** Liquid wastes resulting from health and safety measures such as compulsory shower, on site PPE washing amongst others, as well as sewage generated from the toilet facilities is estimated to be about 600,000litres/annum. Sewage will be collected in a septic tank from where they will be pumped, treated and disposed in line with regulatory provisions.
- ***Chemical Spills:*** Appropriate measures shall be employed in managing chemical spills. Where applicable, direct flushing with water shall be carried out. Covered containers shall be provided for the chemicals used on a routine basis in order to minimize spills.

- ***Hydrocarbon Spills:*** Minor hydrocarbon spills shall be cleaned immediately using appropriate absorbent granules and powders. Direct flushing into the river or environment shall not be permitted.

To ensure that wastes collected from the facility are disposed at designated waste management facilities and in the same condition and quantity, Harvestfield Agrohao Industries Ltd has developed and will adopt the use of a Waste Tracking Log. The log includes the Date, Type(s) and Quantity of waste transferred for handling/disposal. The supervisor of the waste generating facility ensures that all records of waste transferred are logged.

ES 4.0 Description of the Project Environment

The baseline environmental and social conditions were established using available literatures and a one-season field exercise carried in the study area. Dry season field sampling exercise was carried out between Thursday 12th and Friday 13th December, 2019. The wet season result was adapted from previous Environmental Impact Assessment Report of the Agro-Chemical Industrial Development by Harvestfield in November, 2014 and February 2015.

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

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

1) Weather and climate
2) Air quality and Noise
3) Groundwater
4) Soil
5) Plankton and benthos
6) Vegetation and wildlife
7) Geology
8) hydrology

The sampling was carried out in accordance with the requirements of FMEnv *EIA Cap E12 LF 2004*. A total of ten (10) geo-referenced sampling stations and additional two (2) control points were established in line with the ESIA Terms of Reference (ToR) for Soil

and Vegetation Study while a total of eleven (11) geo-referenced sampling stations and additional two (2) control points were established for Air Quality and Noise. One (1) sampling locations and one control for Groundwater while three (3) sampling locations with one (1) control were established for surface water and sediment within 2km spatial boundary. Soil, Groundwater and flora samples collected on the field were preserved with ice chests and immediately taken to Anila Resources (Nigeria) Limited, 5, Afisman Drive, Anifowoshe, Ikeja, Lagos State. Anila Limited is accredited by DPR and FMEnv.

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

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

Ogun State has two main rock types. These are the basement complex rocks of the pre-Cambrian age which are made up of the older and younger granites in the northern parts of the state, and the younger and older sedimentary rocks of both the tertiary and secondary ages in the southern parts (lloeje, 1983). The sedimentary rock overlies Dahomey basin which extends almost from Accra in Ghana, through the Republic of Togo and Benin to Nigeria where it is separated from Niger Delta basin by Okitipupa ridge at the Benin hinge flank.

Air pollutant gases and greenhouse gases are important air quality indicators. In view of the nature of the project with potential for emissions, these gases were determined in situ. The concentration of volatile organic compounds in the air was very low and below the FMEnv limit of 160 µg/ m^3 for dry season. However, VOC was not detected during 2014 wet and 2015 dry seasons. Suspended particulate matter determination yielded results within the range of 0.001 to 0.008 µg/m^3 for PM10 and 0.00 to 0.004 µg/m^3 for PM 2.5 during dry season 2019 while the same parameter (for PM10) ranged from

10.856 to 12.083 µg/m^3 during 2014 wet and ranged from 10.728 to 12.134 µg/m^3 during 2015 dry seasons. However, the values

In the study area, CO concentration obtained ranged from 0.00 – 0.01ppm during dry season 2019 The CO concentrations detected during the dry season under review were far below the FMEnv limit of 10ppm. However, CO ranged from 5 to 13ppm for 2014 wet season and 4 to 12ppm during 2015 dry season. This might be as a result anthropogenic activity during these periods of time.

The NOx detected from all the sampling locations during the dry and wet seasons (2014.2015 and 2019) were below the FMEnv limit which is 0.04 – 0.06 ppm. Also, SOx concentration detected at the sampling locations during the two seasons under review (wet season 2014, dry season 2015 and dry season 2019) were below the FMEnv limit of 0.1ppm. in the same vein, H_2S concentration detected at the sampling locations were below the FMEnv limit. However, this parameter was not measured during 2014 wet and 2015 dry seasons. The NH_3 values detected at the sampling locations were below the FMEnv limit. However, this parameter was not measured during 2014 wet and 2015 dry seasons.

Soil pH is a measure of the acidity or alkalinity of soil. A pH of 7 is neutral, a pH below 7 is acidic or sour, and a pH above 7 is alkaline. The pH value of soil affects the quality of plant growth because it directly affects nutrient availability in the soil. During dry season 2019, the pH of the proposed study ranged from 4.7 to 4.8 with a mean value of 4.75 for the top soil while the bottom soil ranged from 4.3 to 5.4 which shows that there has not been any serious variation. Generally, the pH of the study area is acidic. The Electrical Conductivity had concentrations ranging from 265 to 427µS/cm for the top soil; and 251.7 to 292.6 µS/cm for the bottom soil.

The exchangeable cations (K^+, Na^+ and Ca^{2+}) varied across the sampling locations and with depth .In the topsoil samples during the dry season, sodium ranged from 12.33 mg/kg to 29.81 mg/kg, potassium ranged from 6.08 mg/kg to 10.91mg/kg, magnesium ranged from 5mg/kg to 9.07mg/kg while calcium ranged from 20.05 mg/kg to 37.67mg/kg. In the bottom soil, sodium ranged from 15.15 mg/kg to 25.08 mg/kg, potassium ranged from 10.94 mg/kg to 14.37mg/kg, magnesium ranged from 5.79mg/kg to 9.32mg/kg while calcium ranged from 20 mg/kg to 35.51 mg/kg.

The exchangeable anions (NO_3^-, SO_4^{2-} and PO_4^{3-}) in the soil samples from the project area in the dry season, the mean concentrations of nitrate, sulphate and phosphate in topsoil and bottom were 3.28 and 2.83 mg/kg, 130 and 140 mg/kg and 8 and 8.5 mg/kg

respectively. During the study, the distribution of exchangeable anions in soil did not generally follow any particular trend.

For heavy metals, Cadmium values for both the top and bottom soil were below detection limit. Copper ranged from 16.47 to 33.45mg/kg for top soil while bottom soil ranged from 9.23 to 20.22mg/kg. Iron, ranged between 23mg/kg and 45mg/kg with a mean value of 34mg/kg for top soil while the subsoil ranged between 84 and 360mg/kg with a mean value of 222mg/kg. Nickel in both top and subsoil was below the detection limit (<0.001mg/kg) of the equipment used for the analysis. Lead in the top soil has a mean value of 0.02mg/kg, while the subsoil ranged between 0.01 and 0.02mg/kg with a mean value of 0.015mg/kg. Zinc concentration in the top soil ranged between 0.68 to 3.01mg/kg with a mean value of 1.845mg/kg, while subsoil ranged between 1.98 and 3.89mg/kg with a mean value of 2.94mg/kg.

Groundwater pH values ranged from 5.8 to 6.1 during dry season 2019 while the same parameter ranged from 5.96 which was acidic to 7.65 which was basic 2015 dry season and 6.06 to 6.13 during wet season 2014. Conductivity and TDS values ranged between 384 to 454 us/cm and 185 to 202 mg/L respectively during dry season 2019; 100.7 to 159.7 us/cm and 70.20 to 111.20mg/L respectively during 2015 dry season while it ranged from 99.5 to 142.80 us/cm respectively during wet season of 2014.

The water temperature ranged from 35.2 to 36.8^{0}C with a mean of 36.0^{0}C during dry season of 2019 while it ranged from 30.6 to 34.1^{0}C with a mean value of 32.35^{0}C during dry season of 2015 and 28.20 to 30.90^{0}C with a mean value of 29.55^{0}C during wet season of 2014. The DO values ranged between 4.5 to 5.1mg/L during dry season of 2019 and4.15 to 4.22mg/L during dry season of 2015 season while it ranged from 3.90 to 4.309mg/L during 2014 wet season. The results reveal that the water body in the project area can sustain life forms.

The BOD in the ground water was between 2.2 and 4.2mg/l during the dry season and 8.54 to 8.62mg/L during the dry season of 2015 and 9.30 to 9.70mg/L during wet season of 2014. On the other hand, COD which is an indirect measurement ranged between 18mg/L and 35mg/L for the dry season 2019 but was not measured during 2014 and 2015 field activities. Turbidity values recorded ranged from 2NTU to 3NTU for dry season but was not measured during 2014 and 2015 field activities.

The concentration of sulphate ranged from 20 to 21mg/L during dry season of 2019; 23.18 to 23.62mg/L during 2015 dry season and 23.39 to 23.50 during 2014 wet season. Chloride ranged from 20 to 21mg/L during 2019 dry season but was not

measured during 2014 and 2015 field activities. Phosphate on the other hand ranged from 0.41 to 0.48mg/L during dry season 2019; 0.13 to 0.39mg/L during dry season 2015 and 0.08 to 0.45mg/L during 2014 wet season.

Cations concentrations on the other hand for dry season 2019, Sodium ranged between 0.75mg/l and 1.23mg/l, Potassium, Magnesium and Calcium ranged from 0.12 to 0.18mg/L, 0.117 to 0.125mg/L and 12.02 to 14.01mg/L respectively. During dry season 2015, Sodium ranged from 1.39 to 1.40mg/L, Potassium ranged from 0.48 to 0.52mg/L, Magnesium ranged from 0.68 to 0.73mg/L and Calcium ranged from 0.03 to 0.08mg/L. Also during wet season 2014, Sodium ranged from 1.42 to 1.45mg/L, Potassium ranged from 0.50 to 0.51mg/L, Magnesium ranged from 0.72 to 0.75mg/L and Calcium ranged from 0.02 to 0.10mg/L The results indicate that the values obtained during the dry season 2019 are higher than what was obtained in 2015 dry season and 2014 wet season.

In 2019 dry season, the mean(s) of heavy metals concentration were as follow:
Cu(<0.015mg/kg); Cr(<0.001mg/kg); Fe(9.1mg/kg); Pb(<0.001mg/kg), Zn(<0.001) and Ni(< 0.001mg/kg).
In 2015 dry season similarly, the mean(s) concentration of the heavy metals were Cu(<0.01mg/kg); Cr(<0.02mg/kg); Fe(0.42mg/kg); Pb(0.06mg/kg), Zn(<0.01) and Ni(< 0.03mg/kg).
In 2014 wet season similarly, the mean(s) concentration of the heavy metals were Cu(<0.02mg/kg); Cr(<0.01mg/kg); Fe(0.52mg/kg); Pb(0.05mg/kg), Zn(<0.01) and Ni(< 0.04mg/kg). In all, the heavy metals results were below WHO and FMENV limits for heavy metals.

The larger percentage of the plant species encountered within the proposed site are grasses majorly *Panicum maximum* belonging to the family Poaceae. Plant species that were noted to be abundant and widely distributed at the site area include: *Panicum maximum, Cynodon dactylon, Aspilia Africana, Chromolaena Odorata, Sida acuta, Sida corymbosa, Commelina nudiflora, Tridax procumbens, Sporobolus Pyramidalis, Axonopus compressus, Amaranthus spinosus*.

The proximity of the proposed site to a major dual carriage road, Lagos-Ibadan Express, which a busy road with noise affected the sighting and detection of wildlife in the plot. Nevertheless, birds were mostly encountered, and they included partridges, starlings, wood pecker, and species of amphibians. Some of the wildlife species reported around the project area are Fire-footed tree squirrel, Giant Port Rats, Giant tree squirrel, Black

Kite, Common Sandpiper, Red-eyed Dove, African Pied Hombill, Blue-breasted Kingfisher, Senegal Coucal e.t.c

In order to determine the socio-economic status of the people of the Makun/Lenuwa communities, structured questionnaires were distributed to about seventy-five members of the community and sixty questionnaires were retrieved which is made up of forty-two (42) males and eighteen (18) females. The project is located at Makun community in Obafemi-Owode Local Government of Ogun State. Over 30% of the inhabitants claimed to be Christians and 60% claimed to be Muslim.

It was gathered that there are more males than females in the communities and It was also revealed that residents within 21 – 30years seem to be the most educated. The educational facilities in the communities are inadequate. There was no Government primary or secondary school close within the Community but there are private nursery and primary school.

There are some health facilities in the communities in Obafemi-Owode. These include public and a few private health care facilities. These health facilities range from maternity home, Health Centres, Dispensaries, Traditional Birth Attendants (TBAs) and Voluntary Health Workers (VHW). Others are Traditional Healing Homes, Spiritual Healing Homes and Patent Medicine Shops.

The supply of water to these communities comes from wells and boreholes (private) which are claimed to be good for drinking. The water from wells and boreholes are for home sores like bathing, washing and cooking. The community is connected to the national grid for power supply although irregular and they rely mostly on generators for their electricity. The health status of the communities in the project area was carried out and determined by means of baseline health data collected from below:
(i) Local health statistics from the health centres and clinics.
(ii) Consultation process with major stakeholders.
(iii) Field data in relation to:

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

- **Stakeholder engagement**

Stakeholder engagement is continuous and ongoing. The Social Impact Assessment undertaken for this ESIA included a comprehensive social survey to determine attitudes to the proposed project. This survey included semi-structured questionnaires and quantitative household surveys, focus group discussions. The issues that were raised by the public and responses to these issues are indicated in the body of the EIA report.

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

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

Pre-Construction phase activities

- Land take for Plant
- Mobilisation (transport) to site (equipment, personnel and construction modules)
- Energy requirements (provision of energy for construction)
- Labour requirements
- Site Preparation (vegetation and land clearing)
- Excavation of land area
- .

Construction phase activities

- Soil Excavation
- Site fabrication (welding) and coating
- Construction of Modules
- Backfilling
- Construction of silos
- Construction of office complex
- Installation of Transformer and Generator
- Commissioning of Plant
- Demobilization

The operational phase activities are

- Operations/ maintenance

The decommissioning activities include

- Demolition and Evacuation

The overall intent of the ESIA study is to identify and characterizes all the associated and environmental impacts or effects that will be caused by Harvestfield's proposed Aflasafe Plant project in Makun. Obafemi Owode LGA, Ogun State. Though there are a number of approaches for the prediction and evaluation of project environmental impacts, the ISO 14001 method was selected for this study. The ISO 14001 method is simple to apply, provides a high level of details and relies on limited data. Based on the method adopted, impacts ranging from low to severe significance were identified, qualified and quantified. Among the impacts that have high significance ranking include:

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

E.S.6 Mitigation Measures

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

Residual Effects can be considered as those that remain significant following the application of mitigation measures, although they are likely to have been reduced in magnitude as a result of the mitigation measure implemented. Overall, on balance, with the provision of the proposed mitigation measures outlined, the positive impacts of the scheme will considerably outweigh the negative impacts. The public as a whole will benefit from the completion of the project. Once the mitigation measures outlined are implemented, the residual impact of construction and operation on the different elements identified will not be significant. An overall mitigation measure is to undertake

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

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

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

Waste shall be managed in the following ways:

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

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

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

Environmental management activities of the proposed Harvestfield project shall be governed by a series of regulations that impose standards and mitigation of environmental hazards. Thus, it is a planned and integrated programme aimed at ensuring that both identified and unidentified impacts that may arise during the various phases of the project are brought to an acceptable level.

The Management commitment and responsibility of Harvestfieldare detailed in its Health, Safety and Environmental (HSE) policy. The company operates in strict

compliance with all the provisions of this HSE policy which specifies the need for adherence to national standards and guidelines by every member of staff and contractors, no matter how stringent. The HSE policy of Harvestfield states that projects are planned and executed in a manner that achieves the following:

- preserves the health, safety and security of its employees, the employees of Harvestfield contractors, and all members of the public who may be affected by its operations;
- minimizes the impact of its operations on the environment; and
- be sensitive to the needs and concerns of Harvestfield host communities.
- integrate health, safety and environmental matters into every aspect of its activities and set objectives to drive continual improvement;
- comply with all relevant health, safety and environmental laws and regulations;
- initiate and maintain effective arrangements for communication within the organisation, with contractors, the public or its agents and other stakeholders regarding health, safety and environmental matters;
- apply relevant standards, good engineering practices and principles of risk management to protect health, safety and the environment and to ensure the integrity, reliability and efficiency of the plant facilities;
- exhibit socially responsible leadership, demonstrate exemplary health, safety and environmental performance and publicly report performance;
- conserve Harvestfield's assets and natural resources, and minimise the impact of the plant's activities on the environment, by conducting impact assessments, and ensuring responsible management of emissions, discharges and waste streams. This includes efficient use of energy in its operations;
- identify present or future potential health, safety and environmental hazards resulting from plant operations, conduct risk assessments and select and implement appropriate measures to manage the risks;
- develop and implement a health, safety and environment plan which includes implementation of prioritised procedures to form a complete management system;
- maintain adequate emergency preparedness and response capabilities;
- effectively communicate Harvestfield's health, safety and environmental requirements to all contractors and subcontractors and require them to manage HSE in accordance with the Harvestfield's policy;
- ensure conformity with this policy by a comprehensive compliance program including audits; and

- adequately resource health, safety and environment functions throughout the business.
- focus on HSE to safeguard our people and assets
- adopt Health, Safety and Environmental best practices in the design, construction and operation of her facilities.
- comply with National and applicable International standards and laws on Health, Safety and Environment in the conduct of her operation.
- demonstrate social and ethical responsibility by working together with all relevant stakeholders to promote harmonious HSE compliant relationship.
- engage and consult with employees and others on Health, Safety and Environmental conditions and provide Occupational Health Services.
- maintain emergency response capability to minimize the impact of unfavorable negative incidents related to her operation.
- liaise closely with relevant government agencies in the formulation of Health, Safety and Environmental protection legislations, regulations or policies that may significantly impact the Group business returns to shareholders.
- publicly report on her HSE performance.
- ensure all staff have the right and duty to intervene and stop any unsafe acts and conditions or when activities are not in compliance with HSE policy and commitment.
- ensure that our Customers, Partners, Visitors and other Stakeholders comply with this HSE Policy.

E.S.8 Decommissioning and Restoration Plan

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

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

The Aflasafe plant and its ancillary installations have a design life of 30 years. It is expected that a time will come when the facility technology will either be outdated or its operation no longer economically viable. Since the Project depends on non-renewable

petroleum resources, the field project will eventually have to be abandoned and decommissioned at some point in its life cycle. Harvestfield would need to decommission the entire system when this situation arises. While this is not expected to occur within the **next thirty years**, it is, all the same, necessary to start planning, at this stage, for the closure stage, when the use of the facility have to be discontinued. This would ensure a safe, environmentally friendly, and efficient decommissioning/abandonment programme.

E.S.9 Conclusion

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

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

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

CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND INFORMATION

Harvestfield Agrohao Industries Limited is an Agriculture and Agro-Allied company duly registered in Nigeria. The company has a factory office at Km 40, Lagos Ibadan Expressway while the Head office is at Isheri Road, Omole Phase II, Lagos. One of Nigeria's leading agro-chemical companies with a mission to become the major driver of Agrochemical, Bio-control agents, spraying equipment, seed and public Health business in Nigeria, employing the best brains and offering quality products for **CROP PROTECTION (** Chemicals – Fungicides, Pesticides, Herbicides, Bio-Control –Aflasafe, Bio-Stimulants – Nodumax), **SEEDS (**Vegetables, Grains {Rice, Maize}), **PUBLIC HEALTH (**Insecticide Treated Nets, Fumigants, Rodenticides), **AGRICULTURAL EQUIPMENT (**Agro-Chemical Sprayers, PPE).

Harvestfield Industries Limited proposed to construct Aflasafe Bio-control Plant for the production of Aflatoxin safe-products into the Nigerian market for use by farmers. The factory will be constructed on four acres of land within Ogun Property Investment Corporation (OPIC) Industrial Estate, Makun, along Lagos -Ibadan Express Road, Ogun State.

Aflasafe commercialization in Nigeria is being driven by Harvestfield Industries Limited. The engagement started in 2017, with a non-exclusive distributorship agreement with IITA's Business Incubation Platform (BIP). The one-year agreement provided HIL opportunity to test the market potential and entry strategy for Aflasafe. With the signing of a TTLA with IITA in 2018, HIL strengthened its position as the appointed and exclusive manufacturer and distributor of Aflasafe in Nigeria.

In compliance with the requirements of the *Environmental Impact Assessment (EIA) Act Cap E12, LFN 2004* of Federal Ministry of Environment (FMEnv) Harvestfield through her consultant, Spatial Ecosystems Limited (SPEC), accredited by Federal Ministry of Environment (FMEnv) and National Environmental Standards and Regulations Enforcement Agency (NESREA), wishes to carry out an Environmental and Social Impact Assessment of the proposed Aflasafe Bio-control Plant. The ESIA presents the baseline environmental condition of the receiving environment, identified associated and potential impacts of the proposed development and recommended control techniques/mitigation measures to manage the impacts.

1.2 OBJECTIVES OF THE ESIA STUDY

In general, an ESIA is aimed at assessing the potential impacts of proposed project activities on the physical, chemical, biological, health and social components of the project environment with the aim of proffering appropriate mitigation measures to reduce the potential project's adverse impacts and enhance the beneficial ones.

The specific objectives of this ESIA for the proposed Aflasafe Bio-control Plant are to:

- describe the proposed project's environment; by providing specific details of the baseline characteristic of the environment of the proposed project;
- provide details of the proposed plants and process design, along with their detailed operations and activities, hazardous materials to be used, their wastes stream including emissions and discharges, their planned disposal methods, and the built-in pollution control measures;
- assess the impacts of the proposed Aflasafe Bio-control Plant project activities at the different phases (design, construction, operation and decommissioning stages) on the environment including its area of influence;
- evaluate in quantitative terms, the adverse impacts in (magnitude, prevalence, duration, frequency of occurrence, risk and importance) and recommend reasonable and cost effective measures, procedures and practices to be followed during the design, construction, operation and decommissioning of the proposed

project to ensure that the environmental adverse effects are mitigated, minimized or ameliorated;

- recommend an Environmental and Social Management Plan for the Plant's life time, including compliance monitoring, auditing and contingency planning;
- provide the basis for regular and sustained consultation with the relevant regulatory authorities, the public and other stakeholders;
- ensure Client's strict compliance with the regulatory requirements and company policy on health, safety and environment (HSE) issues; and
- prepare all of the above in a report that is simple, concise and reader friendly.

1.3 ESIA Scope

The ESIA scope of work include:

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

1.4 ESIA Methodology

The methodology adopted for conducting this ESIA is summarized as follows:

(i) Preliminary Activities

Preliminary activities included developing/preparation of ESIA TOR for FMEnv approval.

(ii) Desktop/Literature Survey

Desktop/literature survey was conducted largely through consultation of existing environmental baseline studies/survey data collection from previous studies with FMEnv ESIA approval within the Local Government Area. Baseline data was carried out to determine the baseline condition of the natural environment through field work and laboratory analyses at **Anila Resources (Nigeria) Limited, 5, Afisman Drive, Anifowoshe, Ikeja, Lagos State, Nigeria**. This was done to verify and complement information obtained from desktop research. The fieldwork covered all the relevant aspects of the ecological and socio-economic and health environment.

(iii) Consultation with Regulators, Stakeholder and Experts

Consultation was an integral part of every phase in the ESIA implementation. This involved information dissemination and interaction/dialogues with the various stakeholders in the project including professionals in relevant fields of engineering, science, health and environmental issues. This was to intimate them of the project and associated activities, solicit/articulate their views, concerns and expectations on pertinent issues of environmental, social and health concern for integration into the impact prediction, assessment, evaluation and mitigation. SPEC on behalf of the proponent, consulted with all relevant stakeholders to ensure that their views and opinions concerning the proposed project and its associated and potential impacts were integrated into the ESIA process.

(iv) Impact Identification and Evaluation

At this stage of the ESIA study, the existing, potential and cumulative adverse or beneficial impacts of the project activities on the existing environment were identified by considering the interactions of the environmental aspects with the existing environment at the different phases of the project. The ESIA Guidelines (FMEnv 1995), the World Bank Environmental Assessment Source Book (1991), and the conceptual project description among other source references, were used in the process. Evaluation of the identified impacts were carried out using such criterion as legal/regulatory requirements

in respect of the current activities, magnitude of impacts, risk posed by impacts, public perception and importance of affected environmental component. The results are documented in chapter five of this report.

(v) Impact Mitigation

In proffering mitigation measures designed to prevent, reduce or control the adverse impacts of the environmental aspects of the project, professional judgment (based on scientific deductions) project experience, knowledge of the ecosystem in which the project is located and consensus of opinions among experts were used as tools Other resource materials also consulted include the FMEnv ESIA Guideline and the World Bank Environmental Source Book, etc. Also, enhance measures were proffered to ensure optimization of the beneficial impacts of the project. Chapter six of this report documents the mitigation measures prescribed for identified significant impacts of the project.

(vi) Reporting and Review

The Environmental and Social Impact Assessment (ESIA) of the project was subsequently documented as contained in this document. The final version of the report shall be issued at the end of regulators/stakeholders' review meetings. This shall incorporate all pertinent issues and comments arising from the review meeting as shall be directed by FMEnv. Also, in order to allow for on-going improvement of operational practices if those initially established prove inadequate, post auditing or monitoring has been designed into the Environmental and Social Management Plan (ESMP) developed for the project. The ESMP shall also enable a rapid rescue/response if an unforeseen social or environmental impact occurs from the proposed project.

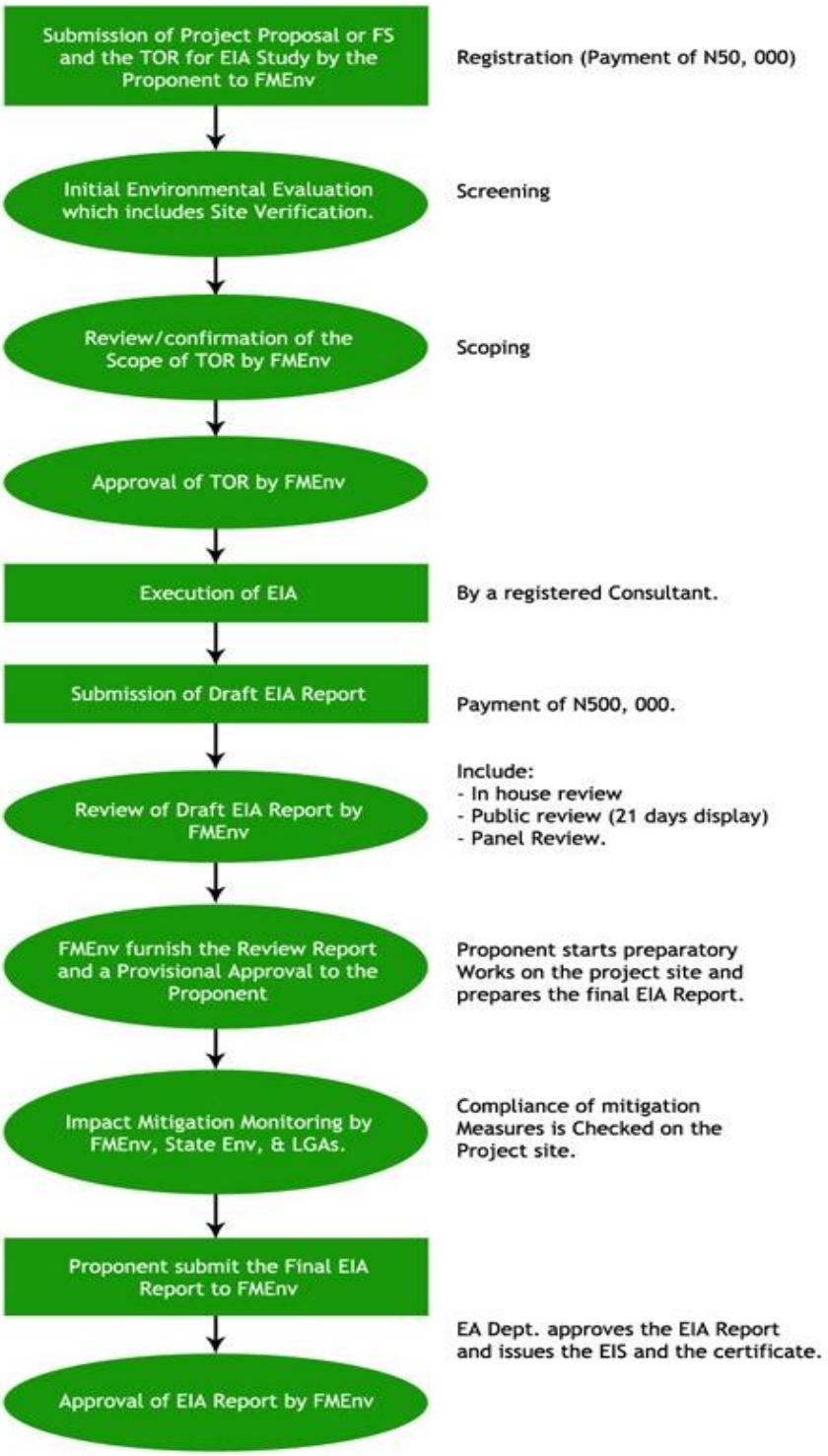

Figure 1.4: THE FMENV ESIA PROCEDURE

1.5 Legal and Regulatory Framework

In this section, relevant environmental conventions to which Nigeria is signatory, and relevant and applicable National and State environmental Regulations & Legislations and State Edits were carefully listed and concisely summarized. Applicable Corporate Health, Safety and Environmental (HSE) issues were also reviewed.

1.5.1 National Legislations

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

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

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

- **Federal Ministry of Environment (FMEnv)**

The Federal Ministry of Environment (FMEnv) was created in 1999 to take over the

function of the Federal Environmental Protection Agency (FEPA).

The FMEnv has a mandate to co-ordinate the environmental protection and conservation of natural resources for sustainable development in Nigeria. Their specific responsibilities include:

- monitoring and enforcement of environmental protection measures;
- prescription of standards and development of regulations on air quality, water quality, pollution and effluent limitations, the atmosphere and ozone layer protection, control of toxic and hazardous substances; and

As contained in FEPA Acts 58 of 1988 and 59 of 1992, FMEnv has put in place statutory documents to aid the monitoring, control and abatement of industrial waste and clearly state the restrictions imposed on the release of toxic substances into the environment and the responsibilities of all industries whose operations are likely to pollute the environment. Such responsibilities include provision of anti-pollution equipment and adequate treatment of effluent before being discharged into the environment, etc. (S.1.8 & 1.9).

A summary of statutory regulations enforced by the FMEnv include;

- National Environmental Protection (Effluent Limitation) Regulations, 1991 – S.I.8
- National Environmental Protection (Pollution Abatement in Industries and facilities Generating Wastes) Regulations, 1991 – S.I.9.
- National Environmental Protection (Management of Solid and Hazardous) Regulations, 1991 – S.I.15
- Environmental Impact Assessment Decree, 1992, Decree No. 86. now EIA Act CAP E12 LFN 2004.

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

The EIA institutional framework is provided by *Environmental Impact Assessment (EIA) Act. CAP E12, LFN 2004*. Environmental Impact Assessment (EIA) is an assessment of the potential impacts whether positive or negative, of a proposed project on the natural environment. The EIA Act makes EIA mandatory for all new major public and private

projects in Nigeria. The Act gives specific powers to FMEnv to facilitate environmental assessment of projects. It 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 organizations and persons when the proposed activities are likely to have significant environmental effects

- ➢ ***National Environmental Protection (Effluent Limitation) Regulation 1991, S. 1.8 Regulation 1991:*** Official Gazette, Federal Republic of Nigeria No. 42, Vol.78, August 1991, which requires installation of anti-pollution equipment for detoxification of effluents and chemical discharges from the company's existing facilities.

- ➢ ***National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Waste) Regulation 1991, S. 1.9 Regulation 1991:*** Official Gazette, Federal Republic of Nigeria No. 42, Vol. 78, August 1991, which imposes restrictions on the release of hazardous or toxic substances into the air, water and land into Nigeria's ecosystems beyond the limits approved by FEPA.

- ➢ ***National Environmental Protection (Management of Solid and Hazardous Waste) Regulation 1991, S. 1.15 Regulation 1991:*** Official Gazette, Federal Republic of Nigeria, No. 102, Vol. 78, 31st December, 1991; describes the requirements for Groundwater protection, surface impoundment, land treatment, waste piles, landfill, incinerators, etc.

- ➢ **Land Use Act L5 LFN 2004**

The Land Use Act L5 LFN of 2004 protects the rights of all Nigerians to use and

enjoy land in Nigeria which must be protected and preserved. Land acquisition must follow all the due process of law.

- **Forestry Law CAP 55, 1994**

This Act provides for the preservation of forests and the setting up of forest reserves.

- Prohibits any act that may lead to the destruction of or cause injury to any forest produce, forest growth or forestry property in Nigeria.
- Prescribes the administrative framework for the management, utilization and protection of forestry resources in Nigeria.

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

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

- **Labour Act, 1999**

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

- **Workmen Compensation Act, 1987**

This is an Act for the provision of compensation for injuries and death suffered by workmen in the course of their employment. This legislation, which was the first of its kind in Nigeria, sought to incorporate international standards relating to workmen's compensation and cater for the welfare of injured workmen.

(1) An employer shall pay compensation to any of his employees who suffers injury from any accident arising out of and in the course of his employment. (2) An employer shall pay compensation to the person or persons entitled to the estate of any of his

employees who dies as a result of any accident arising out of and in the course of his employment.

- **Abandonment Guidelines 1995**

The guidelines help to ensure the environment is returned to, as much as reasonably practicable, its original/baseline conditions.

- **National Environmental Standards and Regulations Enforcement Agency (Establishment) Act (2007)**

In a notice in the Federal Government Official Gazette No. 92, Vol. 94 of 31st July 2007, the establishment of this Agency was published. The Agency, Parastatals under the supervision of the Federal Ministry of Environment was established by an Act of the National Assembly, National Environmental Standards and Regulations Enforcement Agency (Establishment) Act, 2007. The Agency has responsibility for the protection and development of the environment, biodiversity conservation and sustainable development of Nigeria's natural resources in general and environmental technology, including coordination and liaison with relevant stakeholders within and outside Nigeria on matters of enforcement of environmental standards, regulations, rules, laws, policies and guidelines.

The NESREA Act repealed the Federal Environmental Protection Agency Act (FEPA Act) and established the National Environmental Standards and Regulations Enforcement Agency (NESREA). Although the NESREA Act repealed the FEPA Act, it nonetheless saved the subsidiary regulations made pursuant to the FEPA Act. The following FEPA regulations are still applicable under the NESREA Act:

- The National Environmental Protection (NEP) (Effluent Limitation) Regulations;
- The NEP (Pollution Abatement in Industries and Facilities Generating Waste) Regulations; and
- The NEP (Management of Solid and Hazardous Waste) Regulations.

Failure to comply with the provisions of the NESREA Act and the EIA Act gives rise to criminal and civil liabilities. For instance, with reference to pollution, section 20 (i) of the FEPA Act, cap 131, “discharge in such harmful quantities of any hazardous substance into the air or upon the land and the waters is prohibited except where such discharge is permitted or authorized under any law in force in Nigeria.

The followings are other excerpts from these regulations:

1. An industry or a facility shall:
    a) Have a pollution-monitoring unit in its premises {In-house Health, Safety and Environment team}
    b) Have on-site pollution control or assign the responsibility for pollution control to an Environmental consultant accredited by the agency.
    c) Analyze and report any form of discharge (solid, liquid or gaseous) to the nearest office of the Agency every month through the Discharge Monitoring Report.
2. An industry or facility shall submit to the nearest office of the Agency, a list of the chemicals used in the manufacturing of its products specifying.
    a) Details of stored chemicals and storage conditions.
    b) Where chemicals are bought and sold, obtain the name of the secondary buyers.
3. An industry or a facility shall set up machinery for combating pollution hazards.
4. The surrounding of a facility shall be maintained to preserve its aesthetic and sanitary conditions.

These regulations made it mandatory for industrial facilities to put in place appropriate measures that ensure the mitigation or abatement of environmentally degrading activities due to such facilities' activities. Specifically, for instance, Section 15 (6) of S.I.9 says “an industry or a facility with a new point source of pollution or a new process line

with a new point source shall apply to the Agency for discharge permit not later than 180 days before commencing the discharge of any effluent arising from any operation"

Furthermore, the under-listed regulations have equally been gazetted as supplementary to National Environmental Standards and Regulations Enforcement Agency (Enforcement) Act, 2007:

- The National Environmental (Wetlands, river bank and lake shores) S.I 26 of 2009, Regulations
- The National Environmental (Watershed, Mountainous, Hilly and Catchments Areas) S.I 27 of 2009, Regulations
- The National Environmental (sanitation and waste control) S.I 28 of 2009, Regulations
- The National Environmental (Mining and processing of coal, ores and Industrial Minerals) S.I 31 of 2009, Regulations
- The National Environmental (Food, beverages and Tobacco sector) S.I 33 of 2009, Regulations
- The National Environmental (Textile, Wearing Apparel, Leather and Footwear Industry) S.I 34 of 2009, Regulations
- The National Environmental (Noise standards and control) S.I 35 of 2009, Regulations
- The National Environmental (chemical, Pharmaceutical, soap and Detergent manufacturing Industries) S.I 36 of 2009, Regulations

These regulations are to prevent and minimize pollution from all operations and ancillary activities from all these sectors and maintained a healthy environment for all people in Nigeria.

Specifically, S.I 34 of 2009, Section 8 (1) says "every facility shall put in place organizational system for pollution control". It shall assign environmental pollution control Manager who oversees pollution control and prevention duties.

Section 11 (2a) says "no facility shall discharge or cause to be discharged any effluent, or oil in any form into water system, public drains, or underground injection and land without a permit from the agency."

- **National Agency for Food and Drug Administration and Control (NAFDAC) Act Cap NI LFN 2004**

In exercise of the powers conferred on the Governing Council of the National Agency for Food and Drug Administration and Control (NAFDAC) by Sections 5 and 30 of National Agency for Food and Drug Administration and Control Cap NI Laws of Federation of Nigeria 2004 and powers enabling it in that behalf, the Governing Council of the National Agency for Food and Drug Administration and control with the approval of the Honourable Minister of Health hereby makes the following Regulations:

- **Pesticides Registration Regulations, 2005**
- **Chemical Products (Monitoring) Regulations, 2010**

In addition to above listed regulations, there are draft regulations such as:

- Biofertilizer Advert Regulation 2014
- Bio-fertilizer Labeling Regulation 2014
- Bio-fertilizers Registration Regulation 2014
- Biopesticide Advert Regulation 2014
- Biopesticide Labeling Regulation 2014
- Bio-Pesticides Registraton Regulation 2014
- Fertilizer Advert Regulations 2014
- Fertilizer Labeling Regulation 2014
- Fertilizer Registration Regulation 2014
- Good Manufacturing Practices Regulation 2009

- **Harmful Wastes CAP HI LFN 2004**

Harmful Waste (Special Criminal Provisions etc) Act (Cap H1 LFN 2004). The Act was enacted with the specific object of prohibiting the carrying, depositing and dumping of

hazardous wastes on any land, territorial waters and matters relating thereto. This Act is essentially a penal legislation. The offences are constituted doing any of the act or omission stated in the section 12 of the act. The jurisdiction of the Act is far reaching as it sought to remove any immunity conferred by diplomatic immunities and privileges Act on any person for the purpose of criminal prosecution. It however important to note that despite its far-reaching jurisdiction, it focuses mainly on criminal prosecution of damage and does not provide compensation to the victim of the damage.

A synopsis of foregoing legislation and other relevant national legislations, guidelines, standards and regulations with their administering government bodies is thus presented in **Table 1.1** below.

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

S/N	Regulation	Requirement	Regulating Agency/Body
1	Environmental Impact Assessment (EIA) Act. CAP E12, LFN 2004	Permitting and Certification of Project and Monitoring	FMEnv.
2	Labour Act 1974 Cap 198 Vol. X p.7336	General provisions as to protection of wages and conditions of employment for unskilled labour.	Minister, Labour and Productivity
3	Labour Regulations 1974 Cap 198 Vol. X p 7418	Regulation for Labour Health areas	Minister, Labour and Productivity
4	National Environmental Protection (Effluent Limitation) Regulations 1991	Permitting Requirement, Effluent Discharge, Atmospheric Emission	FMEnv, DPR.

S/N	Regulation	Requirement	Regulating Agency/Body
5	National Environmental Protection (Pollution and Abatement in Industries in Facilities Producing Waste) Regulations 1991	Permitting Requirement, Solid Waste, Effluent Discharge, Atmospheric Emission	FMEnv, DPR.
6	National Environmental Protection (Management of Solid Hazardous Waste)	Solid Waste	NESREA.
7	Harmful Wastes (Special Criminal Provisions etc.) Act 1988, Cap 165, Vol. IXp. 6303	Solid Waste, Effluent Discharge	State Authorities, Ministry of Works and Housing
8	Guidelines and Standards for Environmental Pollution Control in Nigeria, 1991 Part I: Interim Guidelines and Standards for Industrial Effluent, Gaseous Emissions and Noise Limitations Part II: Guidelines for the Management of Solid Hazardous Waste	The basic instrument for monitoring and controlling industrial and urban pollution in all states and regions in Nigeria	FMEnv.

1.5.2 Ogun State Legislation

- ***Ogun State Environmental Protection Agency (OGEPA)***

The Ogun State Environmental Protection Agency (OGEPA) was signed into law in November 1996 with the primary responsibility of safeguarding the integrity of the environment in Ogun state. The establishing Act also empowers OGEPA to apply enforcement measures to combat environmental degradations of all kinds within the state. The agency though supervised by the Ogun State Ministry of Environment, retains the following functions among others:

- Policy formulation
- Establishment of guidelines and standards
- Prescription of procedure, penalties and compensation required for pollution abatement.
- The monitoring and control of all forms of environmental degradation from agricultural, industrial and government operations;
- The monitoring of surface, underground and potable water, air, land and soils within the State to determine the pollution level as well as collect baseline data.

- ***Environmental Pollution Control Law CAP 46***

This law establishes and mandates the Ogun State Ministry of Environment, to provide for the control and protection of Ogun State environmental resources, and also provides for the control and protection of the environment from pollution due to poor waste management. This law also prohibits the following;

- Discharge of any form of oil, grease; spent oil brought about in the course of business operations, especially into public drains and water course.
- Air pollution by emission of toxic gases and provides for the use of clean up equipment for vehicular emission
- The discharge of raw, untreated human waste into any public drain, water course, storm water drain or into any land or water.
- The storage of chemicals, lubricants, petroleum products, gases and radio-active materials in a residential and commercial area of the state without a written

permission from the Ministry

- Dumping of waste without prior written permission from the Ministry
- The treatment of waste water generated by industries prior to discharge to a satisfactory level.

➢ ***Ogun State Urban and Physical Planning***

This edict is basically meant to provide for the control of urban and regional planning activities in Ogun State. The Board, by the edict, is empowered to perform among others, the following functions:

- Formulate state policies for urban and regional planning and the physical development of the state, including spatial location of infrastructural facilities.
- Advise state government and initiate actions towards establishment of local planning authorities in the State.

1.5.3 International Conventions Ratified by Nigeria

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

Harvestfield is committed to its environmental management by complying with relevant international legislation covering various environmental effects arising from the operation of Aflasafe Bio-control Plant, including noise, gaseous emission, particulate, liquid effluent and solid waste.

➢ **Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and Their Disposal, 1989 (Nigeria signed the Basel Convention document on 15th march, 1990 and ratified it on 13th march, 1991. Nigeria also ratified the amendment to the Basel Convention on 24th may, 2004)**

The convention focuses attention on the hazards associated with the generation and disposal of hazardous wastes. The convention defines the wastes to the regulated and controls their trans-boundary movement to protect human and environmental health against their adverse effects. Some highlights of the convention include:

- The generator of hazardous waste should carry out duties with regard to the transport and disposal of such generated waste in a manner that is consistent with the protection of the environment, whatever the place of disposal,
- All should recognize that any State has the sovereign right to ban the entry or disposal of foreign hazardous wastes and other wastes in its territory,
- It should be recognized also that there is an increasing desire for the prohibition of trans boundary movements of hazardous wastes and their disposal in other States, especially developing countries,
- Hazardous wastes and other wastes should, as far as is compatible with environmentally sound and efficient management, be disposed of in the State where they were generated,
- Trans boundary movements of such wastes from the State of their generation to any other State should be permitted only when conducted under conditions which do not endanger human health and the environment, and under conditions in conformity with the provisions of this Convention,
- Control of trans boundary movement of hazardous wastes and other wastes will act as an incentive for their environmentally sound management and for the reduction of the volume of such trans boundary movement,
- States should take measures for the proper exchange of information on and control of the trans- boundary movement of hazardous wastes and other wastes from and to those States.

- **UNFCCC, Paris agreement of 2016 [The agreement was signed on 22 September, 2016 and ratified by Nigeria on 16th May, 2017]**

The Paris Agreement builds upon the Convention and for the first time brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort.

The Paris Agreement central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives. The Agreement also provides for enhanced transparency of action and support through a more robust transparency framework

- **Agenda 21 – United Nations Conference on Environment and Development**– also called the **Earth Summit [Nigeria signed the Basel Convention document in 1992 and ratified in 1994]**

Held in Rio de Janeiro, Brazil (1992), with recommendations from the WHO Commission, more than 150-member states adopted ***Agenda 21*** – an action plan to guide future strategies for health and environment activities on a national and international level which in fact provided the background for FEPA's EIA framework to ensure environmental sustainability of all types of activities in the Agro-chemical industry (FEPA, 1995).

- **United Nations Guiding Principles on the Human Environment [Nigeria signed the Basel Convention document in 1992 and ratified in 1994]**

The United Nations (UN) published the concept of Guiding Principles on the Human Environment in 1972. 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 Rio Declaration on Environment and Development [Nigeria signed the Basel Convention document in 1992 and ratified in 1994]**

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 was done 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 was also to aid work towards international agreements, which respect the interests of all, protect the integrity of the global environmental development system, and recognize the integral and interdependent nature of the earth.

- **Polluters Pays Principle (Adopted by Nigeria in 1999)**

In environmental law, the polluter pays principle is enacted to make the party responsible for producing pollution responsible for paying for the damage done to the natural environment. It is regarded as a regional custom because of the strong support it has received in most Organisation for Economic Co-operation and Development (OECD) and European Community (EC) countries.

The polluter pays principle underpins environmental policy such as an ecotax, which, if enacted by government, deters and essentially reduces greenhouse gas emissions. Some eco-taxes underpinned by the polluter pays principle include: the Gas Guzzler Tax, in US, Corporate Average Fuel Economy (CAFE) - a "polluter pays" fine. The U.S.

Superfund law requires polluters to pay for clean-up of hazardous waste sites, when the polluters can be identified.

Polluter pays, is also known as extended producer responsibility (EPR). This is a concept that was probably first described by Thomas Lindhqvist for the Swedish government in 1990. EPR seeks to shift the responsibility dealing with waste from governments (and thus, taxpayers and society at large) to the entities producing it. In effect, it internalised the cost of waste disposal into the cost of the product, theoretically meaning that the producers will improve the waste profile of their products, thus decreasing waste and increasing possibilities for reuse and recycling.

- **World Bank Guidelines on Environmental Assessment**

The World Bank requires an Environmental Impact Assessment (EIA) of projects proposed for Bank financing to help ensure that they are environmentally sound and sustainable in order to improve decision making. Additionally, the policy specifies that the Bank undertakes environmental screening of each proposed project to determine the appropriate extent and type of EIA. The Bank classifies projects into one of four categories, depending on the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential environmental impacts.

World Bank Operational and Safeguard Policies

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

The World Bank policies that have been triggered by the proposed Aflasafe Bio-control Plant project are:

- **Operational Policy (OP)/Bank Procedure (BP) 4.01: Environmental Assessment (last updated February 2011)**.
  This is the umbrella policy for the Bank's environmental 'safeguard policies' which among others include: Natural Habitats (OP 4.04), Forests (OP 4.36) and Physical Cultural Resources (OP 4.11).
- **Operational Policy/Bank Procedure 4.04** - ***Natural Habitat*** - seeks to ensure that World Bank-supported infrastructure and other development projects take into account the conservation of biodiversity, as well as the numerous environmental services and products which natural habitats provide to human society.
- **Operational Policy/Bank Procedure 4.36** - ***Forests.*** This policy aims to reduce deforestation, enhance the environmental contribution of forested areas, promote afforestation, reduce poverty, and encourage economic development.
- **Operational Policy 4.09 - *Pest Management* -** policy recognizes that pesticides can be persistent and harmful to the environment for a long time. If pesticides must be used, the policy requires that Pest Management Plan (PMP) be prepared by the borrower, either as a stand-alone document or as part of an Environmental Assessment.
- **Operational Policy /Bank Procedure 4.11 - *Physical Cultural Resources*** seeks to avoid, or mitigate, adverse impacts on cultural resources from development projects that the World Bank finances.

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

Such EA are carried out by the borrower to evaluate a project's potential environmental

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

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

- **Nagoya Protocol of 2010**

The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity, also known as the Nagoya Protocol on Access and Benefit Sharing (ABS) is a 2010 supplementary agreement to the 1992 Convention on Biological Diversity (CBD). Its aim is the implementation of one of the three objectives of the CBD: the fair and equitable sharing of benefits arising out of the utilization of genetic resources, thereby contributing to the conservation and sustainable use of biodiversity. However, there are concerns that the added bureaucracy and legislation will, overall, be damaging to the monitoring and collection of biodiversity, to conservation, to the international response to infectious diseases, and to research.

- **Kyoto Protocol of 2004**

The Kyoto Protocol is an international treaty which extends the 1992 United Nations Framework Convention on Climate Change (UNFCCC) that commits state parties to reduce greenhouse gas emissions, based on the scientific consensus that (part one) global warming is occurring and (part two) it is extremely likely that human-

made CO_2 emissions have predominantly caused it. The Kyoto Protocol was adopted in Kyoto, Japan on 11 December 1997 and entered into force on 16 February 2005. There are currently 192 parties (Canada withdrew from the protocol, effective December 2012) to the Protocol.

The Kyoto Protocol implemented the objective of the UNFCCC to reduce the onset of global warming by reducing greenhouse gas concentrations in the atmosphere to "a level that would prevent dangerous anthropogenic interference with the climate system" (Article 2). The Kyoto Protocol applies to the six greenhouse gases listed in Annex A: Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur hexafluoride (SF6).

The Protocol is based on the principle of common but differentiated responsibilities: it acknowledges that individual countries have different capabilities in combating climate change, owing to economic development, and therefore puts the obligation to reduce current emissions on developed countries on the basis that they are historically responsible for the current levels of greenhouse gases in the atmosphere.

- **Stockholm Convention Against Persistent Organic Pollutants of 2004**

Stockholm Convention on Persistent Organic Pollutants is an international environmental treaty, signed in 2001 and effective from May 2004, that aims to eliminate or restrict the production and use of persistent organic pollutants (POPs). In 1995, the Governing Council of the United Nations Environment Programme (UNEP) called for global action to be taken on POPs, which it defined as “chemical substances that persist in the environment, bio-accumulate through the food web, and pose a risk of causing adverse effects to human health and the environment”.

Following this, the Intergovernmental Forum on Chemical Safety (IFCS) and the International Programme on Chemical Safety (IPCS) prepared an assessment of the 12 worst offenders, known as the *dirty dozen*. The INC met five times between June

1998 and December 2000 to elaborate the convention, and delegates adopted the Stockholm Convention on POPs at the Conference of the Plenipotentiaries convened from 22–23 May 2001 in Stockholm, Sweden.

The negotiations for the Convention were completed on 23 May 2001 in Stockholm. The convention entered into force on 17 May 2004 with ratification by an initial 128 parties and 151 signatories. Co-signatories agree to outlaw nine of the dirty dozen chemicals, limit the use of DDT to malaria control, and curtail inadvertent production of dioxins and furans.

Parties to the convention have agreed to a process by which persistent toxic compounds can be reviewed and added to the convention, if they meet certain criteria for persistence and transboundary threat. The first set of new chemicals to be added to the Convention were agreed at a conference in Geneva on 8 May 2009.
As of June 2018, there are 182 parties to the Convention, (181 states and the European Union). Notable non-ratifying states include the United States, Israel, Malaysia, and Italy.
The Stockholm Convention was adopted to EU legislation in REGULATION (EC) No 850/2004.

- **Cartagena Protocol on Bio-safety of 2003**

The Cartagena Protocol on Biosafety to the Convention on Biological Diversity is an international agreement on biosafety as a supplement to the Convention on Biological Diversity effective since 2003. The Biosafety Protocol seeks to protect biological diversity from the potential risks posed by genetically modified organisms resulting from modern biotechnology.

The Biosafety Protocol makes clear that products from new technologies must be based on the precautionary principle and allow developing nations to balance public health against economic benefits. It will for example let countries ban imports of genetically

modified organisms if they feel there is not enough scientific evidence that the product is safe and requires exporters to label shipments containing genetically altered commodities such as corn or cotton.

- **Montreal Protocol on Substances that Deplete the Ozone Layer, 1988**

The Montreal Protocol on Substances that Deplete the Ozone Layer (a protocol to the Vienna Convention for the Protection of the Ozone Layer) is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion. It was agreed on 26 August 1987, and entered into force on 26 August 1989, followed by a first meeting in Helsinki, May 1989. Since then, it has undergone eight revisions, in 1990 (London), 1991 (Nairobi), 1992 (Copenhagen), 1993 (Bangkok), 1995 (Vienna), 1997 (Montreal), 1998 (Australia), 1999 (Beijing) and 2016 (Kigali, adopted, but not in force). As a result of the international agreement, the ozone hole in Antarctica is slowly recovering. Climate projections indicate that the ozone layer will return to 1980 levels between 2050 and 2070.

The treaty is structured around several groups of halogenated hydrocarbons that deplete stratospheric ozone. All of the ozone depleting substances controlled by the Montreal Protocol contain either chlorine or bromine (substances containing only fluorine do not harm the ozone layer). Some ozone-depleting substances (ODSs) are not yet controlled by the Montreal Protocol, including nitrous oxide (N_2O). For a table of ozone-depleting substances controlled by the Montreal Protocol see. For each group of ODSs, the treaty provides a timetable on which the production of those substances must be shot out and eventually eliminated. This included a 10-year phase-in for developing countries identified in Article 5 of the treaty.

The stated purpose of the treaty is that the signatory states: "Recognizing that worldwide emissions of certain substances can significantly deplete and otherwise modify the ozone layer in a manner that is likely to result in adverse effects on human

health and the environment. Determined to protect the ozone layer, precautionary measures were taken to control total global emissions of substances that deplete it, with the ultimate objective of their elimination on the basis of developments in scientific knowledge".

- **The 13th UN Biodiversity Conference – COP 13 of Cancun-Mexico, December 2016**

The UN Biodiversity Conference was held from 2-17 December 2016, in Cancun, Mexico. The Conference opened with a High-Level Segment on 2-3 December under the theme "Mainstreaming Biodiversity for Well-being." The main part of the UN Biodiversity Conference started Sunday afternoon, 4 December, and included the thirteenth meeting of the Conference of the Parties (COP 13) to the Convention on Biological Diversity (CBD), the eighth meeting of the Conference of the Parties serving as the Meeting of the Parties to the Cartagena Protocol on Biosafety (CP COP-MOP 8) and the second meeting of the Conference of the Parties serving as the Meeting of the Parties to the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (NP COP-MOP 2). More than 8,000 delegates participated in the Conference, representing parties and other governments, UN agencies, intergovernmental, non-governmental, indigenous and local community organizations, academia and the private sector.

The Conference addressed jointly: issues related to operations of the Convention, including integration among the Convention and its Protocols, and reporting; capacity building and technical and scientific cooperation; cooperation with other conventions and international organizations; and resource mobilization, the financial mechanism and the budget for the next biennium.

CBD COP 13 further considered a series of substantive, organizational and financial issues, and adopted 37 decisions. Among other items, it reviewed progress towards implementation of the Strategic Plan for Biodiversity 2011-2020 and the achievement of

the Aichi Biodiversity Targets, and related means of implementation; and considered strategic actions to enhance implementation of the Strategic Plan and achievement of the Aichi Targets, including with respect to mainstreaming and the integration of biodiversity within and across sectors.

CP COP-MOP 8 adopted 19 decisions. It considered the report of the Compliance Committee; reviewed the Framework and Action Plan for Capacity Building; provided guidance on the operation and activities of the Biosafety Clearing-House; and addressed issues on risk assessment and risk management, including a coordinated approach on the issue of synthetic biology, and socio-economic considerations, among other items.

NP COP-MOP 2 reviewed progress towards Aichi Target 16 on the Nagoya Protocol, and adopted 14 decisions on, among other issues, on the need for and modalities of a global multilateral benefit-sharing mechanism, and the Access and Benefit-sharing (ABS) Clearing-House.

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

Table 1.3: International Regulations and Conventions Relating to Environmental Protection in Nigeria

Sn	Regulation/Convention	Year Ratified
1	Convention on the Continental Shelf (CSC).	1958
2	African Convention on the Conservation of nature and Natural Resources.	1968
3	Convention Concerning the Protection of the World Cultural and National Heritage (World Heritage Convention).	1972
4	Protocol Concerning Cooperation in Combating Pollution in Cases of Emergency in the West and Central African Region.	1981

Sn	Regulation/Convention	Year Ratified
5	Convention for the Protection of the Ozone Layer.	1985
6	Protocol on Substances that Deplete the Ozone Layer. Note: The protocol was amended for the first time on 29 June 1990 in London. A second set of amendments was adopted in Copenhagen in November 1992; these entered into force on 1994.	1987
7	Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal of 1989 (Basel Convention).	1989
8	United Nations Framework Convention on Climate Change (UNFCCC)	1992
9	Convention on Biological Diversity.	1994
10	World Bank Environmental Assessment Source Books	1998

1.5.4 International Best Practices

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

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

➢ **The IFC Performance Standards**

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

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

✓ **Labour and Working Conditions:** For any business, its workforce is a valuable asset and a sound worker-management relationship is a key component of the overall success of the enterprise. By protecting the basic rights of workers, treating workers fairly and providing them with safe and healthy working conditions, commercial clients/investees can enhance the efficiency and productivity of their operations and strengthen worker commitment and retention.

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

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

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

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

- ✓ **Indigenous Peoples:** Indigenous Peoples are recognized as social groups with identities that are distinct from other groups in national societies and are often among the marginalized and vulnerable. Their economic, social and legal status may

limit their capacity to defend their interests and rights to lands and natural and cultural resources. Commercial clients/investees are required to ensure that their business activities respect the identity, culture and natural resource-based livelihoods of Indigenous Peoples and reduce exposure to impoverishment and disease.

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

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

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

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

- ***The "Equator Principles"***

The Equator Principles (EPs) are a voluntary set of guidelines which provide credit risk management framework for determining, assessing and managing environmental and social risk in project finance transactions. They apply globally to development projects with a capital cost of $50 million or more in all industry sectors. Equator Principle Financial Institutions (EPFIs) commit to implementing the EP in their internal environmental policies, social policies, procedures and standards for financing projects, and they will not provide Project Finance or Project-Related Corporate loans to projects where the client will not, or is unable to comply with the EP. The latest revision to the EPs (referred to as The Equator Principles III – 2013) is effective from 4th June, 2013.

The EPs, which are broadly aligned with the IFC Sustainability Framework (2012), cover the areas Seen in Table ***1.4*** below:

Table 1.4: IFC Equator Principles

Code	Principle	Description
1	Review and categorization	Screening to determine the magnitude of the proposed project's potential environmental and social risks and impacts
2	Environmental and social assessment	Aimed at addressing the relevant environmental and social risks and impacts of the proposed Project, as well as, propose measures to minimize, mitigate, and offset adverse impacts in a manner relevant and appropriate to the nature and scale of the proposed Project
3	Applicable environmental and social standards	Ensure compliance with relevant host country laws, regulations and permits that pertain to environmental and social issues

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

Code	Principle	Description
10	Reporting and transparency	Ensure that, at a minimum, a summary of the ESIA is accessible and available online

1.6 Harvestfield Health, Safety and Environment (HSE)

Our goal is to protect our people, the public, our property and the environment in which we operate. It is a commitment that is in the best interest of our customers, our employees and all other stakeholders.

It is possible to execute all operations without injuries or damage to equipment or the environment:

- We are committed to the prevention of injury and ill health to our employees, contractors, visitors and other persons by adopting a planned and systematic approach to the management of occupational health and safety and providing the resources for its successful implementation and continual improvement.
- We will comply with all applicable laws and relevant industry standards of practice.
- We will continually evaluate the Health, Safety and Environment (HSE) aspects and impacts of our operations.
- We believe that effective HSE management is good business and we are committed to the continual improvement of HSE management practices.
- From top management through to entry level, everyone is responsible and accountable for HSE.
- We are committed to the integration of HSE objectives into our management systems at all levels. This will enhance our business success by reducing risk and adding value to our services.
- We shall communicate this policy to all persons working under the control of Harvestfield to ensure that they are made aware of their individual Occupational Health and Safety (‘’OH&S”) obligations and shall be made available to interested parties.

This policy shall be reviewed periodically to ensure it remains relevant and appropriate to the organization.

AIM

The aim of this policy is to ensure:

- All hazards and risks to health, safety and environment are identified, assessed and effectively controlled
- Measures to control hazards and risks to health, safety and environment are regularly monitored and evaluated
- Employees are consulted and encouraged to contribute to the decision making process on health and safety matters affecting their health and safety at work.
- All employees receive appropriate information, instruction, training and supervision they need to safely carry out their responsibilities.

Application of the Policy

This policy shall be applicable to Harvestfield Nigeria Plc in all its operations and functions.

1.7 Structure of the Report

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

Cover Page
Title Page
Table of Contents
List Tables
List of Figures
List of Plates
List of Acronyms and Abbreviations
List of ESIA Preparers
Acknowledgement
Declaration

CHAPTER TWO
PROJECT JUSTIFICATION

2.1 Introduction

Maize and groundnuts are significant sources of human food, animal feed and income in sub-Saharan Africa. Maize is Africa's most important food crop grown on nearly 30 million hectares of land and supporting over 300 million people on the continent (Fisher *et al.,* 2015). It is an important income generating food staple in Nigeria and its importance has been increasing over the years (Abdoulaye *et al.,* 2018). Nigeria is the largest maize and groundnut producer in West Africa (FAOSTAT, 2017). Maize and groundnuts are particularly prone to aflatoxin contamination (Bandyopadhyay *et al.*, 2016; Liu and Wu, 2010). Ogara *et al.* (2017) reported that 47% of their samples of Nigerian maize exceeded the European Union limit of 4 µg/kg for aflatoxins in food. Aflatoxin is a highly toxic metabolite produced by members of *Aspergillus* section *Flavi* – primarily *Aspergillus flavus* and *Aspergillus parasiticus* – commonly found in soils and on grain and legume crops (Bandyopadhyay *et al.*, 2016; Williams *et al.*, 2004).

2.2 Need for Project

Chronic aflatoxin ingestion has been linked to liver cancer, immune-system suppression, growth retardation, and more rapid progression of HIV/AIDS (Gong *et al.*, 2002; Turner *et al.*, 2003; Williams *et al.*, 2004). Furthermore, individuals already infected with Hepatitis B are at higher risk of liver cancer when co-exposed to aflatoxin B_1 (Groopman *et al.*, 2008).

Acute aflatoxicosis can cause rapid death from liver failure, as exemplified by the death of 125 Kenyans in 2004 (Azziz-Baumgartner *et al.,* 2005). Beyond the human health impacts of directly consuming aflatoxin-contaminated food, there are also negative impacts on farm animals consuming aflatoxin-contaminated feed, which lead to a reduced growth rate and productivity of the animals (Bryden, 2012) and attendant loss of income by poultry, dairy and fish industries. Furthermore, aflatoxin residues have

been found in dairy, meat, and poultry products originating from animals fed aflatoxin-contaminated feed (Iqbal *et al.*, 2014; Keyl and Booth, 1971). Hence the need for this proposed project (Aflasafe Plant) to combat the problem of aflatoxin in Nigeria production of maize and groundnut. Aflasafe is a safe natural solution to the problem of aflatoxin. It works from the plot to your plate to stop contamination from reaching dangerous levels and keep foods like maize and groundnuts safe to eat.

Aflasafe tackles toxic tragedy using harmless types of *Aspergillus flavus.* Surprisingly, this is the same kind of fungus that produces aflatoxin, but in this case, they are kindlier cousins that do not and cannot ever produce the toxin. Each country has its own version of Aflasafe using a mixture of four fungal strains, all found growing naturally in local soils. The friendly fungi are coated onto ordinary sorghum grain, which acts as a vehicle to help them get established and can easily be broadcast onto fields. It seems strange for the same fungus to be both poison and cure, but it is a bit like sending a thief to catch a thief: only *Aspergillus* can stop *Aspergillus*.

2.3 Benefit of the Project

Aflasafe dramatically cuts the amount of deadly aflatoxin in food, getting it down to zero or to very low levels. However, the most obvious benefit is that it could prevent severe outbreaks of aflatoxin poisoning, like the one that killed over 120 people in Kenya in 2004. But these tragedies are fortunately rare, and these deaths are only the tip of the aflatoxin iceberg.

Keeping aflatoxin out of our food, as we can do with Aflasafe, will also prevent aflatoxin building up in our bodies over months and years, and help us avoid a whole range of health problems down the line:

- Eliminating aflatoxin means getting rid of one of the major causes of cancer in Africa. Liver cancer is the third most common cancer on our continent, and at least 30% of cases are down to aflatoxin. Liver cancer is also incredibly deadly,

killing about 95% of its victims, so by stopping it we could save tens of thousands of lives each year.

- It can protect our children from stunting and blighted development due to the damage caused by aflatoxin.
- It can prevent harm to our immune systems. We can never know the exact causes of all sickness, but many diseases are always happy to see aflatoxin since it makes us generally weaker against them. We know that it contributes to HIV/AIDS and malaria, and makes vaccines less powerful.
- We can make sure we are better able to digest food by preventing damage to the intestine, reducing malnutrition and helping us get proper nourishment.

Economic benefits

- Aflasafe is highly cost-effective, reaping rich rewards for farmers and the food industry, and opening up new opportunities for individual businesses and national economies alike.
- Aflasafe is cheap to apply, costing only around USD 12–20 per hectare and fetching a premium on growing markets. Early studies show an excellent return on investment for farmers and other agricultural businesses.
- Aflasafe offers more trade opportunities, opening up export markets with stringent aflatoxin controls, such as the European Union. It is estimated that reducing aflatoxin contamination would add USD 281 million each year to groundnut exports in Nigeria alone.
- The rapidly-expanding poultry and livestock industries are keen to get their hands on aflatoxin-safe maize. Used in feed, it boosts productivity and reduces mortality in chickens by 40%.
- By reducing sickness, disability and early death due to conditions like liver cancer, immune system suppression and stunting, Aflasafe can help to reduce not only individual suffering but also the burden of healthcare costs and lost working income for families and nations.

These benefits extend to almost everyone in Africa, since we nearly all have some aflatoxin in our bodies. Aflatoxin exposure starts even before birth, and continues and builds up throughout our lives. By using Aflasafe to get this toxic killer out of our food we can break this cycle.

The project is in line with one of the Millennium Development Goals (MDGs) to eradicate poverty, through the creation of employment opportunities. The project is poised to improve overall economic activity for Obafemi Owode LGA. It is estimated that over 200 skilled and unskilled workers will directly or indirectly be engaged throughout the project lifecycle – pre-construction, construction, operations & maintenance and decommissioning phase.

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

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

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

- **Decommissioning:** The facility is likely to remain in place for about 50 years and therefore any decommissioning works would be a long time in the future. During this phase however, labour will be required for activities such as

dismantling/demolishing, recycling, re-planting etc. This will largely be sourced from the local community.

2.4 Value of the Project

The anticipated cost of the proposed project will be in the region of about 1.5 billion naira. A substantial amount of this fund will be injected into the local economy through various contracts and sub-contracts. In addition, the project has local and national economic values in terms of employment opportunities for various categories of Nigerian professionals, skilled and semi-skilled craftsmen, business opportunities and additional revenue for the government. Importantly, the site of the project was strategically selected with the intent to accomplish long term economic growth that will create local employment for various categories of indigenes in particular and Nigerian professionals in general.

2.5 Sustainability of the Project

2.5.1 Environmental Sustainability of the Project

The project's activities are guided by national and international environmental regulatory and design standards. The incorporation of the findings and recommendations of this ESIA at various stages of the Project shall comply with and meet environmental sustainability requirements. The company's strict adherence to the Environmental and Social Management Plan (ESMP) of this ESIA shall also help safeguard the environment at the various phases of the project activities and ensure sustainability.

In addition, the project activities shall be guided by the Harvestfield's HSE Policy. A standard Environmental Management System (EMS) which conforms with ISO 14001:2015 shall be developed for management of aspects and anticipated impacts of the plant.

The environmental sustainability of the project is premised on the following:

- Harvestfield shall ensure that all the plant is designed and installed in a manner that will keep all the potential adverse environment effects to the minimum and within the acceptable regulatory levels.
- A standard Waste Management Plan (WMP), aimed at pollution prevention strictly in line with regulator and best industry practice shall be developed for the plant.
- The principle of Best Available Technique (BAT) that prevents pollution and ensures maximum output shall be adopted
- Harvestfield and the project's contractors will maintain effective stakeholder relations and the establishment/maintenance of a conducive environment within the project's area of influence throughout projects lifecycle.

2.5.2 Technical Sustainability of the Project

The technical sustainability of the proposed project stems from the application of best available technology (BAT). To ensure technical sustainability of the plant, the following principles shall be enshrined by Harvestfield:

- Harvestfield have employed tested personnel who possesses years of valuable experience in the Bio-control Industry.
- Local content will be generously utilised in the plant design, construction and operation
- Skills transfer will be encouraged between expatriates' engineers and local engineers to close gap in knowledge throughout the plant life.
- Harvestfield shall ensure training and retraining of local Engineers.
- The time and resources expended towards evaluating the risks, uncertainties and overall potential of this project show that the project is technically feasible within reasonable cost.
- Also, strict adherence to international and national terminal engineering design, construction standards and codes of practices which shall be adopted at all

stages of the proposed project development to ensure the technical viability of the project.

2.5.3 Economic Sustainability

Harvestfield will ensure standard business ethics and transparency; preventing corruption, encourage public advocacy and lobbying, transparency in payment of taxes, encouraging human right and security. Money accruing from the sales of Aflasafe will continually enable Harvestfield meet its production and investment costs, contribute additional revenue to Ogun State and Federal Government of Nigeria from tax payments, create more jobs and meet its financial, socioeconomic and material obligations to the host communities. The favourable enabling environment ensures that the plant will continue to exist for decades as a business venture and as an industry.

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

- It contains four atoxigenic *A. flavus* strains native to Nigeria;
- There is a ready and viable market for Aflasafe products from the plant;
- Envisaged revenue accruing to the Plant from the sales of Aflasafe products will be sufficient to meet production and investment costs;
- The Plant will continuously support the government and host communities with respect to taxes, employment generation, and facility improvement among others.
- The proposed development of Aflasafe, formulation and packaging will reduce the cost of importation and also help in foreign trade with international countries.

2.5.4 Social Sustainability

To ensure social sustainability of the project, Harvestfield will ensure:

- ***Robust Stakeholder Engagement****:* Harvestfield will ensure effective Stakeholder Engagement in a structured and culturally appropriate manner with likely to be affected Communities. The consultation process will be tailored to the risks and impacts of the Project; the Project's phase of

development; the language preferences of the Affected Communities; their decision-making processes; and the needs of disadvantaged and vulnerable groups.

- ***Establish A Grievance Mechanism:*** designed to receive and facilitate resolution of concerns and grievances about the Project's environmental and social performance as part of its Environmental and Social Management System (ESMS). Sources of grievances could include community youths, militia group, etc.
- ***Corporate Social Responsibility***: The social sustainability of the project at Makun which will also emanate from the CSR of Harvestfield toward the host community and Obafemi Owode LGA at large and these include the following: skills acquisition, empowerment, employment and business opportunities, provision of social infrastructure, etc.

2.6 Project Options and Alternatives

Established ESIA processes including the requirements of Nigerian regulations call for an analysis of reasonable alternatives to various elements of the proposed project. To align with the Federal Ministry of Environment's (FMEnv) *National Environmental Protection Regulation of 1991* which mandates early selection of best engineering and operational options for new point sources, a range of alternatives and options were evaluated to facilitate identification of the most appropriate means of meeting the project's environmental objective.

Project alternatives analysis in environmental assessment is designed to bring environmental and social considerations into project selection as well as the early stages of project planning, and the later stages of site selection, design and implementation. The benefits of evaluating alternatives are for the selection of the best project design, selection of the best project location, and most efficient use of resources which will aid avoidance of adverse impacts and achievement of sustainable development goals. Therefore, the following options and alternatives were appraised:

- Project options: No project options; Delayed project options; and Go-ahead option
- Project alternatives: Alternative location/site, alternative design/technology, Delivery channels alternative.

2.6.1 Project Options

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

This option assumes that the project will not take place which means that no further development will take place in Makun because of non-viability of the feasibility studies. The No Project option will have a negative impact on the local and national economies. The significant socio-economic and industrial development benefits associated with the proposed development such as increased business opportunities, increased revenue to government, increased foreign exchange earnings, employment opportunities, etc. will be forfeited. As a result, the 'No Project option' was not considered to be a viable or acceptable option for the proposed project.

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

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

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

The Project option admits and emphasizes the vital need of the planned development. Considering its many benefits, this option was significantly weighed positive. This option will contribute to improved and increased production which will enhance the revenue

base of Nigeria. It will also enhance the job creation and many more direct and indirect socioeconomic benefits. This Go-Ahead option was deemed viable and therefore considered. The proposed project (Aflasafe Plant) should therefore be executed as planned.

2.6.2 Project Alternatives

During the formulation of the proposed project design, possible alternatives have been considered in compliance with the requirements of Nigeria's ESIA procedures together with international best practice and the IFC Performance Standards. The project alternatives are considered against location, technology/design, and storage tanks type.

Alternative 1: Technology Alternatives

The proposed plant shall strictly adhere to international and national terminal engineering design, construction standards and codes of practices which shall be adopted at all stages of the proposed project development to ensure the technical viability of the project. During operational stage, the proposed facility will serve as formulation plant, where local active ingredients are mixed with applicable solvents and packaged with latest technology for the Nigerian market. The technology includes cleaning, sterilisation, inoculation and packaging.

Alternative 2: Sites/ Location Alternatives

Several alternative sites for the Aflasafe facility location were evaluated. Selection of the preferred location for Harvestfield Company's facility was based on the following criteria (amongst others);

a) Transport: Proximity to the major road; Lagos-Ibadan Expressway
b) Sensitive area (Many of the existing environmental resources/values are not of prime importance) The project site: (1) does not contain any valuable ecological resources (either terrestrial or aquatic), (2) does not contain any items of archaeological significance or historical importance, (3) is not subject to floods or seismic disturbances, (4) is not heavily populated; The unit shall be located at least a radial distance of 1 km away from any human habitation (5) is not the

location of significant mineral resources or mining activities, and (6) is not a prime area for tourism, recreation, or aesthetic pursuits.

c) **Availability of already acquired land***:* Taking the proposed development to another location will mean that a new land will have to be acquired. Shifting the project to another location will incur additional cost on investment because new land has to be purchased; new business strategy needs to be adopted, etc. This action plan will also result in loss of time. The necessary approval for the current site has been obtained and all required fees have been paid by the proponent. It is obvious that the issue of liability and compensation is not likely to arise throughout the life span of the project. No community will be displaced as a result of the project, and so there is no resettlement or compensation case for any aggrieved person or group of persons.

Alternative 3: Delivery Channels Alternatives

In delivery of finished products to customers and farmers nationwide, Harvestfield will employ the following channels: Delivery to maize and groundnut farmers through National associations, Agro-dealers, HIL branch networks**.** Harvestfield will at no time deal with people or individuals who are going to monopolise the products.

Furthermore, the proposed development is expected to progress in an environmentally sustainable manner and from these adjudged criteria, the built at site option was considered the best suitable option.

2.8 Summary

In summary, the proposed project plan, including the current locations, is the most optimal. As such, the professional recommendation that can emanate from the foregoing is that the project can proceed as planned, as long as adequate measures are put in place to effectively mitigate/ameliorate the negative environmental and social impacts that may attend the proposed project. The various environmental impacts and

the proposed mitigation options for the negative impacts are discussed in subsequent sections of this report.

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CHAPTER THREE

PROJECT AND PROCESS DESCRIPTION

3.1 Introduction

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

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

3.2 Proponent

Aflasafe commercialization in Nigeria is being driven by Harvestfield Industries Limited. The engagement started in 2017, with a non-exclusive distributorship agreement with IITA's Business Incubation Platform (BIP). The one-year agreement provided HIL opportunity to test the market potential and entry strategy for Aflasafe. With the signing of a TTLA with IITA in 2018, HIL strengthened its position as the appointed and exclusive manufacturer and distributor of Aflasafe in Nigeria. The company has a factory office at Km 40, Lagos Ibadan Expressway while the Head office is at Isheri Road, Omole Phase II, Lagos.

3.3 Project Location

The Proposed Aflasafe Bio-control Factory for the production of Aflatoxin safe-products shall be located on N6.849003, E3.517855 (Point A), N6.844751, E3.514750 (Point B), N6.845192, E3.514682 (Point C), N6.845484. E3.514758(Point D) on four acres of land within OPIC Industrial Estate, Owode-Obafemi Local Government Area, Ogun State. The proposed site is about 1 kilometer from the existing EIA Approved project of Harvestfield Factory Location, Km 40, Lagos –Ibadan Expressway. The project site is occupied mostly by

vegetation (typically herbs, grasses, shrubs and trees). No human settlement is present within the land. However, there are communities about 1km from the site.

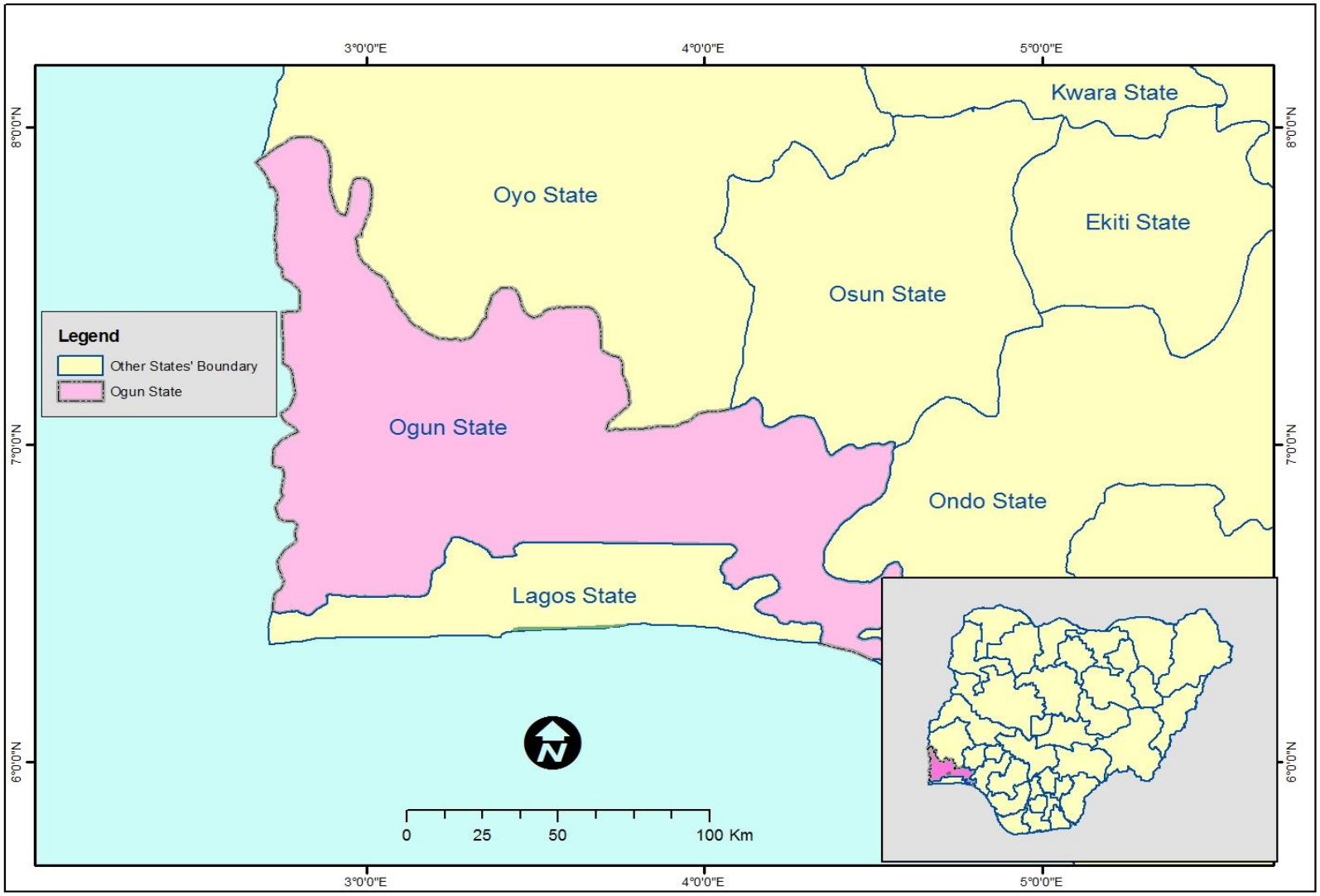

Figure 3.1: Map of Nigeria Showing Ogun State

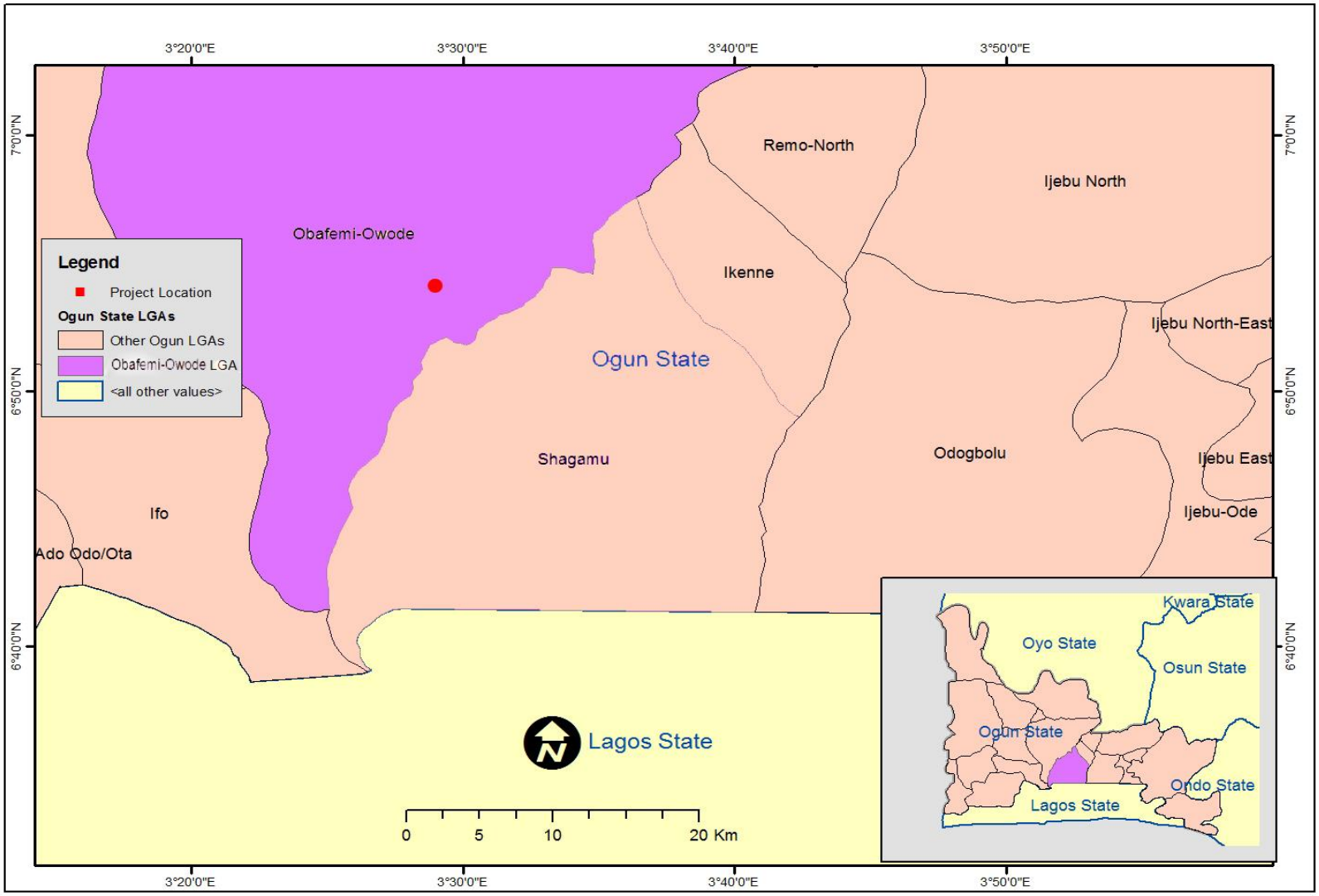

Figure 3.2: Map of Ogun State Showing Obafemi LGA and the project location Source: Harvestfield 2020

3.3 Project Description

Harvestfield Industries Limited proposed to construct Aflasafe Bio-control Plant for the production of Aflatoxin safe-products into the Nigerian market for use by farmers. This would help farmers to effectively controls aflatoxin during crop development and post-harvesting.

Aflasafe uses a few simple elements:

- The active ingredient is a combination of **four friendly strains of the fungus *Aspergillus flavus*** that do not and can never produce aflatoxin. Each country has its own custom mixture, made of highly effective aflatoxin-busting strains that have been collected and tested locally. These spores are cultivated and made into a liquid suspension.
- A seed treater is used to coat the spores onto **ordinary sorghum grains** that have been cleaned and roasted, to kill and sterilise them so they cannot sprout or carry any other nasties. The sorghum acts both as vehicle and as food to support the spores of the friendly strains.
- **Blue food colouring** is added to distinguish Aflasafe from other sorghum for food or feed use – giving Aflasafe its distinctive blue colour (the exact shade can vary a bit).
- A small amount of **maize starch** (technically referred to as *polymer*) helps the spores to stick to the grain.

All that remains is to package up the Aflasafe into bags, and take samples for quality control testing before it is dispatched to farmers and distributors.

All the machinery used to make Aflasafe, such as the cleaner and roaster for the sorghum, the seed treater, and the packaging equipment, is available off-the-shelf throughout Africa, as it is commonly used by companies such as seed producers and feed manufacturers.

Table 3.1: Business Model and Strategy

S/N	TARGET MARKET SEGMENT	SIZE (ha)	AFLASAFE DELIVERY CHANNELS	VALUE PROPOSITION
1	Smallholder farmers	≃6.5m	Delivery to maize and groundnut farmers through National associations, Agro-dealers, HIL branch networks.	• Safe crops, reduction in poisonous Aflatoxin levels and linkage to premium markets.
2	Multinationals and large-scale farmers	≃2.8m	B2B supply and delivery through HIL branch networks to out-grower schemes.	• 100% natural biological control. • Reduction of aflatoxin levels below 10ppb
3	Federal government	As appropriated	Delivery through HIL branch networks	• Reduction of aflatoxin levels to an average below 10ppb.

Source: Harvestfield, 2019

With this business model and strategy, Harvestfield shall unlock smallholder farmers demands which include: (1) Advocate for grain testing and quality certification process at Government's silos. (2) Continuous creation of awareness on the adverse impacts of aflatoxins.

3.3 Process Description

The process of making and producing Aflasafe include the following (see figure 3.4):

a) **Intake:** The crop received in bag or bulk is dumped into Lowry Dump pit. From the pit the crop is conveyed by a screw auger and elevated using belt and bucket elevator into a Bulk Weigher (W) for weight determination

b) **Weighing and Cleaning**: Weighing is carried out using AccuTech model AC200 Process weigher with print out option, used for weight determination. After weighing, the grain flows by gravity into the cleaner for cleaning. This cleaning comprises threshing using Carter Day Debearder, Pre-cleaning using Carter Scalperator and Fine cleaning using Carter Day Model 510 Fine Cleaner.

c) **Clean Grain Storage:** After cleaning the grain is elevated into clean grain storage silo (capacity 100 tons) for storage.

d) **Sterilization:** From the clean grain storage silo the grain is conveyed into the Grain Roaster for sterilization. Sterilization is carried out by heating the grain using LPG to very high temperature so that it exits the Roaster at over 140 0C.

e) **Cooling:** From Roaster the grain is conveyed into the Cooler. Since the grain exits the roaster at very high temperature not conducive for handling, a cooler is incorporated to cool the grain to near ambient temperature. Cooling is effected using air filtered through an HEPA filter.

f) **Sterilized Grain Storage:** After cooling, the sterile grains are conveyed using the grain loop into one of the 50-ton Sterilized grain storage silo. These silos are air tight to avoid any contamination and equipped with temperature and relative humidity sensors.

g) **Inoculation:** When production is required, the sterile grains stored in the Sterilized grain storage silos are conveyed using the grain loop into a seed treater for inoculation. USC

Model AT500EXT treater is installed to coat the sterile sorghum grains with the inoculum (mixture of 4 strains of Aspergillus flavus), dye and polymer.

h) **Packaging (Weighing and Sealing):** After inoculation, the grain is conveyed to AccuTech bagging unit. This bagging unit is composed of electronic weighers (for weighing to set weights), heat sealer for sealing the packets and ink jet for printing the batch/lot number.

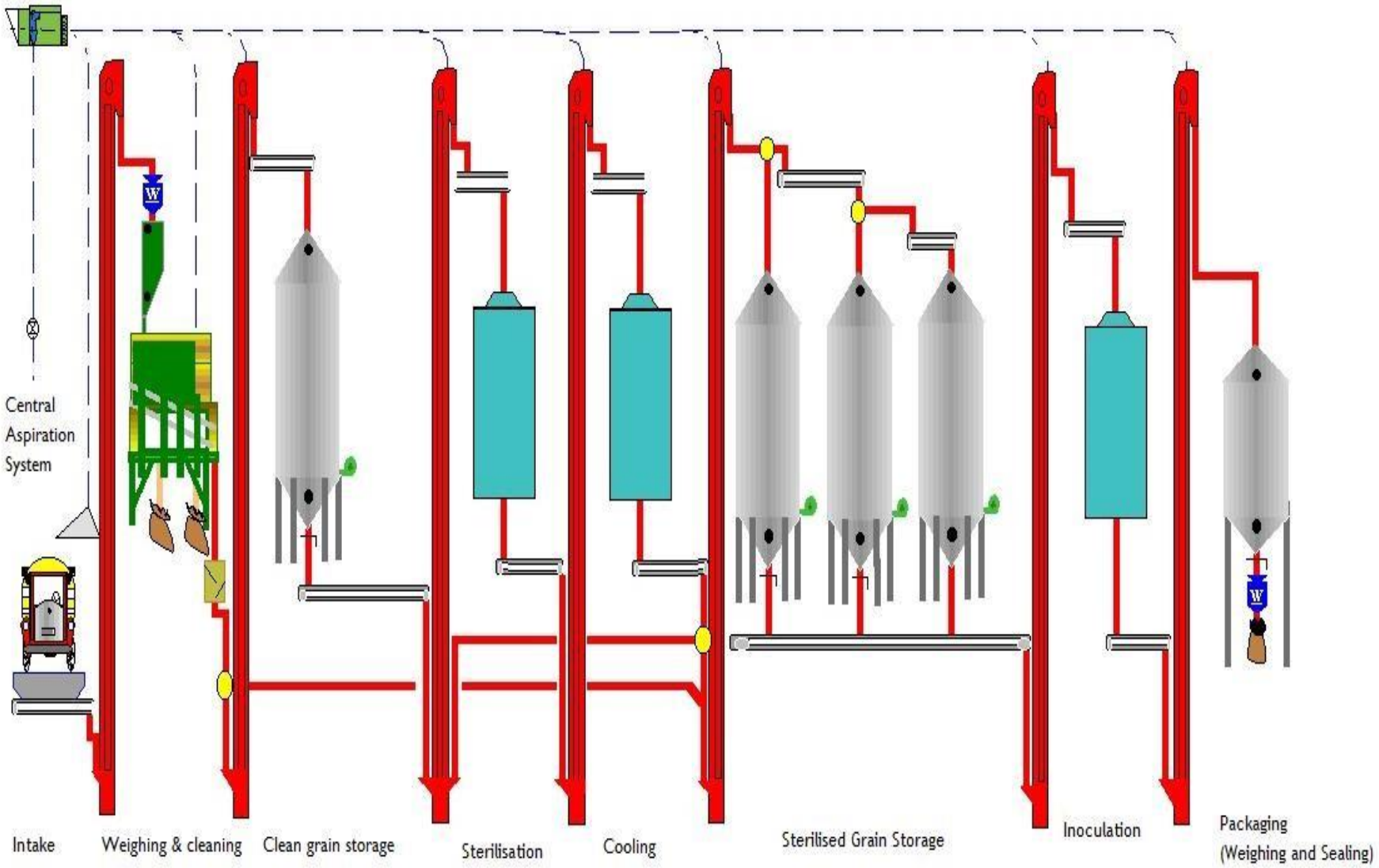

Figure 3.4a: Aflasafe Manaufacturing Plant Block Diagram

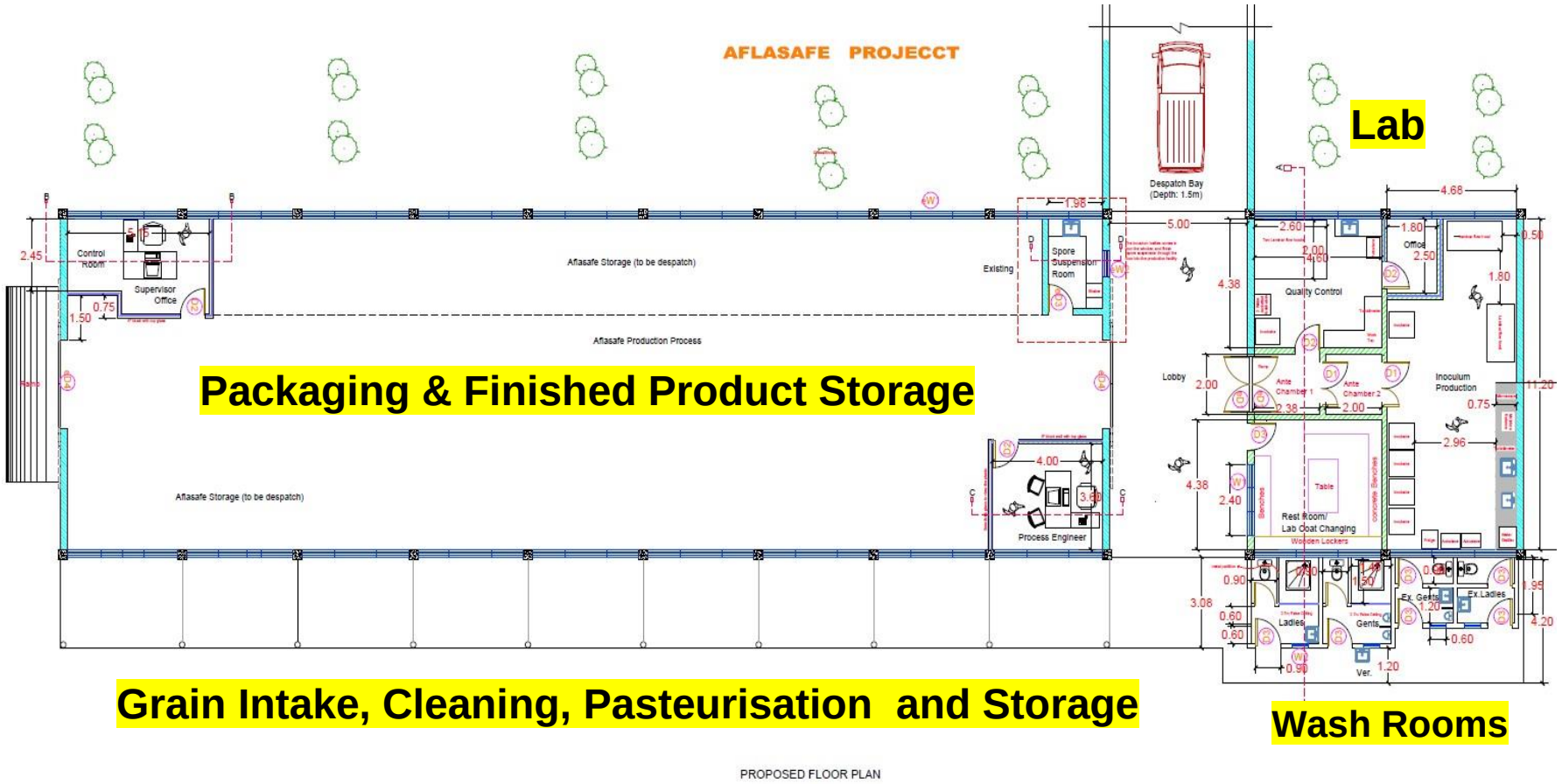

Figure 3.4b: Production Block Diagram

3.4 The Plant

Building: Approximately 10 m tall; 20m wide; 30 m long.
Silos hold about 20 tons each. .
Hoppers also in coater and packing

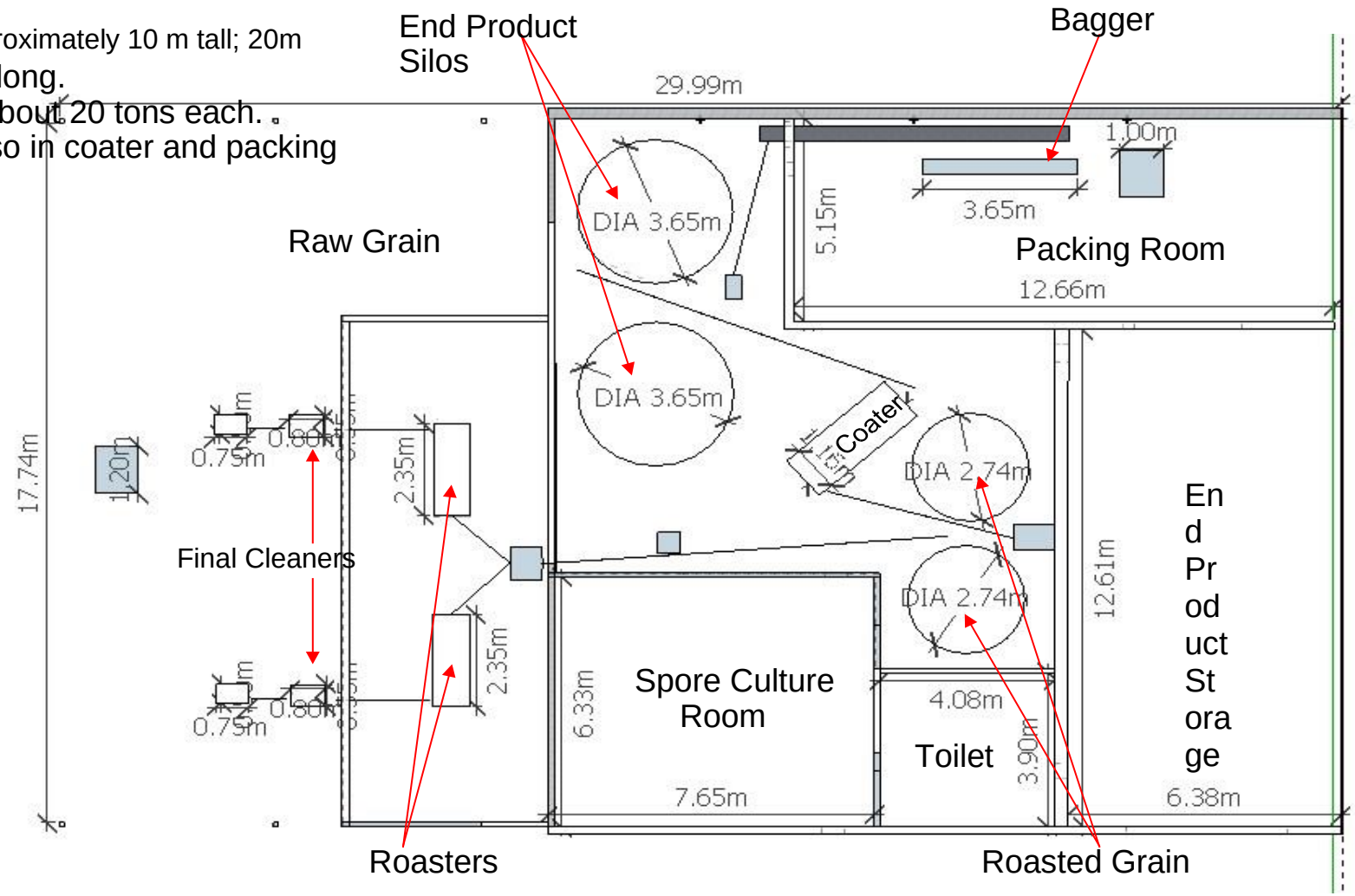

Figure 3.5a: The Modular Plant Schematic Diagram

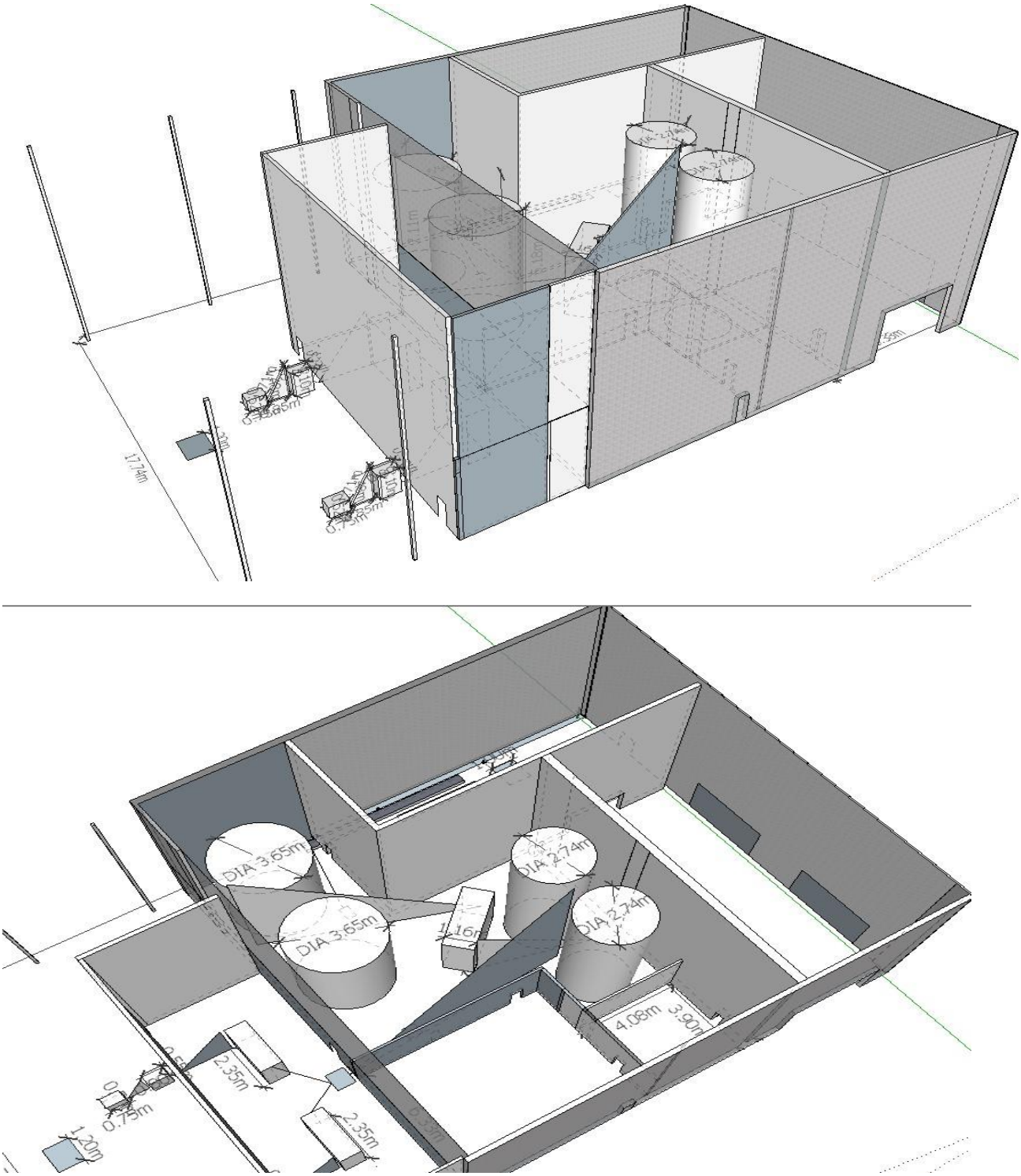

Figure 3.5ba: The Modular Plant Schematic Diagram

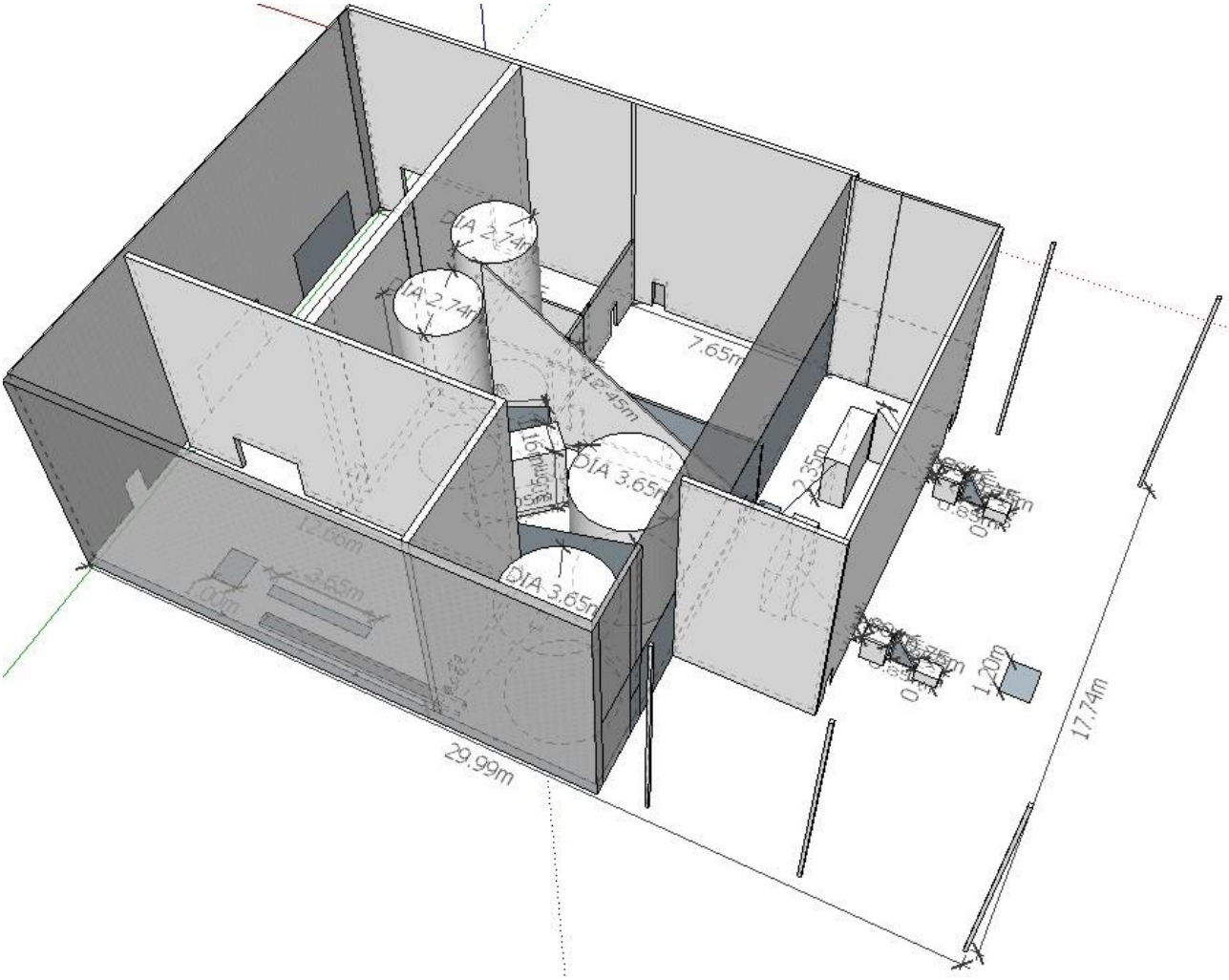

Figure 3.5c: The Modular Plant Schematic Diagram

3.4 The project activities

The project activities will broadly cover the following areas:

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

- **Construction activities include**
  - building of the Aflasafe Bio-control Factory structures

- construction of office complex
- installation of various equipment compressors, power generation equipment etc.)
- civil works.

- **Operational activities include**
  - operation of the Aflasafe plant,
  - Packaging and
  - supply of same to customer locations etc.
- **The decommissioning activities include**
  - Removal of plant components for relocation or sale

3.4.1 Site Preparation

The area (***4 acres of land***) in which the plant will occupy shall be cleared of all vegetation, graded and compacted to ensure adequate strength to accommodate the plant. As part of the site preparation, the existing road that leads to the site will be reinforced to allow movement of heavier traffic. The engineering design for the proposed project shall be made which will be followed by movement of construction materials.

3.4.2 Construction

This shall involve construction of the Aflasafe Bio-control Factory structures, office complex and installation of various equipment (compressors, power generation equipment etc.) in accordance to FMEnv requirement. Also, the civil work of the plant shall also be done during this phase. Upon completion of various equipment, the plant shall be started up and tested.

3.4.3 Operation and Maintenance

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

3.4.4 Plant Decommissioning

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

3.5 Plant Facilities

Generator Specifications: The plant shall rely solely on power supply from its generators to power its equipment due to the epileptic nature of power supply from National Grid. As such, power shall be generated from 2nos of diesel generators (500KVA each). The diesel storage tank of capacity of 10,000 litres shall be located close to the generators to store the generators' diesel.

Water Supply and Consumption: Plant water supply to the site will be from borehole water piped to the site and stored in the water storage tank. Two number of water storage tanks with capacity of 10,000 litres each shall be installed.

Firefighting system: This system shall comprise Fire extinguishers (DCP & CO_2), fire detection device, fire water tank, fire water hydrant system with fire hose reel shelter where the hose are kept and fire water pump. This shall provide boost the firefighting capability as well as providing coverage to fight/extinguish fire in the entire plant in an event of a fire outbreak.

Access Road and Perimeter Fence

Access road and perimeter fencing shall be a typical service provided at the Aflasafe Plant. As the name implies, the road shall provide easy access to the facility for entrance of the staff while the fence serves as an additional security and or access control. Thus, it ensures that only authorized personnel are allowed access at regular times.

Utility Vehicles

Utility vehicles, usually 4-wheel drive light pickup trucks (Hilux) shall be provided within the facility to ease logistics and provide support services for routine activities.

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

Smoke detectors: As part of a safety system, smoke detectors shall be installed to detect the presence of smokes with a control system so a process can be automatically shut down. The smoke detectors shall sound an alarm to operators in the area where the smoke is occurring, giving them the opportunity to leave.

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

Drainage System: Well-constructed and well-maintained drainage channels shall be installed to accommodate events of flood and spillage. The drainage channels shall run the entire perimeter of the plant.

Laboratory: Harvestfield Agrohao Industries Ltd shall develop a well-equipped quality control laboratory within its production facility that shall test the following parameters for each product;

- Potency;
- Emulsification;
- Density;
- Colour;
- pH;

- Particle Size (where required); and
- Suspension (where required).

Other standard laboratory product quality processes such as;

- Product's identification and verification;
- Stability Tests;
- Shelf-life determination; and
- Accelerated Studies.

The laboratory shall also be involved to establish products quality assurance protocols, in accordance with stipulated international quality standards and adopted best practices. Labels must be easy to read and shall meet the requirements of statutory regulations.

Laboratory Safety Protocols

Protective clothing shall be worn at all times within the production facility and the laboratory, by formulators or visitors. The protective garb shall include coveralls, a broad-brimmed hat, long-sleeved shirt, long socks, unlined neoprene or rubber gloves, long pants, and unlined neoprene or rubber boots. Eye goggles and/or a respirator shall also be used when required during the formulation process. All equipment shall also be checked and calibrated before use, with worn out equipment replaced promptly.

3.6 Waste Management

Aflasafe formulation and packaging processes shall generates both hazardous and non-hazardous solid and liquid wastes. However, Harvestfield is committed to the management of waste generated within its facility by adopting best waste management principles and practices as represented below.

3.6.1 Estimate of Waste to be Generated at The Harvestfield Ltd

Estimation of the waste both hazardous and non hazardous, solid and liquid is calculated for a 20, 000, 000 litres annual production capacity annually with a normal staff strength of

about 20 persons. However, projections have been made based on staff strength of 100 persons.

3.6.1.1 Solid waste

1. Impurities of Active Ingredient (AI) can generate solid waste as a low percentage which might not be soluble in the solvent or water of the formulation. An estimation of 1 % of total impurity can be produced as hazardous solid waste.
2. Tanks from supply of liquid raw materials, bags from supply of powdery raw materials including will be given back to the suppliers through take back scheme. However, the company has put in incentive measure which meant farmers (product end users) to help the company retrieve the bottles for reuse.

It is expected that no-hazardous solid waste (paper, plastic e.t.c) to be generated from normal office activities is not expected to exceed 4,800 kg/annum. Organic wastes, generated during operations shall be collected, segregated and transported to an approved disposal facility. No dumping of wastes in swamps, bush or rivers shall be permitted. All operational solid wastes shall be segregated prior to disposal, packaged and sold to appropriate third-party contractors or disposed of by the Ogun contractors authorized by the Ogun State Ministry of Environment/ Ogun State Environmental Protection Agency (OGEPA).

3.6.1.2 Liquid waste

An estimated liquid effluent amounting to 100,000 litres/annum is expected to be generated in the worst-case scenario (total failure of treatment to a reasonable 20,000 litres) could be recorded.

- ***Industrial Wastewaters*:** Liquid wastes resulting from health and safety measures such as compulsory shower, on site PPE washing amongst others, as well as sewage generated from the toilet facilities is estimated to be about 600,000litres/annum. Sewage will be collected in a septic tank from where they will be pumped, treated and disposed in line with regulatory provisions.

- ***Chemical Spills:*** Appropriate measures shall be employed in managing chemical spills. Where applicable, direct flushing with water shall be carried out. Covered containers shall be provided for the chemicals used on a routine basis in order to minimize spills.
- ***Hydrocarbon Spills:*** Minor hydrocarbon spills shall be cleaned immediately using appropriate absorbent granules and powders. Direct flushing into the river or environment shall not be permitted.

3.6.2 Waste Minimisation and Prevention

Waste minimization is the process and the policy of reducing the amount of waste produced by a person or a society. Waste minimisation is also strongly related to efforts to minimize resource and energy use by prevention of waste production. It usually requires knowledge of the production process, cradle-to-grave analysis and detailed knowledge of the composition of the waste. Waste prevention requires knowledge of the production process and products life.

Waste prevention covers 'Prevention, Reduction at source' and 'Re-use of products while waste minimization is a broader term than prevention and it includes the waste management measures 'quality improvements' (such as reducing the hazardous substances) and 'recycling'.

Harvestfield Waste Management minimization practice emphasises the development of measures such as:

- Promotion of clean technologies and products,
- Reduction of the hazardousness of wastes,
- The use of environmentally friendly materials as against certain dangerous substances in products
- Promotion of re-use and recycling schemes,
- Conducting Life-cycle analysis,

Below are some of the waste minimization activities being practiced at Harvestfield.

3.6.2.1 Resource Optimization

This involves minimizing the amount of waste produced by Harvestfield employees and its contractors by optimizing their use of raw materials.

3.6.2.2 Re-use of and Management of Plastic Scrap Material

The solid wastes especially those that falls under the category of general waste which is not as a result of production processes shall be re-used. These general wastes shall be converted to secondary materials through recycling and reused within the facility.

The management of Harvestfield Agrohao Industries Ltd shall enter into an arrangement with a plastic re-cycling firm within Ogun and Lagos state of Nigeria to recycle and re-use the plastics containers used for storage after their contents have been discharged. The likely materials that these scrap plastics can be recycled into clued Plastic chairs, bowls, kegs, wheelie bins and all these can still be used within the plant.

3.6.2.3 Electronic-waste Re-cycling

The management of the Harvestfield Agrohao Industries Limited shall enter into agreement with Lagos State Environmental Protection Agency (LASEPA) for the re-cycling of its electronic waste (e-waste) at the e-waste re-cycling plant located at Odogiyan, Ikorodu, in Lagos State.

3.6.3 Waste Treatment and Disposal

For waste streams that cannot be re-used or re-cycled, a waste treatment and disposal option that aligns with regulatory requirements and locally applicable best practices shall be adopted. However, the analytical laboratory of Harvestfield Agrohao Industries Ltd will on a weekly basis and on request monitor all treated effluent by analyzing the pollutant concentration level before it is passed on for disposal based on Nigerian regulation.

3.6.3.1 Waste Transportation

Arrangements to transport waste streams from our facility to the point of re-use, recycling and disposal as the case may be will be undertaken by the waste contractor assigned to manage the waste concerned. However, the responsibility for managing waste transported from our facility exceeds beyond the point of handing over the waste contractor. The responsibility extends to the point of re-use, recycle or final disposal as is evident from our waste tracking system.

3.6.3.2 Waste Treatment

As mentioned in an earlier section, air emissions primarily in form of fumes and dust particles will be generated from the Aflasafe formulation process. An air scrubber will be installed to manage the fumes that will be generated. The air scrubber will rid the fumes of all air pollutants including VOCs before discharging the cleansed air into the atmosphere.

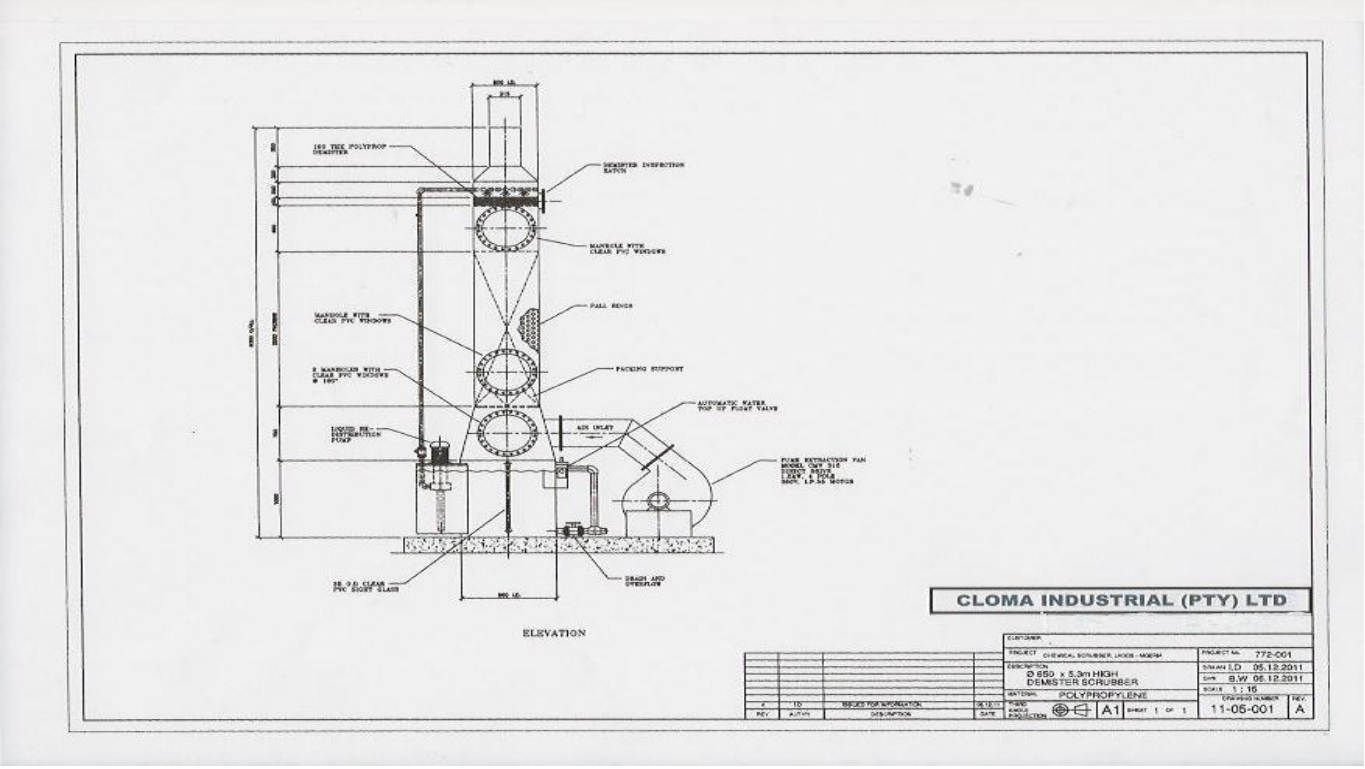

Fig 3.6: Air Scrubber

Included in the facility design is the installation of a dust extractor. Its function is to extract and treat dust particles that will be formed within the facility. The captured dust from the dust extractor will be recycled through the process plant. Air quality monitoring will be done weekly to check the air quality from the air scrubber discharge.

As part of measures to ensure that the installed equipment operate at optimum capacity always, the Harvestfield Agrohao Industries Limited has commenced the development of an Environmental Management System (EMS).

3.6.5 Waste Tracking

To ensure that wastes collected from the facility are disposed at designated waste management facilities and in the same condition and quantity, Harvestfield Agrohao Industries Ltd has developed and will adopt the use of a Waste Tracking Log. The log includes the Date, Type(s) and Quantity of waste transferred for handling/disposal. The supervisor of the waste generating facility ensures that all records of waste transferred are logged.

3.6.6 Effluent Treatment Plant (ETP)

As earlier discussed during operation which strictly involve formulation and packaging, a minimal effluent discharge is expected to be generated as waste and this will be treated in an Effluent Treatment Plant (ETP) using the reverse osmosis technique.

3.6.6.1 The Operation of the Reverse Osmosis Plant

As discussed above, grey water is the water produced from showers, sinks and laundry. The water is directed into a waste water tank from where it is sent into the reverse osmosis tank which treats the waste water by separating suspended solids particles from liquid, resulting in the formation of cakelike solid residue and clean portable water. The reverse osmosis process includes:

- Filtration for separation of filterable solids; flow and load equalization;
- Sedimentation for suspended solids reduction using clarifiers;
- Biological treatment, typically aerobic treatment, for reduction of soluble organic matter (BOD); chemical or biological nutrient removal for reduction in nitrogen and phosphorus;
- Chlorination of effluent when disinfection is required;

It is common to achieve 60-80% reduction in BOD in a reverse osmosis process and effluent suspended solids (SS) range of 10-30 mg/l. In a reverse osmosis tank, the BOD reduction increases to 80-95% but the effluent SS increases to 40 - 60 mg/l. This is due to an increase in algae growth, which is responsible for reducing the BOD. The resultant water from the effluent treatment will not only meet the Nigeria Federal Ministry of Environment (FMEnv) criteria for clean water but will meet the WHO standard for portable water.

3.8 HEALTH AND SAFETY POLICY

Harvestfield Agrohao Industries Ltd is committed to ensuring a safe working environment for her staff and thus has the following:

- Harvestfield Agrohao Industries Ltd ensures that all representatives and subsidiaries working for and with it, comply with industry HSE standards. This is done through ensuring that the HSE component of the job is part of the contract agreement with the contractors and sub-contractors
- Harvestfield Agrohao Industries Ltd makes appreciable efforts towards providing PPEs for the staff and ensures that the contractors do so for their workers on site
- Harvestfield Agrohao Industries Ltd ensures that all applications for regulatory permits are pursued by the contractors as this forms part of the required documentations for invoicing and payments
- In the offices, regular fire drills are organized and as well short trainings to ensure that the awareness of safety is maintained.

The more comprehensive HSE policy is included in *the appendix.3.1.*

3.4.1 Project Plans/Schedule

The preconstruction activities at the proposed project site are scheduled to begin in the 2nd Quarter of 2020 and are expected to be completed about a year thereafter. The planned project activities and their approximate timelines and schedules are shown in Table 3.1.

Table 3.1: Proposed project Timeline

Activities	Year 2019					Year 2020								
	Months													
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Land Acquisition and Survey														
Project Meetings														
Preliminary Site Visits														
EIA and Community Consultation Activities														
FMEnv EIA Approvals and Permits														
Vegetation Clearing/Location Prep														
Preconstruction Activities														
Mobilization to Site														
Civil Works and Site Construction														
Waste and Aesthetics Management														
Demobilization from Site														
Plant Operation	Continuous													

The life span of this project is unlimited lifespan however, components with specific lifespan will be change when due. Every other components of the project shall be revisited quarterly for efficiency and any part that has gone beyond repair will be replaced with new ones.

CHAPTER FOUR

DESCRIPTION OF THE PROJECT ENVIRONMENT

4.1 Background Information

The biological, chemical, physical and socio-economic characteristics of the environmental components of project area were studied using field observations, measurements and literature data. A comprehensive description of the existing physical, chemical, biological and socio-economic status of the area obtained during the field study is presented. The field data gathering process covered *in-situ* parameter measurements, collection of samples of soil, water, vegetation, climate and meteorology studies.

The baseline environmental and social conditions were established using available literatures and a one-season field exercise carried in the study area. Dry season field sampling exercise was carried out between Thursday 12th and Friday 13th December, 2019. The wet season result was adapted from previous Environmental Impact Assessment Report of the Agro-Chemical Industrial Development by Harvestfield in November, 2014 and February 2015.

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

4.2 Study Methodology

4.2.1 Sampling Design

The sampling was carried out in accordance with the requirements of FMEnv *EIA Cap E12 LF 2004*. A total of ten (10) geo-referenced sampling stations and additional two (2) control points were established in line with the ESIA Terms of Reference (ToR) for Soil and Vegetation Study while a total of eleven (11) geo-referenced sampling stations and additional two (2) control points were established for Air Quality and Noise. One (1) sampling locations and one control for Groundwater while three (3)

sampling locations with one (1) control were established for surface water and sediment within 2km spatial boundary. The samples location distribution is attached in *Appendix 4.1while figures 4.1-2* show the sampling locations.

Figure 4.1: Map *showing sampling stations for air quality, noise, soil and vegetation Source: Fieldwork, 2020*

Figure 4.1: Map *showing sampling stations for Groundwater, Surface water and Sediment Sources: Fieldwork, 2020*

Figure 4.3: Map *showing sampling stations for during 2014 wet/2015 dry and 2019 dry seasons Sources: Fieldwork, 2020*

4.2.2 Sampling Equipment and Laboratory Technique

Sample collection, handling, storage, transfer, data coding and documentation followed the Federal Ministry of Environment Guideline. All the samples collected on the field were preserved with ice chests and immediately taken to **Anila Resources (Nigeria) Limited, 5, Afisman Drive, Anifowoshe, Ikeja, Lagos State. Anila Limited is accredited by FMENV and DPR.**

The reception of samples by the laboratory followed the guidelines lay down by the Federal Ministry of Environment on data recording. The samples were then stored adequately in designated freezers at <4^{o}C prior to analysis. Laboratory analysis was timely carried out in line with the samples' respective analytical times as recommended in FEPA (1991) ***(Table 4.1)*** and APHA *et al*, 1980; Golterman *et al*., 1978; and US EPA, 1979.

Table 4.1: Sampling and Laboratory Technique

Parameter	Symbol	Unit	Test method
Physico-chemistry			
pH	Ph		in situ
Temperature	T	^{o}C	in situ
Conductivity	EC	S/cm	in situ
Dissolved oxygen	DO	mg/l	in situ
Salinity	S	‰	in situ
Turbidity	Turb	NTU	in situ
Total suspended solids	TSS	mg/l	APHA 2540D
Total dissolved solids	TDS	mg/l	APHA 2540C
Heavy metals			
Arsenic	As	mg/l	AAS
Cadmium	Cd	mg/l	AAS
Arsenic	As	mg/l	AAS
Chromium	Cr	mg/l	AAS
Copper	Cu	mg/l	AAS
Mercury	Hg	Mg/l	AAS
Ferric iron	Fe3+	mg/l	AAS
Ferro iron	Fe2+	mg/l	AAS
Lead	Pb	mg/l	AAS
Nickel	Ni	Mg/l	AAS

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

FEPA, 1991

4.2.3 Sampled Parameters

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

4.2.4 Abiotic Component

a) Climate and meteorological studies

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

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

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

A weather station was set up at the same sampling stations for soil sampling during the field survey. Sampling was allowed to run for a minimum of 30 minutes in order to establish a microclimatic data of that particular station. All precautions taken when setting up a weather station and during measurements were observed for the onsite measurements according to the World Meteorological Organization (WMO) standard. These include setting up the weather station away from obstacles like buildings and

tall vegetation, using an instrument shelter to display all temperature sensitive instruments, orienting the instrument shelter so that the sun's radiation does not fall directly on the instrument during reading and setting up the weather station in an area representative of the study area's totality. ***Table 4.2*** below presents weather data acquisition techniques.

Table 4.2: Weather Study Equipment

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

b) Ambient air quality and air borne noise level investigations

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

Plate 4.1: Air quality sampling from different sampling stations within the proposed project area

c) Water quality investigations (groundwater and surface water)

Groundwater samples were collected from existing 2 boreholes within the proposed project area and surface water samples were collected from 3 locations (down, mid and up streams) and one control form Lenuwa stream which is about 2km to the project area. These samples were immediately analysed for parameters with short holding analytical time such as pH, dissolved oxygen (DO), temperature, and turbidity. All samplings were carried out in line with standard quality control/quality assurance procedures. ***Plate 4.2*** below shows in situ measurement of groundwater pH using a hand-held Hanna pH meter during the field sampling.

Plate 4.2a: Taking of Groundwater Samples/pH meter being used for in situ measurement of water quality

Plate 4.2b: Sampling of Surface water Samples

d) Sediment studies

Sediment samples from 3 locations and one control were also collected from Lenuwa stream where the surface water samples were taking from.

e) Soil quality investigation

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

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

4.2.5 Biotic Components

f) Vegetation and Wildlife Studies

Vegetation

Vegetation studies were carried out at the same sampling stations with soil studies to determine the species composition, diversity, and population of plant species as well as phytochemical analysis of plant tissues. The density and percentage of the key tree species and the herbaceous layer were determined while rare and endangered plant species and all those of special significance to the ecosystem and the local economy were categorized (Oosting, 1956). The species diversity of the plants was calculated as the ratio between the number of species and “importance value” which, for the purpose of this study, were taken as the number of individuals per quadrant (Odum, 1971).

The vegetation studies were carried out using a combination of line transects and quadrant sampling technique. At each sampling location, two quadrants measuring 10m x 10m and 1m x 1m were used to study trees and shrubs, and herbs respectively. The plant community structure was observed and the plant species within each quadrant were identified. The floral and vegetative parts of unidentified plant species were collected, pressed in the field with herbarium press, and taken to

the laboratory for herbarium studies and identification. The population of the dominant plant species in each quadrant was determined by counting.

Field Methodology

The vegetation studies were carried out at the same sampling stations with soil studies. Random quadrat sampling technique was employed in the field at predetermined geo-referenced locations within the proposed project location.

At each sampling location, 15m x 15m quadrat was used to study trees while 25m x 25m quadrat was used to study shrubs and herbs. The plant community structure was generally observed and the plant species within each quadrat was identified. The floral and vegetative parts of unidentified plant species were collected, pressed in the field with herbarium press, and taken to the laboratory for herbarium studies and identification. The dominant species were worked out.

The population of the dominant plant species in each quadrat was determined by counting (Kershaw, 1973). The density and percentage cover of the key tree species and the herbaceous layer including grasses were determined while rare and endangered plant species and all those significant to the ecosystem and the local economy were categorized (Oosting, 1956). The species diversity of the plants were calculated as the ratio between the number of species and “importance value” which, for the purpose of this study, is being taken as the number of individuals per quadrat (Odum, 1971). Both general and specific characteristics of the vegetation were assessed by determining its floristic composition, life form and biological spectrum. Photographs were taken of the key vegetation types and other features of interest.

Wildlife/Vertebrate/Invertebrate Fauna

Assessment of the wildlife fauna of the proposed project area was carried out through field observation, interviews with local hunters/trappers, and reference to specialist institutions and experts both local and international. Information on animals not sighted in the field was obtained from local hunters or trappers by showing them voucher specimens or photographs. Also, assessment of insects, soil animals, land mollusks

and Arachnids in the project area was carried out through field observation, interviews and literature review. In each of the study location, the vertebrates, invertebrates, insects, soil animals, land mollusks, Arachnids were observed along with the vegetation and soil study locations. These locations form the basic study unit for all systematic collection and observation.

Systematic field data collection for birds centered on a series of 100 m bird observation transects located around the study location. Birds were also recorded while moving from one community to another up to 50 m either side of the road, with the aid of a pair of binoculars, depending on the extent and density of vegetation. Birds not sighted but heard were also recorded. Identification and nomenclature were based on the field guide of birds of Nigeria and West Africa (Elgood, *et al*., 1994; Serle *et al*., 1977). Record of mammals was obtained from interviews with local hunters, bush meat traders and villagers. In addition, we monitored the variety of bush meat displayed along the road and in designated bush meat markets. Identification and nomenclature of mammals was based on Hapold (1987).

g) Microbiology

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

⊙ ***Heterotrophic Bacterial Counts***

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

⊙ ***Determination of Fungal Content***

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

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

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

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

QA/QC procedures cover all aspects of the study, including sample collection and handling, laboratory analyses, generation of data and coding, data storage and treatment and report preparation. The quality assurance programme employed in the fieldwork and laboratory analyses were in accordance with *FEPA (1991)*.

⊙ ***Sample Collection and Handling***

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

⊙ ***Sample Identification***

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

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

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

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

⊙ ***Storage/Preservation***

Samples were stored in ice-chest as a cooling device and transported to the laboratory where they were refrigerated at 4°C or kept in a freezer as appropriate.

Samples for heavy metal analyses were preserved with 1:1 nitric acid and oil and grease with 1 ml of 1:1 H_2SO_4 as soon as they were collected. Adherence to good preservation procedures ensured that errors were not introduced into the analytical process.

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

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

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

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

⊙ ***Evaluation of Results***

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

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

(Cations) plus (anions)

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

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

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

4.2.7 Land Use

Makun and Lenuwa communities are semi-urban and rural settlements which are agrarian in nature. Lands in the communities are used mostly for residential and agricultural purposes. Mixed cropping is the common cropping system within the two communities. Houses in the area are mixture of both modern and old traditional buildings with the former being prominent. Each building houses a man and his immediate family with few relatives in some instances. In general, the major use of land in the study area (Makun/Lenuwa) revolves around agriculture, commercial and residential. Vacant land (vegetation) has the largest land use category in the study area followed by agriculture.

4.3 Socioeconomics

4.3.1 Socioeconomics and health data collection

The socio-economic data gathering involved the use of some techniques like interview schedule, survey question administration, key informant interview and focus group discussion (FGD). These techniques are found to be useful in participatory rural and learning appraisal techniques. Firstly, the conduct of

preliminary investigations during which the extent of the intended area to be surveyed (within 2km radius to the proposed project site) was determined and good rapports were established with the residents of the project area. Subsequently, the. In each of the communities the number of questionnaires administered were as follows.

Table 4.3: Questionnaire administration and retrieval from study communities

S/N	Community	No. of questionnaires administered	No. of questionnaires retrieved
1	Makun community	45	37
2	Lenuwa community	30	23
	Total	**75**	**60**
	Percentage	**100**	**80**

Source: ESIA study, 2019

The questionnaires were administered randomly on the respondents in the area after the administration of the questions through the focal group discussion effort (plate 4.4). Essentially, a total of 75 questionnaires administered and was based largely on the fact that the study area is contiguous in disposition or homogenous in characteristics. However, the variations in the number of questionnaires administered per community depended on the size of the population available for interactions during the interview processes. The adoption of random type of sampling premised basically on the fact that the residents are contiguous in orientation. That is, the residents generally have similar cultural background, religion, tribe, language, and belief system.

Plate 4.4: Interviewing Session in Progress

Public Health Assessment

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

Data were obtained from 60 respondents from 2 villages, namely Lenuwa and Makun villages. The instruments for data collection were mainly through consultation process, questionnaire and structured interview. Data was also collected through

secondary sources including Primary Health Centre, Local Government office, Private Clinics and reviewed relevant literature.

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

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

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

Plate 4.5a: ESIA team in consultation at Makun community *Source: Fieldwork, 2019*

Plate 4.5a: ESIA team in consultation at Lenuwa community *Source: Fieldwork, 2019*

4.4 Physical Setting of Ogun State

4.4.1 Geology

Ogun State has two main rock types. These are the basement complex rocks of the pre-Cambrian age which are made up of the older and younger granites in the northern parts of the state, and the younger and older sedimentary rocks of both the tertiary and secondary ages in the southern parts (lloeje, 1983). The sedimentary rock overlies Dahomey basin which extends almost from Accra in Ghana, through the Republic of Togo and Benin to Nigeria where it is separated from Niger Delta basin by Okitipupa ridge at the Benin hinge flank.

According to Jones and Hockey, (1964) the geology of South-western Nigeria reveals a sedimentary basin which is classified under five major formations according to their geological formation age namely: the Littoral and the Lagoon deposits, Coastal Plain sands, the Ilaro formation, the Ewekoro formation and the Abeokuta formation overlying the crystalline basement complex with their ages ranking from Recent to Cretaceous. Four of these formations excluding Ilaro, constitute aquifers in the Dahomey Basin, from which the geological section of Ogun was drawn.

The Ilaro formation is composed predominantly of shaley clay (argillaceous sediments). Limestone forms the aquifer material in Ewekoro formation while sands and gravels constitute the materials in aquifers of the recent sediments, Coastal Plain sands and Abeokuta formations contain brackish water. Generally, tertiary sediments are unconsolidated sandstones, grits with mudstone band and sand with layers of clay. Quaternary sediments are recent deltaic sands, mangrove swamps and alluvium near the coast.

4.4.2 Geomorphology

Ogun State has a wide area of undulating lowlands belonging to the coastal sedimentary rocks of western Nigeria. There are scattered hills that are interfluves between the different river valleys. Some remnants of a large planation i.e levelling of land in the state include

the out-crop inselbergs found at Abeokuta the Olumo Rockat the southern edge of the Western uplands. One implication of this location of the state is seen in all the rivers that traverse the state which flow southward either as tributaries or main rivers into the coastal lagoons and the Atlantic Ocean. These rivers include Ogun, Osun, Yewa, Yemoji, Ona, Sasa, Oni, Ohu, Ohia, Abafon, Oyan, lju and others. Most of the state is well drained by these streams and rivers, much of which dry up during the dry season.

4.4 Meteorology

Ogun State is categorised to be in the humid tropical climate zone. It has dry and wet seasons and two rainfall maxima regimes during the rainfall period of March to October. It also shows high relative humidity. Annual rainfall figures over the state vary from an average of 1280mm in the southern part of the state to an average of between 1050mm in the northern parts of the state and from about 1000mm in the western part to about 2000 mm the eastern part, especially ljebu and Ogun Waterside LGAs. The average monthly temperature ranges from 23°C in July & August to 36°C in February.

Climatic factors under consideration include the following – Temperature, Rainfall, Relative Humidity, Wind speed, Sunshine & radiation Hours. Mentioned is also made of Atmospheric pressure by way of literature review.

Temperature

Within the period of 1993 to 2017, Ogun State has an average maximum temperature of 32.9^0C and an average minimum temperature of 24.0^0C. The average maximum temperature range is 7.1^0C while minimum range is 2.3^0C. There was an observed decline in the maximum and minimum temperature from February to August and progression from the month of August to December.

Table 4.2: Mean Temperature Values in Ogun State (1994-2017)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Range
Max T(°C)	34.5	36.4	35.4	34.6	33.1	31.3	30.0	29.4	30.4	31.7	33.7	34.5	32.9	7.1
Min T(°C)	23.5	25.1	25.2	25.0	24.3	23.6	23.2	22.9	23.3	23.5	24.0	23.9	24.0	2.3

Source: NIMET

A cursory look at the data presented shows a correlation between temperature and seasons. Higher temperatures were recorded in the Dry season and lower temperatures recorded in the Rainy season where the effects of precipitation result in lower temperatures. From the graph above, the average warmest temperature was recorded in the months of February and March while the lowest was in June.

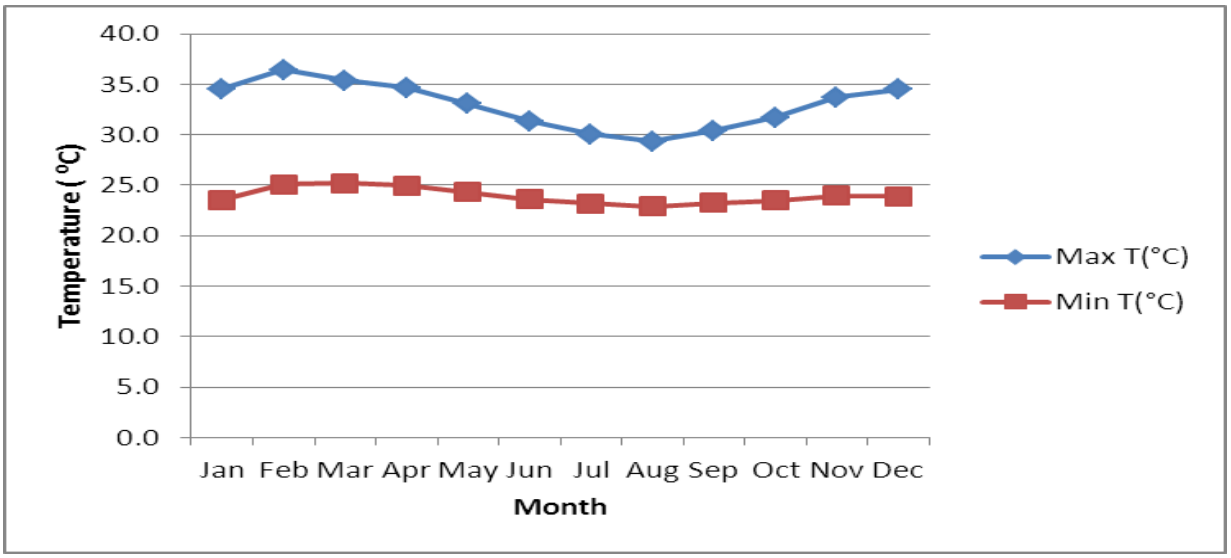

Figure 4.2: Temperature of the Study Area (1994-2017)
Source: NIMET

There was an observed reduction in the maximum and minimum temperatures in Ogun State from February to August followed by a progression from August to December.

Rainfall

Rainfall is the single important definition of the climatic seasons in any region. As shown in the table below and from the preceding graph, there are 2 rainfall peaks in July and September.

Table 4.3: Mean Rainfall Values in Ogun State (1994-2017)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Rainfall(mm)	2.8	23.2	41.7	106.3	191.3	182.3	232.4	130.8	209.7	161.5	30.0	1.6	109.5

Source: NIMET (1993-2017)

Rainfall was witnessed in virtually every month of the year and the 20-year average of rainfall data collected from 1993 to 2017 showed the highest rainfall recorded in July, (232.4mm). The lowest amount of rainfall were recorded in December and January corresponding to the dry season months while the total average of rainfall is 109.5mm for the period under review which is representative of the expected figures.

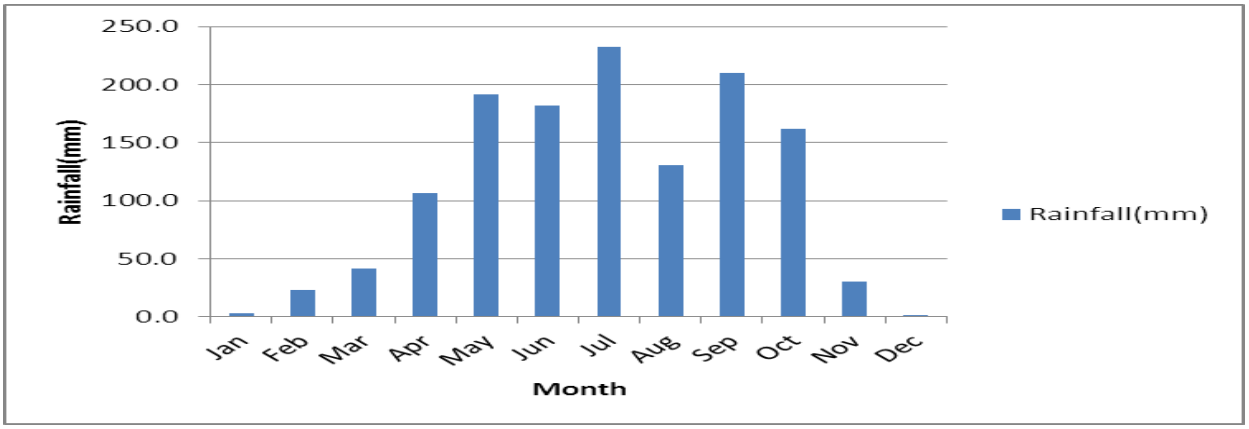

Figure 4.3: Rainfall of the Study Area (1994-2017)
Source: NIMET

Relative Humidity

Humidity indicates the likelihood of precipitation, dew or fog. Higher humidity reduces the effectiveness of sweating in cooling the body by reducing the rate of evaporation of moisture from the skin. Humidity encourages the growth and sustenance of the tall rich

vegetation in this zone. Relative humidity is directly related to the temperature of the air and therefore affects the nature and types of cloud formation and precipitation.

Table 4.4: Mean Relative Humidity Values in Ogun State (1994-2017)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Rel. Humidity (%)	65.9	69.4	72.5	77.9	81.7	86.8	86.7	85.6	85.5	82.9	76.0	71.3	78.5

Source: NIMET (1993-2017)

The mean relative humidity for an average year is recorded as 78.5% over a 20-year period from 1993 to 2017. This ranges from 65.9% in January to 81.6% in August with correspondingly high figures recorded from June to September.

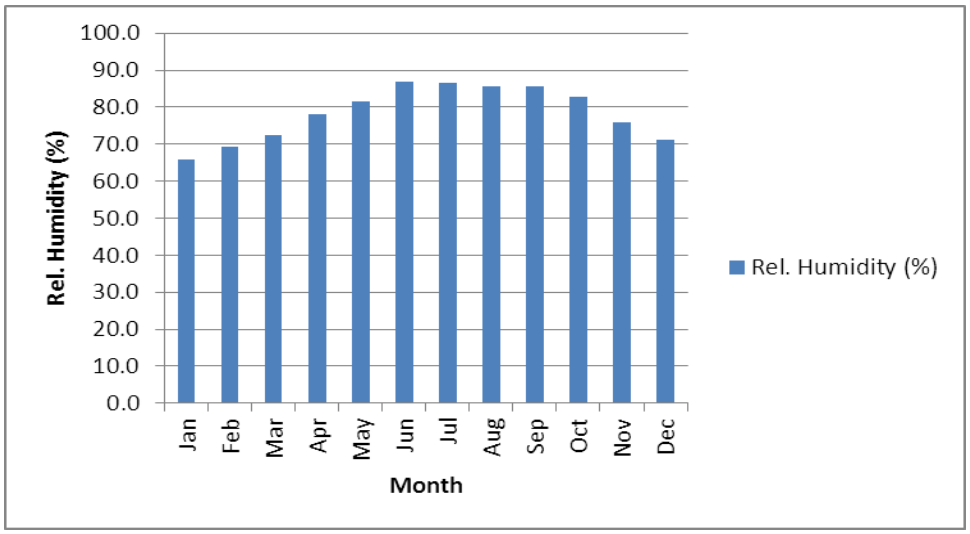

Figure 4.4: Relative Humidity of the Study Area (1994-2017) Source: NIMET

The average relative humidity spanning a period of twenty years (1994-2017) showed that there was no month that had a percentage of relative humidity to be below 65%. From the month of January to June, the relative humidity followed a progression in values and experienced decline in values from June to December. This is in correlation with the rainfall distribution within the area.

Wind Speed

The winds that prevail over Ogun State are the same with that which prevail over Nigeria and these are the Tropical Maritime Air mass and the Tropical Continental air mass

The Tropical Maritime Air mass (MT) is responsible for Nigeria's rainy season which invades the country from **February** in the southern part of Nigeria. The Tropical Continental Air mass (CT) locally known as the Harmattan is a wind originating from North Africa which crosses the Sahara Desert into West Africa to Nigeria. This air mass dominates Nigeria's climate during the dry season from December to March. The Tropical continental air mass is dusty and creates a haze within the atmosphere of South West Nigeria. The haze is caused by the dust within the air mass and this limits visibility and blocking much of the sun's rays from reaching the earth.

Table 4.5: Mean Wind Speed Values in Ogun State (1994-2017)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Wind Speed (Knots)	3.9	4.2	4.1	3.9	3.8	3.2	3.6	3.8	3.2	3.3	3.3	3.7	3.7

Source: NIMET (1993-2017)

Note: 2Kts = 1m/s

The invasion of the MT is as a result of the northward retreat, of the CT. The northward retreat of the tropical continental air mass (CT), is caused by the sun's northward shift from the tropic of Capricorn in the southern hemisphere to the tropic of Cancer in the northern hemisphere This shift begins from **February and ends in June**, when the sun is fully overhead, at the tropic of Cancer in the northern hemisphere. The Tropical continental airmass (CT) loses its strength as a major airmass in the Southern West region of Nigeria around February.

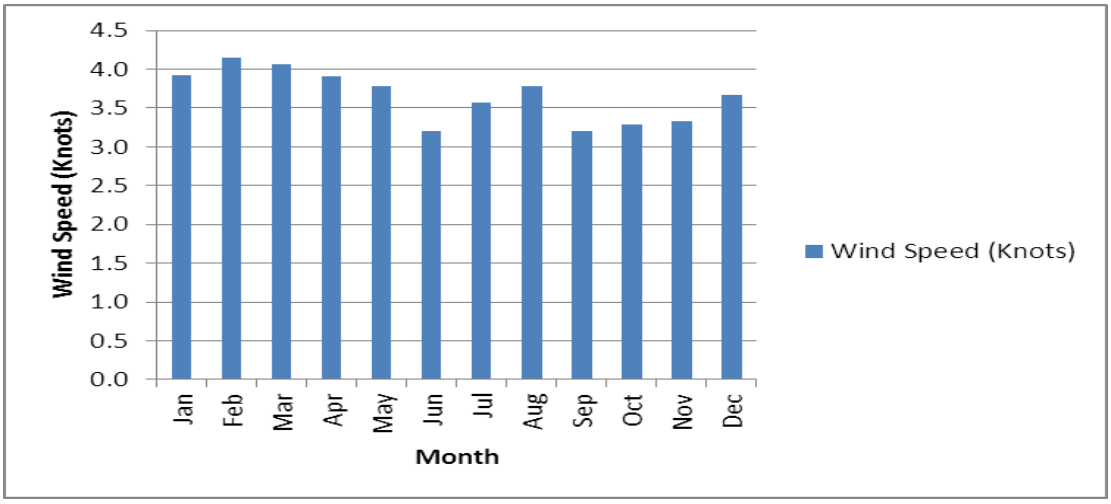

Figure 4.5: Wind Speed of the Study Area (1994-2017)
Source: NIMET

The mean annual wind speed varies between 3.2 knots in September and 4.2 knots in February. Wind speeds show a twin peak in February and March and then a decline from August to December and a rise again in January all the way to March. The wind pattern follows the migratory Inter-Tropical Discontinuity (ITD) or Inter-Tropical Front (ITF) caused by the separation of the North Easterly CT and the South Westerly MT. Also playing a part in the observed wind speed is the influence of sea breezes from the adjourning maritime environment.

- ***Microclimatic data***

The meteorological variables measured at the proposed project site in Makun, Obafemi Owode LGA, Ogun State are presented in Table 4.10 below.

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

S/N	Sample Code	Coordinate	Ambient Temp (^{O}C)	Relative Humidity (%)	Wind speed (m/s)	Wind Direction
1	AQ1	N6.849003 E3.517855	34.0	59.6	1.2	SW
2	AQ2	N6.841468 E3.511587	33.4	56.7	1.1	SW

3	AQ3	N6.844779 E3.514292	34.6	57.9	1.5	SW
4	AQ4	N6.844751 E3.514750	34.1	55.7	1.2	SW
5	AQ5	N6.844630 E3.515179	34.0	54.2	1.5	SW
6	AQ6	N6.844915 E3.514838	32.7	60.1	1.5	SW
7	AQ7	N6.845192 E3.514682	32.5	59.7	1.4	SW
8	AQ8	N6.845403 E3.514773	33.1	55.8	1.5	SW
9	AQ9	N6.845484 E3.514758	32.8	56.7	1.1	SW
10	AQ10	N6.845532 E3.514770	33.1	60.2	1.0	SW
11	AQ11	N6.844904 E3.513964	34.7	56.8	1.0	SW
12	AQ12(Control 1)	N6.844844 E3.513871	31.9	58.2	1.0	SW
13	AQ13 (Control 2)	N6.844564 E3.517361	33.1	54.6	1.4	SW
Average			31.15	63.71	1.69	SW

Source: SPEC Field work, 2019

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

- **Air Quality**

- **Volatile Organic Compounds (VOC)**

VOC is an aggregate parameter defining volatile hydrocarbon species. These are airborne and are usually composed of low and intermediate molecular weight hydrocarbons. The concentration of volatile organic compounds in the air was very low and below the FMEnv limit of 160 µg/ m^3 for dry season. However, VOC was not detected during 2014 wet and 2015 dry seasons.

- **Suspended Particulate Matter (SPM)**

This is the term for a mixture of solid particles and liquid droplets found in the air such as dust, dirt, soot, smoke. These are grouped as 'inhalable coarse particles' with diameters ranging between 2.5 μm and 10 μm; and 'fine particles' having diameters less than 2.5 μm. They can also deface cultural and traditional artefacts, monuments and buildings. On a macro-scale, particulate matter affects the earths-atmospheric heat balance by disturbing the evaporation-condensation cycle (Pope *et al,* 1999). Suspended particulate matter determination yielded results within the range of 0.001 to 0.008 μg/m^3 for PM10 and 0.00 to 0.004 μg/m^3 for PM 2.5 during dry season 2019 while the same parameter (for PM10) ranged from 10.856 to 12.083 μg/m^3 during 2014 wet and ranged from 10.728 to 12.134 μg/m^3 during 2015 dry seasons. However, the values obtained for these seasons were far below the FMEnv limit of 250μg/m^3.

- **Carbon monoxide (CO)**

CO is a colorless, odorless gas emitted from combustion processes of fossil fuel. In urban areas, the majority of CO emissions to ambient air come from mobile sources. At extremely high levels, CO can cause death (Kao, 1994). In the study area, CO concentration obtained ranged from 0.00 – 0.01ppm during dry season 2019. The CO concentrations detected during the dry season under review were far below the FMEnv limit of 10ppm. However, CO ranged from 5 to 13ppm for 2014 wet season and 4 to 12ppm during 2015 dry season. This might be as a result of anthropogenic activities during this period of time.

- **Oxides of Nitrogen (NOx)**

Nitrogen dioxide (NO_2) is a suffocating brownish gas that belongs to a family of highly reactive gases called nitrogen oxides (NO_x). It results from high temperature combustion of fuel and occurs mainly from motor exhaust and stationary sources such as electric utilities and industrial boilers. It is a strong oxidizing agent that reacts with air in the presence of water to form corrosive nitric acid, as well as toxic organic nitrates. It plays a major role in the atmospheric reactions that produce ground level ozone or smog. Exposure to NO_2 concentrations higher than regulatory limits could alter

pulmonary immunologic responses and may increase susceptibility to bacterial infection such as influenza. Levels of NO_2 above 563μg/m^3 may cause pulmonary diseases in man and animals. The NOx detected from all the sampling locations during the dry and wet seasons (2014.2015 and 2019) were below the FMEnv limit which is 0.04 – 0.06 ppm.

- **Oxides of Sulphur (SOx)**

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

The primary threat of SO_2 to urban atmosphere may arise not from SO_2 itself but from the changes it undergoes in the atmosphere such as the formation of sulphuric acid (H_2SO_4), a reaction which is catalysed by particulate matter; and the formation of sulphate aerosols. SO_2 can also be absorbed on small particles such as the salts of iron, manganese and vanadium present in the atmosphere and thus enter the alveoli of the lungs. SOx concentration detected at the sampling locations during the two seasons under review (wet season 2014, dry season 2015 and dry season 2019) were below the FMEnv limit of 0.1ppm.

- **Hydrogen Sulphide (H_2S)**

H_2S is known to be immediately dangerous to life and health (IDLH). It has a pungent smell when in low concentration, but at a high concentration, the odour will no longer be detected by human nose. Hydrogen sulphide has both natural and man-made sources (such as biodegradable waste sites). Hydrogen sulphide does not have regulatory limits, because it is a “non-criteria” pollutant. H_2S concentration detected at the sampling locations was below the FMEnv limit. However, this parameter was not measured during 2014 wet and 2015 dry seasons

- **Ammonia (NH_3)**

Ammonia or azane is a compound of nitrogen and hydrogen with the formula NH_3. It is a colourless gas with a characteristic pungent smell. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to food and fertilizers. Ammonia, both directly or indirectly, is also a building block for the synthesis of many pharmaceuticals and is used in many commercial cleaning products. Although common in nature and in wide use, ammonia is both caustic and hazardous in its concentrated form. The NH_3 values detected at the sampling locations were below the FMEnv limit. However, this parameter was not measured during 2014 wet and 2015 dry seasons

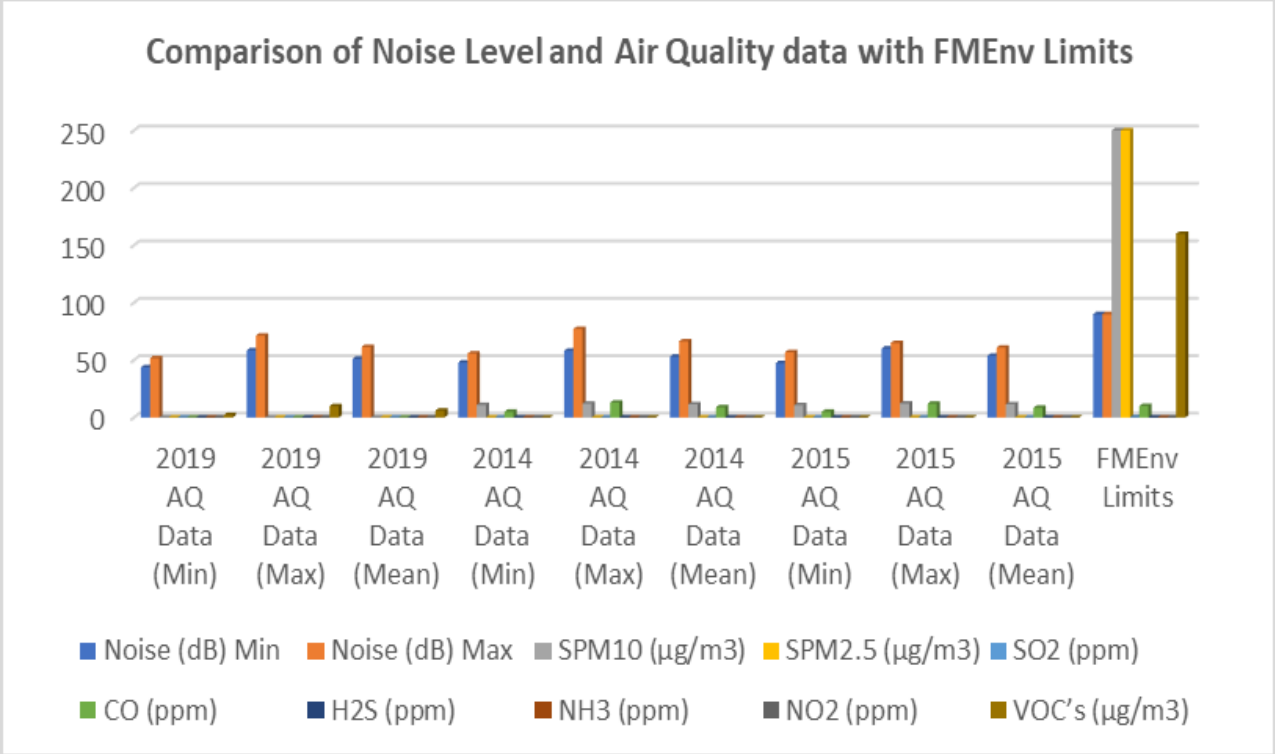

Figure 4.9: Comparison of Noise Level and Air Quality data with FMEnv Limits

- **Noise Level**:

The minimum mean value of noise level at the proposed site during the dry season ranged from 43.1 to 51.6dB (A) and the maximum ranged from 58.5 to 71.3 dB (A).

Also, during 2014 wet season noise level ranged from 47.9 to 55.7dB for minimum level and 58.1 to 77.1 dB for maximum level while noise level ranged from 47.4 to 56.9dB for minimum level and 60.1 to 64.9dB for 2015 dry season. The increase of noise level in some locations might be as a result of the vehicular movement along Lagos/Ibadan Expressway where the proposed site is located. However, despite the differences in the values obtained during these seasons, the values were low compared with the 90.0 dB (A) limit provided by Federal Ministry of Environment for occupational Noise for 8-hour exposure.

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

Sampling Point	Noise (dB)		SPM_{10} ($\mu g/m^3$)	$SPM_{2.5}$ ($\mu g/m^3$)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	NH_3 (ppm)	NO_2 (ppm)	VOC's ($\mu g/m^3$)
	Min	Max								
AQ1	57.9	63.6	0.008	0.001	0.00	0.01	0.00	0.001	0.001	6.93
AQ2	51.7	68.6	0.006	0.004	0.00	0.00	0.00	0.00	0.00	5.79
AQ3	51.2	67.2	0.006	0.003	0.00	0.00	0.00	0.001	0.001	5.27
AQ4	52.1	67.9	0.005	0.002	0.00	0.00	0.00	0.00	0.00	5.10
AQ5	58.5	67.0	0.006	0.001	0.00	0.00	0.00	0.00	0.00	4.05
AQ6	48.9	51.6	0.006	0.001	0.00	0.00	0.00	0.00	0.00	2.85
AQ7	48.2	65.1	0.005	0.000	0.00	0.00	0.00	0.00	0.00	2.14
AQ8	47.9	60.8	0.004	0.003	0.00	0.00	0.00	0.00	0.00	2.38
AQ9	43.7	59.6	0.005	0.000	0.00	0.00	0.00	0.00	0.00	2.41
AQ10	45.1	60.3	0.006	0.001	0.00	0.00	0.00	0.00	0.00	2.50
AQ11	48.9	56.5	0.005	0.001	0.00	0.00	0.00	0.00	0.00	2.63
AQ12(Control 1)	47.5	60.3	0.006	0.001	0.00	0.00	0.00	0.00	0.00	2.80
AQ13 (Control 1)	49.0	71.3	0.001	0.001	0.00	0.001	0.00	0.001	0.00	9.89
Mean	**51.1**	**61.45**	**0.0045**	**0.002**	**0**	**0.005**	**0**	**0.0005**	**0.0005**	**6.015**
FMEnv	**90**	**90**	**250**	**250**	**0.1**	**10**	**NS**	**NS**	**0.04 -0.06**	**160**

Source: SPEC Fieldwork, 2019

Detection limit for NO_2 = 0.001ppm;

Detection limit for SO_2 = 0.001ppm;

Detection limit for CO = 0.001ppm;

Detection limit for SPM = 0.01$\mu g/m^3$*;*

*Detection limit for O_3= 0.008*ppm*;*

Detection limit for H_2S = 0.001ppm

Table 4.11b: Average Noise Level and Concentration of Air Quality Parameters Measured in 2014/2015 and 2019 against FMEnv Limits

	Noise (dB)		SPM_{10} ($\mu g/m^3$)	$SPM_{2.5}$ ($\mu g/m^3$)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	NH_3 (ppm)	NO_2 (ppm)	VOC's ($\mu g/m^3$)
	Min	Max								
2019 AQ Data (Min)	43.7	51.6	0.001	0	0	0	0	0	0	2.14
2019 AQ Data (Max)	58.5	71.3	0.008	0.004	0	0.01	0	0.001	0.001	9.89
2019 AQ Data (Mean)	51.1	61.45	0.0045	0.002	0	0.005	0	0.0005	0.0005	6.015
2014 AQ Data (Min)	47.9	55.7	10.856	-	0.0054	5	-	ND	0.002	ND
2014 AQ Data (Max)	58.1	77.1	12.083	-	0.0086	13	-	ND	0.007	ND
2014 AQ Data (Mean)	53	66.4	11.4695	-	0.007	9	-	ND	0.0045	ND
2015 AQ Data (Min)	47.4	56.9	10.728	-	0.0051	5	-	ND	0.002	ND
2015 AQ Data (Max)	60.1	64.9	12.134	-	0.0084	12	-	ND	0.006	ND
2015 AQ Data (Mean)	53.75	60.9	11.431	-	0.00675	8.5	-	ND	0.004	ND
FMEnv Limits	90	**90**	**250**	**250**	**0.1**	**10**	**NS**	**NS**	**0.04 - 0.06**	**160**

Source: Fieldwork, 2014/2015/2019

4.5.2 Soil Quality Study

Introduction

For projects such as the proposed Aflasafe plant, impacts on the soil may occur at various stages of the project. This study is thus important for the sustenance of the quality of the environment to ensure that activities to be undertaken such as construction of this plant is carried out in such a way to minimize the potential impact on the soil. The project site which is along Lagos/Ibadan expressway is presently a fallow land entirely covered with various forms of vegetation.

Soil pH

Soil pH is a measure of the acidity or alkalinity of soil. A pH of 7 is neutral, a pH below 7 is acidic or sour, and a pH above 7 is alkaline. The pH value of soil affects the quality of plant growth because it directly affects nutrient availability in the soil. During dry season 2019, the pH of the proposed study ranged from 4.7 to 4.8 with a mean value of 4.75 for the top soil while the bottom soil ranged from 4.3 to 5.4 which shows that there has not been any serious variation. Generally, the pH of the study area is acidic. **(Table 4.16 and appendix 4.2).** Factors that affect soil pH include precipitation (rainfall), drainage, soil vegetative cover, type of soil with respect to mineral composition. The result of the present study revealed relatively high amount of sand in the soil aeration which would increase soil pH (reduce acidity).

Table 4.27: Soil pH Classes

pH	Classes
4.5 – 5.5	Very Acidic
5.5 – 6.0	Distinctly Acidic
6.0 – 7.0	Acidic
7.0	Neutral
7.0 – 7.5	Faintly Alkaline
7.5 – 8.0	Alkaline
8.0 – 8.5	Strongly Alkaline
8.5 – 9.0	Extremely Alkaline

Source: Udo, 1986

Electrical Conductivity: Electrical Conductivity (EC) determines the ability of soil water to carry an electrical current, as the major and minor nutrients important for plant

growth take the form of either cations or anions, which are dissolved in the soil water which is the conductor of electrical current. In the dry season, the electrical conductivity had concentrations ranging from 265 to 427µS/cm for the top soil; and 251.7 to 292.6 µS/cm for the bottom soil.

Electrical conductivity in soils in the study area showed temporal variations and variations across the soil profile. The concentrations were higher in the top soil than bottom soil.

Exchangeable Cations

Exchangeable cations are either adsorbed onto clay particles or Soil Organic Matter. The soils in the study area are rich in exchangeable cations with calcium being the most abundant; with the order of abundance being Ca > Na > K. High Calcium soils have more oxygen, drain more freely and support aerobic breakdown of organic matter.

The exchangeable cations (K^+, Na^+ and Ca^{2+}) varied across the sampling locations and with depth. In the topsoil samples during the dry season, sodium ranged from 12.33 mg/kg to 29.81 mg/kg, potassium ranged from 6.08 mg/kg to 10.91mg/kg, magnesium ranged from 5mg/kg to 9.07mg/kg while calcium ranged from 20.05 mg/kg to 37.67mg/kg. In the bottom soil, sodium ranged from 15.15 mg/kg to 25.08 mg/kg, potassium ranged from 10.94 mg/kg to 14.37mg/kg, magnesium ranged from 5.79mg/kg to 9.32mg/kg while calcium ranged from 20 mg/kg to 35.51 mg/kg.

Exchangeable Anions

The exchangeable anions (NO_3^-, SO_4^{2-} and PO_4^{3-}) in the soil samples from the project area in the dry season, the mean concentrations of nitrate, sulphate and phosphate in topsoil and bottom were 3.28 and 2.83 mg/kg, 130 and 140 mg/kg and 8 and 8.5 mg/kg respectively. During the study, the distribution of exchangeable anions in soil did not generally follow any particular trend.

Total Organic Carbon: Total organic carbon content in the entire soils was generally low. The result, see (Table 4.16) indicates that during dry season, the mean values

were 1.07% for top soil and 1.92% for bottom soil. The principal factors responsible for high organic matter in soil include vegetative cover and decay of plant residue. These factors are significantly absent in the proposed project area. Hence, return of organic matter to the soil is poor. This phenomenon is equally responsible for the trend and relatively low amount of total nitrogen in the soils.

Heavy Metals Concentration of the Soils

The study of heavy metals within the soil of the project area becomes paramount in view of the potential impacts they could elicit on buried cables and other equipment. Heavy-metal can react with other chemicals in the soil; accumulate under certain circumstances, for example, in metal components of diverse equipment and could lead to violent explosions.

Some of them are dangerous to health or to the environment (e.g. mercury, cadmium, lead, chromium), some may cause corrosion (e.g. zinc, lead), and some are harmful when present at certain concentration in the environment or absorbed by plants and animals or in contact with underground equipment like buried steel pipes. The result of the heavy metal in the soil from the project area is shown in Table 4.16.

In 2019 dry season the mean(s) of heavy metals concentration were as follow:
The Heavy metal concentration in the top soil and subsoil samples collected from project area recorded the following levels of concentrations:
Cadmium values for both the top and bottom soil were below detection limit. Copper ranged from 16.47 to 33.45mg/kg for top soil while bottom soil ranged from 9.23 to 20.22mg/kg. Iron, ranged between 23mg/kg and 45mg/kg with a mean value of 34mg/kg for top soil while the subsoil ranged between 84 and 360mg/kg with a mean value of 222mg/kg. Nickel in both top and subsoil was below the detection limit (<0.001mg/kg) of the equipment used for the analysis. Lead in the top soil has a mean value of 0.02mg/kg, while the subsoil ranged between 0.01 and 0.02mg/kg with a mean value of 0.015mg/kg. Zinc concentration in the top soil ranged between 0.68 to 3.01mg/kg with a mean value of 1.845mg/kg, while subsoil ranged between 1.98 and 3.89mg/kg with a mean value of 2.94mg/kg.

The concentration of Manganese in both top and subsoil was below the detection limit (<0.001mg/kg) of the equipment used for the analysis. Chromium in both top and subsoil was below the detection limit (<0.001mg/kg) of the equipment used for the analysis.

Organics

During dry season, Total Petroleum Hydrocarbon (TPH) has a constant value of 0.1mg/kg bottom soil. Total TPH content of the control soil was similarly low and below the critical and targeted levels in the soil. Total hydrocarbon content (THC) ranged from 0.525 to 1.461mg/kg with a mean value of 0.993mg/kg for top soil while the bottom soil ranged from 0.26 to 1.79mg/kg with a mean value of 1.03mg/kg. Generally, TPH and THC contents of the general soils were below the critical and targeted levels and therefore do not pose any threat to soil and crop production.

Soil Microbiology

Mean microbial count of organisms were THB ($350.5x10^4$cfu/g), HUB ($155x10^4$cfu/g), THF ($211x10^4$cfu/g), and HUF ($38.5\ x10^4$cfu/g) for top while Mean microbial count of organisms were THB ($223x10^4$cfu/g), HUB ($120.5x10^4$cfu/g), THF ($179.5x10^4$cfu/g), and HUF ($43\ x10^4$cfu/g) for bottom soil. The predominant species of microorganisms isolated were Bacillus spp., Clostridium spp, Nocardia spp, Fusarium spp, Aspergillus spp, Rhizopus stolonifer, Pseudomonas spp, Corynebacteria spp; Trichoderma spp and Mucor spp.

Table 4.16: Summary of Physico-Chemical and Microbiology Result of Soil Samples (Dry Season 2019)

PARAMETERS	DRY SEASON (2019)										
Physico-chemical	TOP OIL				BOTTOM SOIL				STEDV	FMENV Target value (mg/kg)	FMENV Intervention value (mg/kg)
Test	Min	Max	Mean	Control	Min	Max	Mean	Control			
pH	4.7	4.8	4.75	5.03	4.3	5.4	4.85	4.8	0.32	-	-
Conductivity (µS/cm)	265	427	346	329	251.7	292.6	272.15	259.5	73.87	-	-
Sulphate (mg/kg)	130	470	300	256.67	140	390	265	323.33	85.00	-	-
Nitrate (mg/kg)	3.28	4.14	3.71	3.83	2.83	3.98	3.41	3.68	4.15	-	-
Phosphate (mg/kg)	8	19.7	13.85	14.8	8.5	13.6	11.05	10.13	3.43	-	-
Total Nitrogen (mg/kg)	0.64	1.16	0.9	0.73	0.53	0.72	0.63	0.56	0.17	-	-
Ammonium (mg/kg)	2	15.22	8.61	2.2	1.7	2.5	2.1	2.27	4.39	-	-
CEC (meq/100g)	48.78	75.48	62.13	58.33	58.17	73.13	65.65	78.72	11.14	-	-
TOC (%)	0.35	1.79	1.07	1.3	0.73	3.11	1.92	2.61	1.11	-	-
Nitrite (mg/kg)	0.32	2.13	1.225	0.6	0.17	0.57	0.37	0.39	0.50	-	-
THC (mg/kg)	0.525	1.461	0.993	0.8	0.26	1.79	1.03	1.46	0.51	1.00	40.00

TPH (mg/kg)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.04	50.00	500.00
PAH (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	-	-
BTEX (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	-	-
Phenols (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	-	-
Moisture content (%)	16.1	27.1	21.6	20.83	27.2	34.1	30.65	29.5	21.48	-	-
Potassium (mg/kg)	6.08	10.91	8.495	7.6	10.94	14.37	12.66	13.29	2.44	-	-
Calcium (mg/kg)	20.05	37.67	28.86	23.41	20	35.51	27.76	40.04	8.23	-	-
Sodium (mg/kg)	12.33	29.81	21.07	20.47	15.15	25.08	20.12	20.75	4.82	-	-
Magnesium (mg/kg)	5	9.07	7.035	6.85	5.79	9.32	7.56	6.95	1.56	-	-
Iron (mg/kg)	23	45	34	31.67	84	360	222	197.17	456.99	-	-
Chromium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	100.00	380.00
Nickel (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.61	35.00	210.00
Vanadium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	-	-
Barium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.08	-	-
Copper (mg/kg)	16.47	33.45	24.96	23.31	9.23	20.22	14.73	12.48	7.30	-	-
Zinc (mg/kg)	0.68	3.01	1.845	2.4	1.98	3.89	2.94	2.42	0.88	140	720

Manganese (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	-	-
Cadmium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	0.8	12
Lead (mg/kg)	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.00	85	530
Mercury (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	-	-
THB (x 10^4 cfu/g)	213	488	350.5	311.67	169	277	223	210.33	105.39	-	-
HUB (x 10^4 cfu/g)	102	208	155	144.33	70	170	120	139.33	46.61	-	-
THF (x 10^4 cfu/g)	161	261	211	192	112	247	179.5	209	55.89	-	-
HUF (x 10^4 cfu/g)	17	60	38.5	38	25	61	43	31.67	15.04	-	-
Total Coliforms (x 10^4 cfu/g)	31	104	67.5	49.67	20	73	46.5	30	22.94	-	-
HUB/THB Ratio	0.2473	0.8832	0.56525	0.48	0.31	0.73	0.52	0.71	0.21	-	-
HUF/THF Ratio	0.0727	0.3428	0.20775	0.21	0.11	0.3	0.21	0.16	0.11	-	-

Source: Fieldwork, Dry Seasons, 2019

4.8.5 Soil Result and Discussion of Previous study around the project area (2014 and 2015)

Physical Properties of the Soil

The average particle size distribution of representative soils in the study area (Table 4.12).

No significant difference was found in the particle size distribution of the soils from each sampling point in the study area.

The soil texture of the top and bottom soil strata was in the order sand>clay>silt. Further analysis revealed that the sand component of the soil contains relatively higher proportion of fine sand than other sand fractions. The soil texture of the control environment is similar to that of the study area.

Table 4.11: Statistical analysis of physical characteristic of the soil

Parameters	Sand (%)	Clay (%)	Silt (%)
	0-15 cm		
Range	78.36 – 86.36	10.92 – 20.36	1.16 – 5.20
Mean	82.24	15.21	2.55
	15-30 cm		
Range	81.88 – 84.32	10.92 – 14.40	1.25 – 5.24
Mean	83.36	12.73	3.91

The topsoils were observed to be sandy and clay with a higher content of silt while the subsoils are similarly silt with sand and clay. Generally, the topsoil's have higher sand content than the subsoils.

Chemical Properties of the Soil

An overview of soil analysis results is provided below for both the wet and dry seasons.

pH

The mean pH value of the soils was 5.6, which is moderately acidic, with a range tending from Neutral to moderately acidic i.e. from 4.20 to 7.40. The soils on the site were approximately neutral pH (6.5–7.5).

Organic Carbon

The organic carbon (OC) contents of soils are low at less than 1.00%, and considered moderate when it is at a value of 1.50% to high at a value of 2.5%. The OC content of the soils within the study area is considered as low, with a mean value of 0.67; and a range of 0.45 to 1.03.

Nitrogen and Phosphorous

The nitrogen (N) and phosphorus (P) content of soils are a function of the organic matter content in soil. The Nitrogen content of the soils had a mean value of 7.2 and Phosphorus content mean value of 0.48.

Heavy Metals

Wet Season (2014)

The average concentrations of the different heavy metals that were investigated in soils of the study area are in Table 4.12-4.13. Results obtained indicated that concentrations of the various heavy metals considered were very low when compared to corresponding values in naturally occurring unpolluted soils as reported by Alloway (1991) and Allen *et al.* (1964). In order to be able to make sound and rational judgment about the extent of heavy metal contamination and or otherwise of the soils studied, references were made to heavy metal content in unpolluted soils as reported for different countries of the world. The Table also indicated the normal range in unpolluted soils.

From the heavy metal concentration data reported for soils in the study area, there was no evidence of heavy metal accumulation and or bioaccumulation in the soils as at the time of field investigations. This is because the heavy metal concentrations in soils of

the study area were significantly lower ($p < 0.05$) than the concentrations that were reported as the trigger levels for the various heavy metals that were investigated. There was therefore no evidence of soil contamination and or pollution with regards to the heavy metals that were investigated. For Fe, the normal range in soils was not provided by Alloway (1991); however, Brady (2002) indicated that Fe concentrations that are considerably higher than 10,000 mg/kg in soils are not unusual, especially in poorly drained environment such as in the swamps.

Dry Season (2015)

Heavy metal concentrations were generally low at all sampling stations and only detectable in trace amounts, similar to natural occurrence levels (Rusell 1977, Courant *et al*., 1985). Topsoil samples generally showed higher heavy metal concentrations compared to the subsoil samples. In both the wet and dry season surveys, iron was the most abundant followed by zinc, then chromium. A summary of the analysis results are provided in Table 4.14-4.15.

Cation Concentrations

The exchangeable bases/cations (Na, K, Ca & Mg) are also present in low to moderate amount. In general, the average concentrations of K, Mg & Ca are higher than the critical minimum of 0.2, 0.4 and 2.0 cmol/kg soil respectively for the bases, required for optimal crop growth and performance in southern Nigerian soils (Adepetu *et al*., 1979).

The concentration of the monovalent cations in the soils was generally as high as expected. Sodium (Na) concentrations ranged between 1.59 and 3.22 mg/kg in the wet season and 1.43 and 3.20 mg/kg in the dry season while potassium (K) ranged between 22.12 and 50.4 mg/kg in the wet season and 21.7 and 47.9 mg/kg in the dry season. The generally very high potassium content could be attributed to the anthropogenic source.

In general, there is no variation with the heavy metal concentration in the wet and dry seasons and within the two-soil profile.

Information presented in this report was acquired from literature review and the results of field investigation, in situ measurements, and laboratory analysis. All baseline data gathering activities were carried out in accordance with the Federal Ministry of Environment and other applicable international standards and guidelines. Field sampling methods and laboratory procedures were consistent with established and standard methodologies (ASTM, USEPA, etc). The sampling points outside the influence the project are the control areas which are in the range of 2km radius outside the project site.

Table 4.12: Summary of Mean concentration (mg/kg) of Heavy Metals in Top Soils (0-15 cm) of the study Area in Wet season (2014)

Heavy Metals	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10	CONTROL
Fe	2419	2040	2443	2405	2183	2865	2487	2144	2139	2402	2367
Zn	51.2	42.0	31.28	52.89	46.02	67.0	41.25	53.93	54.52	41.25	61.25
Hg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
V	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ni	0.03	0.05	0.04	0.05	0.06	0.10	0.07	0.08	0.06	0.05	0.06
Cd	0.15	0.07	0.89	0.15	1.18	0.07	0.15	0.15	2.44	0.15	0.15
Cu	0.23	0.70	0.15	0.17	0.1	1.25	0.12	0.18	0.22	0.19	0.11
Pb	0.26	0.10	0.18	0.12	0.13	0.25	0.16	0.19	0.12	0.16	0.26
Cr	0.19	0.57	1.14	0.19	1.52	0.1	0.19	0.19	3.13	0.19	0.19
Na	2.14	3.22	1.94	2.03	2.77	3.08	1.59	2.36	3.11	2.58	1.85
K	50.4	25.18	31.41	30.25	26.17	22.12	27.04	31.51	30.43	28.54	27.43
Mg	3.1	2.19	2.72	2.46	2.39	2.05	3.1	2.29	1.54	3.1	3.1
Ca	2.61	3.56	3.89	3.56	3.75	4.81	2.61	3.61	4.38	2.61	2.61

Source: Harvestfield Fieldwork, Nov. 2014

Table 4.13: Summary of Mean concentration (mg/kg) of Heavy Metals in Sub Soils (15-30 cm) of the study Area in Wet season

Heavy Metals	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10	CONTROL
Fe	2387	1984	2382	2316	2167	2843	2439	2087	2117	2265	2163
Zn	48.7	41.3	30.8	51.9	45.0	66.7	40.1	50.8	53.2	40.3	59.6
Hg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
V	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ni	0.03	0.04	0.04	0.05	0.05	0.09	0.07	0.08	0.05	0.05	0.06
Cd	0.15	0.07	0.89	0.15	1.18	0.07	0.15	0.15	2.44	0.15	0.15
Cu	0.22	0.70	0.15	0.17	0.1	1.08	0.12	0.17	0.22	0.18	0.11
Pb	0.21	0.10	0.18	0.12	0.13	0.25	0.16	0.19	0.12	0.16	0.23
Cr	0.19	0.57	1.14	0.19	1.52	0.1	0.19	0.19	3.13	0.19	0.19
Na	2.14	3.22	1.94	2.03	2.77	3.08	1.59	2.36	3.11	2.58	1.85
K	50.4	25.18	31.41	30.25	26.17	22.12	27.04	31.51	30.43	28.54	27.43
Mg	3.1	2.19	2.72	2.46	2.39	2.05	3.1	2.29	1.54	3.1	3.1
Ca	2.61	3.56	3.89	3.56	3.75	4.81	2.61	3.61	4.38	2.61	2.61

Source: Harvestfield Fieldwork, Nov. 2014

Table 4.14: Summary of Mean concentration (mg/kg) of Heavy Metals in Top Soils (0-15 cm) of the study Area in Dry season

Heavy Metals	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10	CONTROL
Fe	2388	2014	2313	2402	2179	2790	2482	2137	2136	2385	2359
Zn	50.8	41.9	30.7	51.6	45.9	66.3	40.8	52.85	53.49	40.16	60.38
Hg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
V	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ni	0.02	004	0.03	0.05	0.04	0.07	0.06	0.08	0.06	0.03	0.07
Cd	0.11	0.05	0.82	0.14	1.02	0.07	0.11	0.15	2.38	0.13	0.18
Cu	0.21	0.67	0.13	0.17	0.16	1.17	0.18	0.21	0.20	0.18	0.14
Pb	0.21	0.13	0.15	0.14	0.13	0.22	0.18	0.17	0.11	0.15	0.22
Cr	0.17	0.55	1.08	0.16	1.43	0.11	0.17	0.21	3.08	0.16	0.17
Na	2.11	3.20	1.87	1.96	2.69	2.88	1.43	2.27	3.03	2.49	1.76
K	47.9	24.3	28.7	28.6	25.03	21.7	26.4	29.2	28.6	27.9	26.1
Mg	3.1	2.1	2.6	2.39	2.41	2.07	2.82	2.18	1.61	3.02	3.06
Ca	2.17	3.61	3.73	3.48	3.62	4.71	2.55	3.54	4.22	2.55	2.28

Source: Harvestfield Fieldwork, Feb. 2015

Table 4.15: Summary of Mean concentration (mg/kg) of Heavy Metals in Sub Soils (15-30 cm) of the study Area in Dry season

Heavy Metals	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10	CONTROL
Fe	2357	2002	2308	2381	2165	2646	2301	2078	2101	2274	2203
Zn	48.2	40.3	29.4	49.8	43.6	60.7	38.9	47.5	52.9	38.7	58.1
Hg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
V	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ni	0.02	0.03	0.02	0.04	0.04	0.05	0.04	0.06	0.05	0.02	0.05
Cd	0.08	0.06	0.75	0.11	0.97	0.07	0.07	0.11	2.23	0.11	0.11
Cu	0.18	0.53	0.11	0.14	0.12	1.09	0.14	0.16	0.13	0.14	0.11
Pb	0.17	0.12	0.15	0.16	0.10	0.19	0.15	0.12	0.09	0.12	0.16
Cr	0.21	0.43	0.88	0.17	1.32	0.15	0.19	0.23	2.93	0.16	0.19
Na	2.08	3.11	1.76	1.87	2.54	2.72	1.36	2.19	2.94	2.37	1.81
K	45.7	23.9	27.8	26.3	24.1	20.8	25.5	27.1	27.3	27.1	26.5
Mg	2.8	2.1	2.5	2.4	2.3	2.1	2.8	2.2	1.6	3.0	3.1
Ca	2.19	3.55	3.69	3.42	3.59	4.62	2.49	3.46	4.18	2.47	2.25

Source: Harvestfield Fieldwork, Feb. 2015

4.5.3 Ground Water

Physico-chemical properties of water samples collected from underground sources within the study area are presented in **Table 4.17 and appendix 4.4.**

Physico-Chemical Characteristics

pH values ranged from 5.8 to 6.1 during dry season 2019 while the same parameter ranged from 5.96 which was acidic to 7.65 which was basic 2015 dry season and 6.06 to 6.13 during wet season 2014. Conductivity and TDS values ranged between 384 to 454 us/cm and 185 to 202 mg/L respectively during dry season 2019; 100.7 to 159.7 us/cm and 70.20 to 111.20mg/L respectively during 2015 dry season while it ranged from 99.5 to 142.80 us/cm respectively during wet season of 2014.

Temperature

Water temperature influences chemical reactions, water density, solubility of gases, and the buoyancy mechanism of plankton. As expected, the wet season had a lower temperature regime than the dry season. The water temperature ranged from 35.2 to 36.8^{0}C with a mean of 36.0^{0}C during dry season of 2019 while it ranged from 30.6 to 34.1^{0}C with a mean value of 32.35^{0}C during dry season of 2015 and 28.20 to 30.90^{0}C with a mean value of 29.55^{0}C during wet season of 2014.

DO

The DO values ranged between 4.5 to 5.1mg/L during dry season of 2019 and4.15 to 4.22mg/L during dry season of 2015 season while it ranged from 3.90 to 4.309mg/L during 2014 wet season. The results reveal that the water body in the project area can sustain life forms.

BOD

The BOD in the ground water was between 2.2 and 4.2mg/l during the dry season and 8.54 to 8.62mg/L during the dry season of 2015 and 9.30 to 9.70mg/L during wet

season of 2014. On the other hand, COD which is an indirect measurement ranged between 18mg/L and 35mg/L for the dry season 2019 but was not measured during 2014 and 2015 field activities. Turbidity values recorded ranged from 2NTU to 3NTU for dry season but was not measured during 2014 and 2015 field activities.

Anions and Exchangeable Cations

From the table 4.17, the concentration of sulphate ranged from 20 to 21mg/L during dry season of 2019; 23.18 to 23.62mg/L during 2015 dry season and 23.39 to 23.50 during 2014 wet season. Chloride ranged from 20 to 21mg/L during 2019 dry season but was not measured during 2014 and 2015 field activities. Phosphate on the other hand ranged from 0.41 to 0.48mg/L during dry season 2019; 0.13 to 0.39mg/L during dry season 2015 and 0.08 to 0.45mg/L during 2014 wet season.

Cations concentrations on the other hand for dry season 2019, Sodium ranged between 0.75mg/l and 1.23mg/l, Potassium, Magnesium and Calcium ranged from 0.12 to 0.18mg/L, 0.117 to 0.125mg/L and 12.02 to 14.01mg/L respectively. During dry season 2015, Sodium ranged from 1.39 to 1.40mg/L, Potassium ranged from 0.48 to 0.52mg/L, Magnesium ranged from 0.68 to 0.73mg/L and Calcium ranged from 0.03 to 0.08mg/L. Also during wet season 2014, Sodium ranged from 1.42 to 1.45mg/L, Potassium ranged from 0.50 to 0.51mg/L, Magnesium ranged from 0.72 to 0.75mg/L and Calcium ranged from 0.02 to 0.10mg/L The results indicate that the values obtained during the dry season 2019 are higher than what was obtained in 2015 dry season and 2014 wet season.

Heavy Metals

The heavy metals concentration of the groundwater was generally low and below the detection limit of the atomic absorption spectrophotometer used for the analysis. In 2019 dry season, the mean(s) of heavy metals concentration were as follow:

Cu(<0.015mg/kg); Cr(<0.001mg/kg); Fe(9.1mg/kg); Pb(<0.001mg/kg), Zn(<0.001) and Ni(< 0.001mg/kg).

In 2015 dry season similarly, the mean(s) concentration of the heavy metals were Cu(<0.01mg/kg); Cr(<0.02mg/kg); Fe(0.42mg/kg); Pb(0.06mg/kg), Zn(<0.01) and Ni(< 0.03mg/kg).

In 2014 wet season similarly, the mean(s) concentration of the heavy metals were Cu(<0.02mg/kg); Cr(<0.01mg/kg); Fe(0.52mg/kg); Pb(0.05mg/kg), Zn(<0.01) and Ni(< 0.04mg/kg).

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

Ground Water Microbiology

The results of microbial counts in underground water samples collected in the project area are presented in Table 4.17. From the table, Total heterotrophic Bacteria (THB) was detected in all the underground water sources sampled with an average load of $1.0x10^4$cfu/ml for dry season 2019. However, HUB, HUF and THF were not detected. During 2015 dry season Total heterotrophic Bacteria (THB) ranged from 1.15 to 5.18 and Total heterotrophic Fungi (THF) ranged from 0.42 to 0.94 while HUB, HUF were not detected. On the other hand, during 2014 wet season, Total heterotrophic Bacteria (THB) ranged from 0.49 to 1.10 and Total heterotrophic Fungi (THF) ranged from 1.0 to 4.50 while HUB, HUF were not detected

Table 4.17: Summary of Physico Chemical Parameters in Ground Water of the Project Area (Dry Season 2019, Dry season 2015 and Wet season 2014)

S/N	Parameters	Dry Season (2019)					Dry Season 2015			Wet season 2014				
		Min	Max	Mean	STDEV	Control	Min	Max	Mean	Min	Max	Mean	WHO Limits	FMENV Limits
A	Physico-chemical Test													
1	pH	5.8	6.1	5.95	0.15	5.9	5.96	7.65	6.81	6.06	6.13	6.10	6 -9	6.5 – 8.5
2	TDS (mg/L)	121	160	140.5	19.5	111	70.20	111.20	90.70	69.40	70.40	69.90	NS	NS
3	EC (us/cm)	257	308	282.5	25.5	287	100.70	159.70	130.20	99.50	142.80	121.15	NS	NS
4	Temp (°C)	30.2	30.9	30.55	0.35	31	30.60	34.10	32.35	28.20	30.90	29.55	NS	NS
5	Turbidity(NTU)	2	3	2.5	0.5	3	-	-	-	-	-	-		
6	DO (mg/L)	4.5	5.1	4.8	0.3	4.85	4.15	4.22	4.19	3.90	4.30	4.10	NS	NS
7	BOD (mg/L)	2.2	4.2	3.2	1	3.3	8.54	8.62	8.58	9.30	9.70	9.50	NS	NS
8	COD (mg/L)	18	35	26.5	8.5	41	-	-	-	-	-	-	NS	4.5
9	TSS (mg/L)	48	53	50.5	2.5	53	-	-	-	-	-	-	NS	NS
10	Acidity (mg/L)	9	11	10	1	15	-	-	-	-	-	-	NS	NS
11	Total Hardness (mgCaCO3/L)	10	20	15	5	53	-	-	-	-	-	-	NS	NS
12	Sulphate (mg/L)	20	21	20.5	0.5	19	23.18	23.62	23.40	23.39	23.50	23.45	NS	NS
13	Chloride(mg/L)	19	21.75	20.375	1.375	24.75							NS	NS
14	Nitrate (mg/L)	0.1	0.15	0.125	0.025	0.04	0.07	0.07	0.07	0.07	0.07	0.07	NS	NS
15	Phosphate (mg/L)	0.41	0.48	0.445	0.035	0.42	0.13	0.39	0.26	0.08	0.45	0.27	NS	NS
16	TOC (%)	0.048	0.051	0.0495	0.0015	0.048							NS	NS
17	THC (mg/L)	<0.001	<0.001	<0.001	0	<0.001	0.29	0.30	0.30	0.29	0.39	0.34	NS	NS
18	TPH (mg/L)	<0.001	<0.001	<0.001	0	<0.001	-	-	-	-	-	-	NS	NS
19	PAH (mg/L)	<0.001	<0.001	<0.001	0	<0.001	-	-	-	-	-	-	NS	NS
20	BTEX (mg/L)	<0.001	<0.001	<0.001	0	<0.001	-	-	-	-	-	-	NS	NS

21	Phenol (mg/L)	<0.001	<0.001	<0.001	0	<0.001	-	-	-	-	-	-	NS	NS
22	Available Phosphate (mg/L)	0.38	0.43	0.405	0.025	0.48	-	-	-	-	-	-	NS	NS
23	Total Nitrogen (mg/L)	0.38	0.4	0.39	0.01	0.55	-	-	-	-	-	-	NS	NS
24	Ammonium (mg/L)	0.25	0.25	0.25	0	0.65	-	-	-	-	-	-	NS	NS
25	Nitrite (mg/L)	0.049	0.067	0.058	0.009	0.056	-	-	-	-	-	-	NS	NS
CATIONS/HEAVY METALS														
26	Sodium (mg/L)	0.75	1.23	0.99	0.24	1.6	1.39	1.40	1.40	1.42	1.45	1.44	NS	NS
27	Potassium (mg/L)	0.12	0.18	0.15	0.03	0.61	0.48	0.52	0.50	0.50	0.51	0.51	NS	NS
28	Magnesium	0.117	0.125	0.125	0.004619	0.198	0.68	0.73	0.71	0.72	0.75	0.74	1	20
29	Iron (mg/L)	7.9	10.3	9.1	1.2	8	0.37	0.46	0.42	0.49	0.54	0.52	NS	NS
30	Chromium (mg/L)	<0.001	<0.001	<0.001	0	<0.001	0.01	0.02	0.02	0.01	0.01	0.01	NS	NS
31	Nickel (mg/L)	<0.001	<0.001	<0.001	0	<0.001	0.02	0.03	0.03	0.03	0.04	0.04	-	5
32	Calcium (mg/L)	12.02	14.01	13.015	0.995	18.53	0.03	0.08	0.06	0.02	0.10	0.06	NS	NS
33	Vanadium (mg/L)	<0.001	<0.001	<0.001	0	<0.001	-	-	-	-	-	-	NS	NS
34	Barium (mg/L)	<0.001	<0.001	<0.001	0	<0.001	-	-	-	-	-	--	NS	NS
35	Copper(mg/L)	0.01	0.02	0.015	0.005	0.076	0.01	0.01	0.01	0.01	0.02	0.02	NS	NS
36	Zinc (mg/L)	<0.001	<0.001	<0.001	0	<0.001	0.01	0.01	0.01	0.01	0.01	0.01	NS	NS
37	Manganese (mg/L)	<0.001	<0.001	<0.001	0	<0.001	0.01	0.01	0.01	0.01	0.01	0.01	NS	NS
38	Cadmium (mg/L)	<0.001	<0.001	<0.001	0	<0.001	0.03	0.05	0.04	0.02	0.05	0.04	NS	NS
39	Lead (mg/L)	<0.001	<0.001	<0.001	0	<0.001	0.05	0.07	0.06	0.04	0.05	0.05	NS	NS
40	Mercury (mg/L)	<0.05	<0.05	<0.05	0	<0.05	ND	ND	ND	ND	ND	ND	NS	NS
MICROBIOLOGY														

41	THB (x 10^4 cfu/ml)	1	-	0.5	0.353553	1	1.15	5.18	3.165	0.49	1.10	0.795	NS	NS
42	HUB (x 10^4 cfu/ml)	-	-	-	0	-	Nil	Nil	Nil	Nil	Nil	Nil	NS	NS
43	THF (x 10^4 cfu/ml)	-	-	-	0	-	0.42	0.94	0.68	1.0	4.50	2.75	NS	NS
44	HUF (x 10^4 cfu/ml)	-	-	-	0	-	Nil	Nil	Nil	Nil	Nil	Nil	NS	NS
45	Total Coliforms (x 10^4 cfu/ml)	-	-	-	0	-	Nil	Nil	Nil	Nil	Nil	Nil	NS	NS
46	HUB/THB Ratio	-	-	-	0	-	Nil	Nil	Nil	Nil	Nil	Nil	NS	NS
47	HUF/THF Ratio	-	-	-	0	-	Nil	Nil	Nil	Nil	Nil	Nil	NS	NS

Fieldwork 2014/2015 and 2019

4.5.4 Surface Water Studies

The main surface water body in the project area is the Lenuwa Stream where samples were collected. The physico-chemical properties of surface water is summarized in **Tables 4.18** and discussed in subsequent subsections, while the detailed results of the physico-chemical analysis and microbiology of surface water are presented in **Appendix 4.3.**

Table 4.18: Summary of Physico-chemical Characteristics of Surface Water (Dry Season)

Parameters	Dry Season				
Physico-chemical Test	**Min**	**Max**	**Mean**	**Stdev**	**SW (Control)**
pH	5.7	6.2	5.95	0.25	6.1
TDS (mg/L)	119	220	169.5	50.5	81
EC (us/cm)	245	410	327.5	82.5	158
Temp (^oC)	30.3	37.3	33.8	3.5	35.5
COD (mg/L)	22	33	27.5	5.5	41
TSS (mg/L)	10	14	12	2	12
BOD (mg/L)	11	14	12.5	1.5	11
DO (mg/L)	4.3	5	4.65	0.35	5.6
Turbidity	2	3	2.5	0.5	2
Acidity (mg/L)	17	25	21	4	20
Total Hardness (mgCaCO3/L)	70	146	108	38	132
Sulphate (mg/L)	18	21	19.5	1.5	26
Nitrate (mg/L)	0.02	0.05	0.04	0.015275	0.04
Phosphate (mg/L)	0.05	0.19	0.12	0.07	0.12
TOC (%)	0.04	0.05	0.04	0.005774	0.05
THC (mg/L)	1.55	4.29	2.92	1.37	4.713
Oil & Grease (mg/L)	<0.001	<0.001	<0.001	0	<0.001
PAH (mg/L)	<0.001	<0.001	<0.001	0	<0.001
TPH (mg/L)	<0.001	<0.001	<0.001	0	<0.001
BTEX (mg/L)	<0.001	<0.001	<0.001	0	<0.001
Phenol (mg/L)	<0.001	<0.001	<0.001	0	<0.001
Available Phosphate	0.05	0.08	0.07	0.015275	0.07

(mg/L)					
Total Nitrogen (mg/L)	0.3	0.65	0.48	0.175024	0.51
Ammonium (mg/L)	0.32	0.49	0.41	0.085049	0.33
Nitrite (mg/L)	0.01	0.02	0.01	0.005774	0.016
Sodium (mg/L)	3.44	4.36	3.9	0.46	5.06
Potassium (mg/L)	1.76	3.73	2.75	0.985004	2.19
Magnesium (mg/L)	0.14	0.72	0.43	0.29	0.201
Iron (mg/L)	0.49	0.8	0.65	0.155027	0.64
Chromium (mg/L)	<0.001	<0.001	<0.001	0	<0.001
Nickel (mg/L)	<0.001	<0.001	<0.001	0	<0.001
Calcium (mg/L)	28.06	45.29	36.68	8.615	53.08
Vanadium (mg/L)	<0.001	<0.001	<0.001	0	<0.001
Barium (mg/L)	<0.001	<0.001	<0.001	0	<0.001
Copper(mg/L)	0.04	0.06	0.05	0.01	0.056
Zinc (mg/L)	<0.001	<0.001	<0.001	0	<0.001
Manganese (mg/L)	<0.001	<0.001	<0.001	0	<0.001
Cadmium (mg/L)	<0.001	<0.001	<0.001	0	<0.001
Lead (mg/L)	<0.001	<0.001	<0.001	0	<0.001
Mercury (mg/L)	<0.05	<0.05	<0.05	0	<0.05
THB (x 10^4 cfu/ml)	148	152	150	2	133
HUB (x 10^4 cfu/ml)	12	17	14.5	2.5	9
THF (x 10^4 cfu/ml)	101	179	140	39	200
HUF (x 10^4 cfu/ml)	6	11	8.5	2.5	10
Total Coliforms (x 10^4 cfu/ml)	36	58	47	11	29
HUB/THB Ratio	0.12	0.08	0.1	0.02	0.0663
HUF/THF Ratio	0.05	0.11	0.08	0.03	0.0518

Source: Fieldwork 2019

pH

The pH is a measure of the hydrogen ion concentration in water. The pH concentration in rivers and streams can be attributed to a series of interactions involving organic acids, biological activities as well as physical processes. Surface water pH recorded ranged from 5.7 which is slightly acidic to 6.2 which is moderately basic with a mean of 5.95 in the dry season of 2019.

Turbidity

Turbidity in water bodies can be attributed to several factors including: increase in waste discharge, urban run-off, bottom feeders that stir up sediments, waves and current actions. In the study area, the dry season had lower turbidity concentrations than the dry season. The turbidity ranged from ranged from 2 to 3 NTU with a mean of 2.5NTU.

Temperature

Water temperature influences chemical reactions, water density, solubility of gases, and the buoyancy mechanism of plankton. The water temperature ranged from 30.3 to 37.3^{0}C with a mean of 33.8^{0}C.

Chemical Oxygen Demand

Chemical Oxygen Demand (COD) is used to measure the total quantity of oxygen-consuming substances in the complete chemical breakdown of organic substances in water. All aquatic plants and animals contribute to chemical oxygen demand through their metabolism and excretion of waste products. COD concentration ranged from 22 to 33mg/l with a mean of 27.5mg/l.

Electric Conductivity/Total Dissolve Solids

Electric conductivity refers to the total ionic composition of water. In many cases, the electrical conductivity can be correlated with the Total Dissolved Solids (TDS) levels. Conductivity ranged from 245 to 410us/cm with a mean of 327.5us/cm. TDS on the hand ranged from 119 to 220mg/L.

Exchangeable Cations

Calcium (Ca), potassium (K) and sodium (Mg) are very abundant elements in the earth's crust/aquatic environment and are key elements required to ensure optimal primary and secondary productivity.

The mean concentration of calcium for the dry seasons was 36.68mg/l; the average sodium concentration was 3.9 mg/l; while potassium retuned average values of 2.75 mg/l. Calcium was the most abundant cation in the wet season, while sodium had the highest abundance in the dry season.

Nutrients

Nitrate levels in surface water ranged from 0.02 mg/l – 0.05 mg/l with a mean of 0.04 mg/l. Nitrites had mean concentrations of 0.01mg/l. On the hand, sulphate concentration ranged from 18 mg/l to 21 mg/l, with a mean of 19.5 mg/l.Phosphates enter water bodies from sewage or runoff from fertilized land/crops. Phosphate levels were generally low in the study, ranging from 0.05 to 0.08mg/l with a mean of 0.07mg/l.

Hydrocarbons/ Total Organic Content

Total Organic Carbon (TOC) ranged from 0.04 – 0.05 %, with a mean of 0.04% while Total Hydrocarbon Content (THC) ranged from 1.55 to 4.29mg/l, with a mean of 2.92 mg/l.THC values may be attributed to run offs from adjoining farmlands, domestic wastes and discharge of sewage.

PAH are a major group of persistent organic pollutants and are mainly produced by anthropogenic activities (Hussein et al, 2015). They are a well-known class of ubiquitous ecotoxicants that are harmful to human health (Essumang et al (2018). Total PAH has a constant value of <0.001mg/l in all the sampling locations. BTEX and phenols were below equipment detection limits of 0.001 mg/l. BTEX rarely occurs in water since they are readily evaporated.

Heavy Metals in Surface Water

Heavy metal concentrations were generally low and within acceptable limits, with Iron ranging from 0.49mg/l to 0.80mg/l, with a mean of 0.645mg/l; barium having a constant value at all the locations with a concentration of 0.001mg/l; while Zinc, Lead, chromium, nickel and vanadium were below equipment detection limits of 0.001mg/l. Also, copper ranged from 0.04 to 0.06mg/l during the dry season of 2019.

Surface Water Microbiology

The density of the Total Heterotrophic Bacteria ranged from 148 x 10^4cfu/ml to 152 x 10^4cfu/ml with a mean count of 150 x 10^4cfu/ml. The population of the Hydrocarbon Utilizing Bacteria ranged from 12 x 10^4cfu/ml to 17 x 10^4cfu/ml with a mean count of 14.5 x 10^2cfu/ml.

The population of THF ranged from 101 x 10^4cfu/ml to 179 x 10^4cfu/ml with a mean count of 140. x 10^4cfu/ml while the total heterotrophic fungi ranged from 106 x 10^4cfu/ml to 185 x 10^4cfu/ml with a mean count of 145.5 x 10^4cfu/ml. HUF ranged from 6 x 10^4cfu/ml to 11 x 10^4cfu/ml with a mean count of 8.5 x 10^4cfu/ml.

4.5.5 Sediment Studies

4.5.5.1Physico-chemical Properties of Sediment

Detailed results of the physico-chemical characteristics of sediment are presented in **Appendix 4.5.** The results of the physicochemical parameters of sediment are summarized in **Tables 4.19.**

The summary of the physico-chemical parameters of sediment during dry season shows that the Total Nitrogen ranged from 0.16 to 0.28 %, with a mean value was 0.22%, while Sodium, Potassium, Magnesium and Calcium had respective mean values of 5.59mg/kg, 3.865 mg/kg, 0.5805mg/kg and 34.065mg/kg. The anions present in sediment; sulphate, phosphate and nitrate recorded mean concentration values of 1290 mg/kg, 7.8 mg/kg and 2.06mg/kg respectively.

The Total Hydrocarbon Content (THC) ranged from 0.03 mg/kg to 0.1 mg/kg with a mean value of 0.065 mg/kg; TPH concentrations has a constant value of <0.001mg/kg, PAH concentrations has a constant value of <0.001mg/kg. Total Organic Carbon (TOC) concentrations ranged from 2.34 to 2.65 % with a mean value of 2.495%, while BTEX and Phenols were below detection limits of 0.001mg/kg.

Heavy Metals in Sediment

The concentrations of heavy metals in sediments are shown in **Tables 4.19.** The results showed a concentration ranging from 170 mg/kg to 675 mg/kg, with a mean of 422.5mg/kg for Iron; 2.42 to 3.85 mg/kg, with a mean of 3.131mg/kg for nickel; while chromium, vanadium, zinc, lead, cadmium and barium were below equipment detection limits of 0.001 mg/kg and mercury with a constant value of <0.05mg/kg. This study showed a relatively high concentration of iron with respect with other heavy metals and this could be a reflection of its relative abundance in the Earth's crust.

Microbiology of Sediment

The results of microbiology analyses of sediment in the wet season, showed that the Total Heterotrophic Bacteria (THB) count ranged from 163 x 10^4cfu/g to 286 x 10^4cfu/g with a mean count of 224.5 x 10^4cfu/g; while the Hydrocarbon-Utilizing Bacteria (HUB) count ranged from 5 to 7 x 10^4cfu/g, with an average count of 6.0 x 10^4cfu/g.

The study revealed a coliform count in sediment ranging from 35 x 10^4cfu/g to 49 x 10^4cfu/g, with a mean count of 42 x 10^4cfu/100g; the total coliforms had higher counts and the presence of coliforms and e-coli in sediments indicates recent faecal contamination and a likelihood of pathogens. The Total Heterotrophic Fungi (THF) count ranged from 119 x 10^4cfu/g to 157 x 10^4cfu/g, with a mean of 138 x 10^4cfu/100g, while the Hydrocarbon Utilizing Fungi (HUF) ranged from 15 x 10^4cfu/g to 20 x 10^4cfu/g, with a mean count of 17.5 x 10^4cfu/g.

Table 4.19: Summary of Physico-Chemical Properties of Sediment (Dry Season 2019)

S/N	PARAMETERS	Wet Season				
	Physico-chemical Test	**Min**	**Max**	**Mean**	**STDEV**	**CONTROL**
1	**pH**	6.9	7.5	7.2	0.3	8.5
2	Conductivity	234	532	383	149	201
3	Sulphate (mg/kg)	780	1800	1290	510	750
4	Nitrate (mg/kg)	1.32	2.8	2.06	0.74	1.81
5	Phosphate (mg/kg)	6.4	9.2	7.8	1.4	6.7
6	Total Nitrogen (%)	0.16	0.28	0.22	0.06	0.12
7	Ammonium (mg/kg)	6.46	17.5	11.98	5.52	7.61
8	Nitrite (mg/kg)	0.76	1.01	0.885	0.125	0.67
9	TOC (%)	2.34	2.65	2.495	0.155	2.01
10	Phenols (mg/kg)	<0.001	<0.001	<0.001	0	<0.001
11	THC (mg/kg)	0.03	0.1	0.065	0.035	0.03
12	TPH (mg/kg)	<0.001	<0.001	<0.001	0	<0.001
13	PAH (mg/kg)	<0.001	<0.001	<0.001	0	<0.001
14	BTEX (mg/kg)	<0.001	<0.001	<0.001	0	<0.001
15	Moisture Content (%, Oven- dry basis)	132	242	187	55	259
16	Sodium (mg/kg)	4.9	6.28	5.59	0.69	5.87
17	Potassium (mg/kg)	3.55	4.18	3.865	0.315	3.71
18	Calcium (mg/kg)	32.12	36.01	34.065	1.945	38.93
19	Magnesium (mg/kg)	0.211	0.95	0.5805	0.3695	0.256
20	Iron (mg/kg)	170	675	422.5	252.5	605
21	Vanadium (mg/kg)	<0.001	<0.001	<0.001	0	<0.001
22	Chromium (mg/kg)	<0.001	<0.001	<0.001	0	<0.001
23	Barium (mg/kg)	<0.001	<0.001	<0.001	0	<0.001
24	Nickel (mg/kg)	2.416	3.846	3.131	0.715	2.689

25	Copper (mg/kg)	0.038	0.061	0.0495	0.0115	0.056
26	Zinc (mg/kg)	<0.001	<0.001	<0.001	0	<0.001
27	Manganese (mg/kg)	<0.001	<0.001	<0.001	0	<0.001
28	Cadmium (mg/kg)	<0.001	<0.001	<0.001	0	<0.001
29	Lead (mg/kg)	<0.001	<0.001	<0.001	0	<0.001
30	Mercury (mg/kg)	<0.05	<0.05	<0.05	0	<0.05
31	THB (x 10^4 cfu/g)	163	286	224.5	61.5	182
32	HUB (x 10^4 cfu/g)	5	7	6	1	8
33	THF (x 10^4 cfu/g)	119	157	138	19	107
34	HUF (x 10^4 cfu/g)	15	20	17.5	2.5	10
35	Total Coliforms (x 10^4 cfu/g)	35	49	42	7	40
36	HUB/THB Ratio	0.0237	0.0289	0.0263	0.0026	0.0429
37	HUF/THF Ratio	0.0947	0.1658	0.13025	0.03555	0.0921

Source: Fieldwork, 2019

4.5.6 Plankton and Zooplankton Analysis

Plankton

In the laboratory, five drops (using a dropper) of the concentrated sample (10ml) was investigated at different magnifications (50X, 100X and 400X) using a Wild II binocular microscope with calibrated eye piece and the average recorded. The drop count microscope analysis method described by Lackey (1938) and modified by Onyema (2007) was used to estimate the plankton flora and fauna. Since each sample drop from the dropper accounts to 0.1ml, the results on abundance / occurrence were multiplied accordingly to give the values as numbers of organisms per ml which is the standard unit of measurement.

To create a suitable plankton sample mount, a dropper was used to take in at least 1.5ml of the sample after shaking properly. This was then allowed to stand for at least 3 minutes. After which one or two drops of concentrated sample from the dropper was then gently dropped on a glass-slide (7.5 cm by 2.5 cm) while placed on a flat laboratory table and covered with a glass-slide (2cm by 2cm). The mount was then placed on the microscope stage, fitted in and all transects thoroughly observed for phytoplankton (cells, filaments, colonies) and zooplankton species (e.g. adults and juvenile stages alike). Final data were presented as number of organisms (cells, filaments, colonies and whole organism) per ml.

Appropriate texts were used to aid identification of the species. (**Phytoplankton**- Hendey 1958, 1964; Wimpenny, 1966; Patrick and Reimer, 1966, 1975; Whitford and Schmacher, 1973; Vanlandingham, 1982; Nwankwo, 1990, 1995, 2004; Bettrons and Castrejon, 1999; Lange-Bertalot, 2001; Witkowski*et al*., 2000; Siver, 2003; Rosowski, 2003; **Zooplankton** - Newell and Newell, 1966; Olaniyan, 1975; Barnes *et al.,* 1993 and Waife and Frid, 2001).

Community Structure Analysis

Biodiversity or Biological Diversity is the sum of all the different species of animals, plants, fungi, and microbial organisms living on Earth and the variety of habitats in which they live. Biodiversity is also the variation of life forms within a given ecosystem, biome or for the entire Earth. Consequently, biodiversity is often used as a measure of the health of systems. A diversity index is a mathematical measure of species diversity in a community. Diversity indices provide important information about rarity and commonness of species in a community. The ability to quantify diversity in this way is an important tool for biologists trying to understand community structure.

The following diversity indices were used for biological data analysis. Furthermore, results on these indices are presented in two (2) decimal places. For phytoplankton and zooplankton community's, eco-mathematical indices (biological indices) were used. Apart from the Total number of species (S), abundance of species (N), Log of Species diversity (Log S) and Log of species abundance (Log N) others used were Shannon-Wiener Index (Hs), Menhinick Index (D), Margalef Index (d), Equitability (j) and Simpson's Dominance Index (C) (Ogbeibu, 2005).

Species Richness Index (d)

The Species richness index (d) according to Margalef (1951) is a measure of diversity and was used to evaluate the community structure. Species Richness is a measure of the number of different kinds of organisms present in a particular area. This index is also referred to as Margalef index. The equation below was applied.

$$d = \frac{S - 1}{\ln N}$$

Where:

d = Species richness index

S = Number of species in a population

N = Total number of individuals in S species.

Menhinick's Index (D).

The Menhinick's Index (D)is one of several diversity indices used to quantify diversity and hence measure diversity in categorical data. It represents a biological association with a number which give a measure of its community structure. The equation below was applied.

$$d = \frac{S - 1}{\ln N}$$

S = Number of species in a population

N = Total number of individuals in S species.

Shannon and Weiner diversity index (Hs).

The Shannon and Weiner diversity index (Hs)is one of several diversity indices used to measure diversity in categorical data. It is simply the Information entropy of the distribution, treating species as symbols and their relative population sizes as the probability. Shannon and Wiener (1963) diversity index is also called Shannon index. The equation below was applied.

$$Hs = \frac{N \log N - (\sum Pi \log Pi)}{N}$$

Where, Hs = Shannon and Wiener diversity Index

i = Counts denoting the ith species ranging from 1 – n

Pi = Proportion that the ith species represents in terms of numbers of individuals with respect to the total number of individuals in the sampling space as whole.

Species Equitability or Evenness index (j).

The Species Equitability or Evenness index (j)is one of several diversity indices used to measure diversity in categorical data. Evenness is a measure of the relative abundance of the different species making up the richness of an area. The equation below was applied.

$$j = \frac{Hs}{\log_2 S}$$

Where

j = Equitability index

Hs = Shannon and Weiner index

S = Number of species in a population

Simpsons dominance index (C).

Simpson's Diversity Index is a measure of diversity. In ecology, it is often used to quantify the biodiversity of a habitat. It takes into account the number of species present, as well as the abundance of each species. Simpson's diversity index (D) is a simple mathematical measure that characterizes species diversity in a community. The proportion of species *i* relative to the total number of species (p_i) is calculated and squared. The squared proportions for all the species are summed, and the reciprocal is taken. The equation below was applied.

$$C = \sum \left(\frac{n_i}{N}\right)^2$$

Where, n = the **total number of organisms of a particular species**

N = **the total number of organisms of all species**

Phytoplankton Spectrum of Lenuwa stream

Nineteen species of phytoplankton were identified ranging from six species of Chlorophyta, five species of Bacilliarophyta, three species of Cyanophyta, one of Dinophyta, two species of Euglenophyta, one of Chrysophyta and one of Rodophyta species appearing slightly. A checklist of the phytoplankton spectrum is presented in Table 4.20 alongside the distribution of the phytoplankton species at the stations investigated. Total number of species recorded per station ranged between 16 and 19.

The species richness was evaluated using Margalef's (d) and Menhinick's (D) indices. Margalef's index ranged between 2.82 (St 2) and 3.64 (St 10) while Menhinick's index range between 1.25 (St 2) and 1.60 (St 10). Evaluating the species diversity in the study area, Shannon-Weiner index (Hs) ranged between 1.03 (St6) and 1.15 (St 10), Equitability index (j) ranged between 0.86 (St 6) and 0.92 (St 2&4) while Simpson's Dominance index (C) ranged between 0.07 (St 5 &10) and 0.11 (St 6) (**Table 4.47**). The key species occurring for the study were *Oedoganium Sp., Cladophoraoligoclona, Ulothrixtenuissima, Spirogyra Sp.,MougeotiaSp.,Zygnemapectinatum, Coscinodiscus Sp., Aulacoseira Sp., Fragillaria Sp., Nitzchia Sp., NaviculaSp, Merismopedia Sp., ChroococcusSp.,Dinophysiscaudata,*and*Euglena Sp.* in terms of occurrence and abundance in Lenuwa Stream.

Zooplankton Spectrum Lenuwa Stream

Two (2) groups of species were recorded for the zooplankton at the 4stations (Table 4.20). They were Phylum – Crustaceaand Phylum – rotifera,. The dominant group of zooplankton was the Phylum – Rotifera, with four families (Asplanchinidae, Gastropodidae, Brachionidae and Conochinidae) while crustacea is represented by

Bosminidae, Calanoidae and Daphniidae. Total number of species recorded per station for zooplankton ranged between 5 (St 3) and 8 (St 2 &). The Shannon-Wiener Index (Hs) was between0.67 (St 3& 8)and 0.87(St 7); Menhinick Index (D) was between 0.60 (St 5& 10) and 0.76 (St 2& 7). Margalef Index (d) values were from 1.00 (St 3) to 1.49 (St 2),

Table 4.20: Composition and Abundance Distribution of Phytoplankton per ml in Lenuwa Stream

Phytoplankton Taxa	St 1	St 2	St 3	St 4
CHLOROPHYTA				
Oedoganium Sp.	30	31	30	22
Cladophoraoligoclona	12	11	12	10
Ulothrixtenuissima	3	-	2	3
Spirogyra Sp.	2	2	2	2
Mougeotia Sp.	13	11	13	12
Zygnemapectinatum	2	2	2	2
BACILLIAROPHYTA				
Coscinodiscus Sp.	10	12	11	10
AulacoSeira Sp.	13	11	10	13
Fragillaria Sp.	10	11	10	9
Nitzchia Sp.	5	6	4	6
NaviculaSp	7	7	6	-
CYANOPHYTA				

Merismopedia Sp.	13	10	11	13
Chroococcus Sp.	17	13	14	17
OscillatoriaSp	2	2	-	2
DINOPHYTA				
Dinophysiscaudata	11	10	-	12
EUGLENOPHYTA				
Euglena Sp.	3	4	2	4
Phacus Sp.	1	-	1	-
CHRYSOPHYTA				
Synura Sp.	1	-	1	-
RHODOPHYTA				
Batrachospermum Sp.	-	-	-	-
Total species diversity (S)	18	15	16	15
Total abundance (N)	155	143	131	137

Source: Spec Fieldwork 2019

Table 4.21: Phytoplankton Community Biological Indices in Lenuwa Stream

Biological indices	**St 1**	**St 2**	**St 3**	**St 4**
Log of Species diversity (Log S)	1.26	1.18	1.20	1.18
Log of abundance (Log N)	2.19	2.16	2.12	2.14
Shannon-Wiener Index (Hs)	1.11	1.08	1.05	1.08

Menhinick Index (D)	1.45	1.25	1.40	1.28
Margalef Index (d)	3.37	2.82	3.08	2.85
Equitability Index (j)	0.89	0.92	0.87	0.92
Simpson's Dominance Index (C)	0.08	0.09	0.10	0.08

Source: Spec Fieldwork 2019

Table 4.22: Composition and Abundance Distribution of Zooplankton per ml

Zooplankton Taxa	**St 1**	**St 2**	**St 3**	**St 4**
Rotifera Asplanchnidae *Asplanchnasp*	25	10	10	25
Gastropodidae *Ascomorphasp*	10	15	-	10
Gastropodidae *Gastropussp*	35	25	15	5
Brachionidae *Brachionussp*	5	10	-	35
Conochilidae *Conochilussp*	15	15	10	15

Crustacea Bosminidae *Bosminasp*	5	15	5	5
Calanoidae *Calanoidsp*	-	5	-	-
Daphniidae *Daphnia sp*	25	15	15	25
Total species diversity (S)	7	8	5	7
Total abundance (N)	120	110	55	120

Source: Spec Fieldwork 2019

Table 4.23: Zooplankton Community Biological Indices

Biological indices	**St 1**	**St 2**	**St 3**	**St 4**
Log of Species diversity (Log S)	0.85	0.90	0.70	0.85
Log of abundance (Log N)	2.08	2.04	1.74	2.08
Shannon-Wiener Index (Hs)	0.76	0.87	0.67	0.76
Menhinick Index (D)	0.64	0.76	0.67	0.64
Margalef Index (d)	1.25	1.49	1.00	1.25
Equitability Index (j)	0.90	0.96	0.96	0.90
Simpson's Dominance Index (C)	0.20	0.14	0.22	0.20

Source: Spec Fieldwork 2019

4.9 Vegetation and Wildlife Studies

Species Identification

Vegetation sampling was conducted using systematic sampling procedure. The vegetation of the proposed permanent site was assessed using a 100m square meter quadrat to estimate both herbaceous and woody flora of the plot. Three quadrat were located at 75 m intervals along a 250 m transect located along North-South corridor of the plot, leaving 25 m un-surveyed at both ends in order to avoid edge effects. Another adjacently placed transect was located along East-West corridor of the plot to sample three quadrats located at 50 m intervals with 50 m left at the ends to avoid edge effects.

The vegetation of the take-off site was randomly assessed for floristic identification using a 1m square meter quadrat because it was mainly composed of herbaceous plants. The coordinates of sampling points are recorded (Table 4.19). All species were identified to species level following Akobundu and Agyakwa (1987), and Hutchinson and Dalziel, (1968). Families and common names of plant species were provided also.

Data Analyses

Relative Importance Values (RIVs) of species all species were computed from their density and frequency values following Kent and Coker, 1992. Also calculated are Shannon-Weiner indices, Margalef index (as a measure of species richness), Dominance and Evenness indices using the PAST software (Harmer, 2001).

Results

Species Composition and Diversity of the Flora

The area encompasses two (2) ecological zones; namely, the Derived Savanna Ecological Zone and Lowland Rain Forest Zone. At the site savanna type grasses and shrubs that are susceptible to fire and therefore they limit the lowland species that can regenerate, thus creating a derived savanna. Presently there is no tree species observed within the study area. The larger percentage of the plant species encountered

within the proposed site are grasses majorly *Panicum maximum* belonging to the family Poaceae. Plant species that were noted to be abundant and widely distributed at the site area include: *Panicum maximum, Cynodon dactylon, Aspilia Africana, Chromolaena Odorata, Sida acuta, Sida corymbosa, Commelina nudiflora, Tridax procumbens, Sporobolus Pyramidalis, Axonopus compressus, Amaranthus spinosus*.

The diversity analyses of the flora of the proposed permanent plot for the establishment of Harvestfield Aflasafe Plant indicated 16 plant species with an estimated abundance of 1568 individuals/hectare (Table 4.19). The Shannon-Weiner index is high, indicating high alpha diversity as supported by the Simpson index of 0.8132 (which tends more to one than zero). There is no dominance among the components of the flora, indicating that are all evenly distributed in the plot.

Table 4.19: Species Composition and Relative Importance Values of Flora at the Proposed Site (Wet Season)

S/N	Species	Family	Common Names	RIV
1	*Mimosa pudica*	Leguminosae	Sensitive Plant	5.32153
2	*Panicum maximum*	Poaceae	Elephant Grass	18.78882
3	*Chromolaena odorata*	Asteraceae	Siam Weed	10.14593
4	*Vigna gracilis*	Leguminosae	Creeping Vigna	2.578314
5	*Asystasia gangetica*	Acanthaceae	Chinese Violet	2.220478
6	*Boerhivia diffusa*	Nyctaginaceae	Hog weed	10.00937
7	*Aspilia africana*	Asteraceae	Haemorrhage Plant	6.531049
8	*Sida corymbosa*	Malvaceae		1.753416
9	*Alchornea cordifolia*	Euphorbiaceae	Christmas tree	5.080144
10	*Calopogonium mucunoides*	Leguminosae	Calopo	6.180125

11	*Axonopus compressus*	Poaceae	Carpet Grass	3.391102
12	*Sporobolus pyramidalis*	Poaceae	Goose Grass	2. 795962
13	*Sida acuta*	Malvaceae	Wire weed	3.090062
14	*Cynodon dactylon*	Poaceae	Bermuda Grass	9.100271
15	*Tridax procumbens*	Asteraceae	Tridax	8.005658
16	*Amaranthus spinosus*	Amaranthaceae	Amaranthus	7.223459

Source: Spec Fieldwork 2019

The Poaceae family has the highest index value which reflects the abundance value while Acanthaceae has the least among the eight families encountered in the site. The high value of Poaceae and Asteraceae is an indication of human interference with the natural habitat/forest of the proposed site thus rendering it a derived savanna

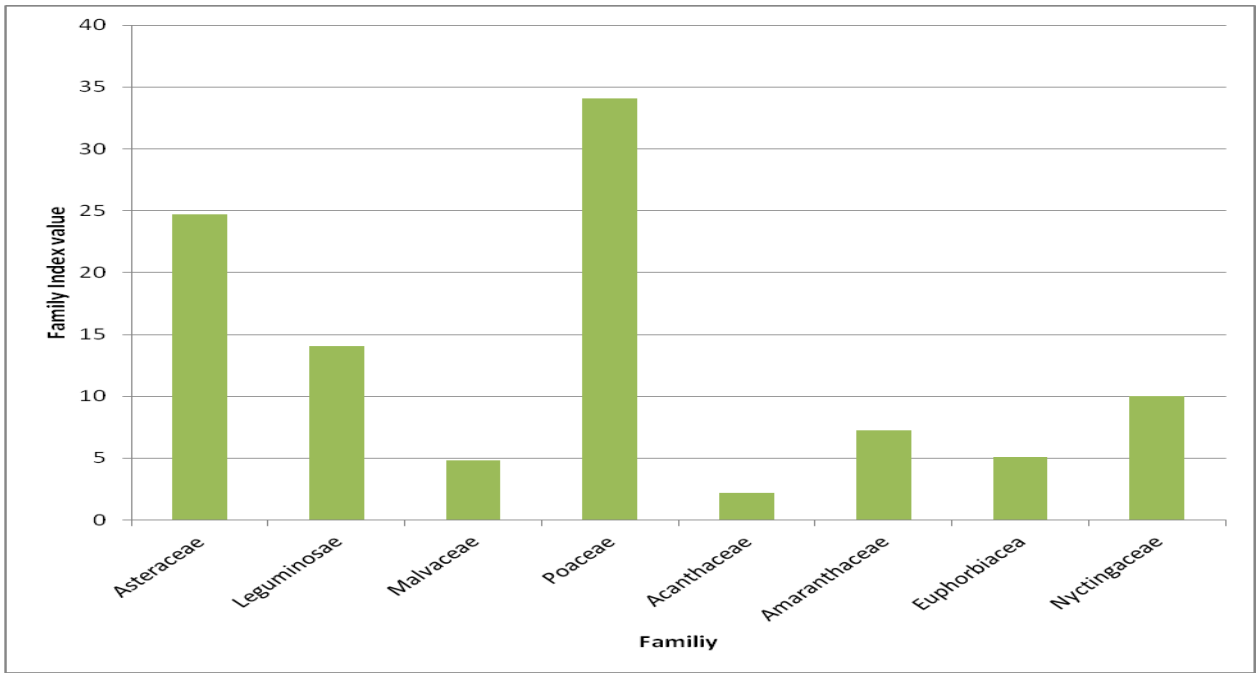

Figure 4.7: Family Index Value of species encountered in the project site

Source: Spec Fieldwork 2019

Table 4.20: Diversity Indices of the Flora at the Proposed Site (Dry Season)

S/N	Taxa	Values
1	Taxa	16
2	Individuals	1568
3	Dominance	0.1673
4	Shannon-Wiener index	2.835
5	Margalef Index	1.678
6	Simpson Index	0.8132
7	Equitability	0.7842

Source: Spec Fieldwork 2019

4.10 Wildlife Status during the wet season

The proximity of the proposed site to a major dual carriage road, Lagos-Ibadan Express, which a busy road with noise affected the sighting and detection of wildlife in the plot. Nevertheless, birds were mostly encountered, and they included partridges, starlings, wood pecker, and species of amphibians. Some of the wildlife species reported around the project area are shown in table 4.21 below.

Table 4.21: List of some wildlife species reported around the project area

Common Name	Biological Name	Abundance status	Conservation status
Mammal			
Fire-footed tree squirrel	*Funisciurus pyrrhopus*	Uncommon	Endangered
Giant Port Rats	*Rattus norvegicus*	Common	Threatened
Giant tree squirrel	*Protoxerus strangeri*	Uncommon	Endangered
	Bird		
Black Kite	*Milvus migrans*	Common	Normal
CommonTem	*Sterna hinmdo*	Common	Normal
Common Sandpiper	*Actitis hypoleucos*	Common	Normal
Red-eyed Dove	*Streptopelia semitorquata*	Common	Normal

African Pied Hombill	*Tockus jasciatus*	Common	Normal
Blue-breasted Kingfisher	*Halcyon malimbicus*	Common	Normal
Senegal Coucal	*Centropus senegalensis*	Common	Normal
Reptile and amphibian			
Egg-eating snake	*Dasypeltis fasciata*	Uncommon	Endangered
Green Mamba	*Dendroaspis viridis*	Uncommon	Endangered
Python	*Python sebae*	Uncommon	Endangered
Spitting Cobra	*Naja nigricollis*	Uncommon	Endangered
Nile Monitor Lizard	*Varanus niloticus*	Common	Threatened
Chameleon	*Chameleo gracilis*	Uncommon	Threatened
Bullfrog (Jumping chicken)	*Dicroglossus occipitalis*	Uncommon	Threatened

Source: Spec Fieldwork 2019

4.11 Socio-Economic Survey

Socio-economic impact analysis is an essential requirement for development projects to succeed. The achievement of development objectives and effective mitigation measures in response to negative (undesirable) side effects of the project on the people and environment are all hinged on a properly conducted environmental impact assessment (EIA) study. The socio-economic study includes areas such as institutional, social and economic aspects of the project. To be successful, a project must consider critically the three aspects.

The socio-economic patterns and institutions of the beneficiaries and surrounding people (people within the areas of potential project influence - APPI) must be considered in terms of the customs, culture and possible disruption of the ways of life of the people and their environment. If it does, what provisions are made to help mitigate the hardships? In many instances, many development projects that failed to consider these factors had often been overly optimistic about rates of acceptance of a project by the people, thereby leading to conflicts.

The social pattern and practices of people within the APPI also need to be examined carefully within the broader social implications of the proposed project. Such areas include: income distribution, possible creation of employment opportunities, adverse social effects of displacement and relocation of people whose land may be taken over by the development project, loss of income and food from destroyed natural resources, availability or non-availability of alternative sources of income; and the changes in quality of life as may be occasioned by increased incidence of diseases and possible pollution of the environment.

The economic aspect requires the determination of the likelihood that the proposed project will contribute significantly to the development of the total economy of the project area. The point of view taken in the economic analysis is that of the society (or environment) as a whole, which is from the viewpoints of both the individual and the society.

The proposed project is expected to impact on the lives of the surrounding communities and groups of people. Hence, efforts were made to examine the socio-economic and health impacts of the proposed project on the areas of potential project influence (APPI).

Demographic and Social Characteristics of Respondents

In order to determine the socio-economic status of the people of the Makun/Lenuwa communities, structured questionnaire were distributed to about seventy-five members of the community and sixty questionnaires were retrieved which is made up of forty two (42) males and eighteen (18) females. Their response was tabulated and presented in table 4.22 below.

The educational status of the young adults in communities was mostly primary and secondary school level while very few attended tertiary institution. The female

population were not as highly educated as their male counterpart. The primary occupation of the respondents was mainly farming, while there were few Civil servants in the community. The females engaged more in trading than farming. There are some female that are civil servants –they work in the only maternity clinic in the community. Cassava and plantain were the major crops on most of the farmer's land. However, the site of the project had been used extensively for cocoa planting, as a lot of the trees are still standing.

More than 83% of the male respondents own the house in which they reside, while 27% of the female owns theirs. Most of them did not respond to their total annual income, as this is seen as a private matter not to be discussed with others. However, for those who responded, only five males and 2 females earn below N100, 000 per annum, while 2 males earn between N200, 000 – N300, 000 per annum. A large number of the male populace have motorcycle as means of transportation, while only the Kings of the communities have cars to themselves but live in Sagamu. The other indigenes of the community that have cars live outside the community (Makun/Lenuwa) and only come home on special occasions.

Table 4.22: Socio-Economic Characteristics of Respondents

Issues		Male	Female	Total
		%		
No. of Respondents		42	18	60
Age Distribution (yrs)	15 - 20	5	2	7
	21 – 30	10	5	15
	31 – 40	15	3	18
	41 – 50	5	6	11
	Above 50	7	2	9
Educational Status	Primary	12	2	14
	Secondary	12	5	17
	Post-secondary	8	0	8
	No Education	10	11	21
Occupation	Farming	27	5	32

		Trading	5	9	14
		Civil servant	5	2	7
		Company worker	0	0	0
		Students and artisans	5	2	7
	Secondary	Farming	0	0	0
		Trading	0	0	0
		Sewing	0	0	0
		No response	0	0	0
Income per annum (₦)		Below 100,000	5	2	7
		101,000 – 200,000	0	0	0
		201,000 – 300,000	2	0	2
		Above 300,000	0	0	0
		No response	35	16	51
Ownership of property		House	35	5	40
		Motor cycle	15	0	15
		Private car	5	1	6

Sources: Spec Fieldwork, 2019

SOCIAL AMENITIES

EDUCATIONAL FACILITIES

There is primary school in where all the children from the communities are taught. The community has secondary school.

ELECTRICITY

The community is connected to the national grid of IBDC although not stable thus making most community inhabitants to operate generator (“better-pass-my neighbour”).

PUBLIC TOILET

There is no public toilet in the community. Most of the household has a pit latrine in their houses. Some have pit toilets.

HEALTH CENTRE

There is a government owned clinic or health centre in the area. There is also a privately-owned medical facility. The community uses traditional/local medicine, as well as buying medicine from a medicine hawker that comes from Ilesha, to treat whatever ailment they may have.

SOURCE OF WATER

The members of the community take water from the borehole for their domestic use. The most easily accessed of all the borehole within the community is the one at filling station beside the proposed site.

RELIGIOUS BELIEF

The majority of the people in the area are Christians, with few traditionalists. There are very few Muslim within the area.

ARCHEAOLOGICAL SITES/SHRINE

There is no sacred place in the study area and members of the community attest to the fact that they do not have any festival/traditional celebration that cannot be seen by outsider.

Table 4.23: Social and Infrastructural Facilities in the town

Facilities	Makun/Lenuwa communities
Surfaced Roads	-
Electricity	-
Potable Water	+
Educational Institutions	
Primary School	+
Secondary	-
Tertiary	-
Health Institutions	
Primary Health Centre Clinic	-
Maternity Centre	+
Method of Waste Disposal	

Water Closet	+
Pit Latrine	+

Sources: Spec Fieldwork, 2019

Key: + where the facilities are available

- Where the facilities are not available

Health and Health Facilities

Health is a state of complete physical, mental and social wellbeing, without any form of infirmity. In examining development in the health domain, the main issues vital to the health of the citizenry include access of the people to social and health facilities, availability of health care services, survival chances, and the issue of reproductive health.

The resident population therefore, depends upon the available drug stores and traditional health attendants (THA) for their health care needs. At best, sick people are transported to the health centre to seek better treatment. No major health problem was identified in the area but the common diseases like typhoid and malaria noted.

The result of the survey is summarized in Table 4.24 and the order of the occurrence of the diseases is computed on the principle of first mention in the two communities. The commonest and most prevalent diseases afflicting all age groups in the two communities on a daily basis are malaria fever, dysentery/diarrhea and stomach disorder. Typhoid fever and respiratory ailment also have a high frequency of occurrence among adults and all age groups respectively. Cholera was reported among all age groups in Makun/Lenuwa (Table 4.24). Sexually transmitted Diseases were recorded in the community among young adults. Ailments such as rheumatism, asthma and tuberculosis are common among the elderly in the communities. The people blamed most of their health problems on poverty, lack of potable water, pollution of water source and air domestic waste and dirty environments.

Table 4.24: Summary of Disease Pattern

	Specific Disease	Frequency
1	Malaria fever	Frequent
2	Typhoid fever	Frequent
3	Dysentery /diarrhoea	Weekly
4	Cholera	Not frequent
5	Respiratory Diseases	Monthly
6	Sexually Transmitted Diseases	Monthly
7	Stomach disorder	Frequent
8	Skin infections	Monthly
9	Rheumatism	Monthly
10	Measles / rashes	Dry season
11	Asthma	Common
12	Tuberculosis	Common

Source: Spec Fieldwork 2019

Health Care Service Indicators

Service Availability

There are some health facilities in the community. These include public and a few private health care facilities. These health facilities range from maternity home, Health Centres, Dispensaries, Traditional Birth Attendants (TBAs) and Voluntary Health Workers (VHW). Others are Traditional Healing Homes, Spiritual Healing Homes and Patent Medicine Shops.

Accessibility of Services

While health facilities in the project areas are physically accessible to some of the communities, it is not so much for others. Findings from the household interviews indicate that as many as 61.8% could usually reach the respective health facilities within

2 hours by the regular means of transport as recommended by WHO, (Vaughan and Morrow 1989), while the rest 38.2% require between 2 and 24 hours (3.8% of households reported 24 hours). While many inhabitants utilize the health facilities, some exhibit cultural preference for Traditional Birth Attendants (TBAs). The commonest problems found for non-use of health facilities in the areas include:

- getting money for treatment,
- distance to health facilities and
- having to take transport.

Also, the cost recovery mechanisms put in place by most health facilities/authorities such as the Drug Revolving Fund Programme (DRF), appears to limit the patronage of these facilities, due to high cost.

Services Provision and Utilization

The health facilities offer primary and secondary health care services. Primary care services include curative and preventive services in the communities. Services commonly provided are principally:

- Immunization services,
- Anti-natal care for pregnant women,
- Treatment of minor ailments,
- Family planning services and
- Tuberculosis and leprosy control services.

Other services provided at the Primary Health Care (PHC) level, which are essentially weak, include the Essential Drugs Programme (EDP), Roll Back Malaria Programme, Control of Sexually Transmitted Diseases, Health Education and Environmental Sanitation.

It is important to note that most public health infrastructure, equipment and drugs in these PHCs have deteriorated appreciably and will require urgent rehabilitation. This limitation has affected the level of service delivery in the communities. General

Hospitals in the project areas are moderately functional and take care of more difficult and complicated cases involving surgeries and, assisted deliveries, but essentially lack the necessary complement of medical equipment and drugs to provide optimal services to the people of the areas.

Waste Generation and Disposal Methods

Wastes generated in the communities were essentially:

- Domestic (refuse and garbage),
- Agricultural wastes
- Wastes from commercial activities
- Human and animal wastes.

Disposal Methods:

The disposal methods can be categorised as:

- Open litter in the communities
- Burning, and
- Dumping at designated sites (Locally refers to as *Akitan*)

Domestic wastes were usually collected in uncovered baskets, disused containers or cartons and were disposed indiscriminately in and around the communities in bushes, rivers, streams and creeks. Wastes from agricultural and fishing activities were collected and disposed off at farm sites, riverbanks, bushes and open dumpsites. Commercial wastes were also disposed of in bushes, surface water bodies, and in open dumpsites.

These poor sanitary practices of waste disposal were accountable for the favourable environment created for domestic flies and other disease vectors like mosquitoes and vermins to breed and transmit infections within the communities.

Sewage Disposal Methods

Sewage disposal was predominantly by pit latrines and water closet system with septic tanks and soak away facilities were installed. Overall, the use of sanitary sewage disposal methods in the communities was high 75%.

Morbidity Patterns/Disease Prevalence

Analyses of disease prevalence in the project areas show that the commonest causes of diseases in the area are communicable diseases. The most prevalent disease among the children and adult populations is malaria. Malaria is highly endemic in these areas as a result of the humid and waterlogged environment, favourable for mosquito breeding.

Others disease conditions are diarrhoea, acute respiratory infections, measles, typhoid fever, and yellow fever. The adult population suffered also from Hypertension and Heart Disease conditions, injuries from various causes, Arthritis, and Skin infections. The high prevalence rate of malaria is sustained by a number of factors including:

- The abundance of mosquitoes (the insect vector of malaria, which consists predominantly of *Plasmodium falciparum*, and less of *Plasmodium vivax* and *Plasmodium malariae),*
- Presence of stagnant water,
- Absence of pest control practices
- Inadequate prophylactic drug supply, and
- Inadequate diagnostic facility

Mortality Rates

The mortality statistics of the communities were determined using the Crude Death Rate (CDR), Infant Mortality Rate (IMR) and Under-five Mortality Rate (U5MR).

Crude Death Rate

The crude death rate is an indicator of the relative health of a people. It is the number of deaths from all causes per 1000 population per year. It indicates the rate at which people are dying probably from poor health and socio-economic conditions, including the lack of access to good quality health care. Hospital records and inputs from in-depth interviews of community stakeholders reveal that communicable diseases such as malaria, measles and respiratory infections were the greatest causes of deaths among children below 5 years of age in these communities. Causes of death among the adult population were predominantly from stroke, strangulated hernia, diabetes, and tuberculosis. Other causes of death include those related to complications from pregnancy and childbirth**.**

The people traditionally patronize the services of Traditional Birth Attendants (TBAs), who reluctantly refer difficult and complicated cases to the nearest referral centres, at the General Hospitals. Often times patients' lives were lost because it was usually too late to make any meaningful intervention by qualified health workers.

Infant Mortality Rate

Infant mortality rate (IMR) is widely accepted as one of the most useful single measures of the health status of a community. It measures the probability of a child dying before his or her first birthday. It is determined by dividing the annual number of deaths in the first year of life by the number of live births in that year and expressed per 1000 live births. Infant mortality rate in the south-western Nigeria was found to be 68.2 per 1,000 live births and is lower than the national rate but higher than the regional rate.

Neonatal deaths, with a rate of 37.6 per 1,000 live births, accounted for 55.1% of all infant deaths while post-neonatal deaths accounted for 44.9% of the deaths. Twelve (44.4%) of all neonatal deaths (27) occurred within 24 hours of delivery while 20 (74.1%) of all neonatal deaths occurred in the first week of life and were prenatal

deaths. These high prenatal rates indicate that more efficient obstetric and public health services are needed in the community (Lawoyin, 2001).

Under-five Mortality Rate

Under - five Mortality Rate measures the probability of death before the age of five. It is determined by calculating the annual number of deaths in children less than five years and dividing it by the number of live births in a year and expressed per 1000 live births. It reflects on the following:

- Level of nutritional and health knowledge of mothers,
- Level of immunization coverage,
- Oral Rehydration Therapy (ORT) for the management of diarrhoeal diseases,
- Availability of maternal and child health services (including prenatal care),
- Income and food security in the family,
- Availability of clean water and safe sanitation, and
- Overall safety of the child's environment.

Immunization status

The inhabitants claimed that most children are usually taken to health centre and Local Government Primary Health Care centre (Akodo) after birth for routine childhood immunization. They also claim to have participated in the house – to – house immunization exercise against Polio disease, which is a programme of the Nigerian Government.

Health Risk Assessment

Various hazards associated with the project are summarized in Table 4.26. The purpose of this matrix is to summarize in a birds's eye view the different existing hazards to health within the community, determine the levels to which the community members are exposed to these hazards and their sensitivities to them. Levels of exposure have been arrived at through questionnaire administration, participant observation and review of the relevant literature. Unless certain epidemiologic conditions relating to agent, host

and environment are met, a health hazard may not necessarily lead to a disease, illness or health condition. Vulnerability scale (1-10) in Table 4.26, therefore, represents our assessment of the levels of interplay of these factors within the respective communities to result in susceptibility to the particular disease condition.

Table 4.25: Health Risk Exposure Matrix (Health Sensitivities)

Health Hazard	**Risk to Health**	**Current levels of Exposure within communities**	**Sensitivity/ Vulnerability Index (Scale 1 - 10)**
BIO-PHYSICAL ENVIRONMENT			
Poor air quality met etc	Respiratory diseases	Moderate	7
High noise levels	Hearing impairment tolerance shift insomnia.	Moderate	7
Biotic factors Wild/venomous animals Disease Vector	Fatalities, injury (from snake bites, wild animals) Disease transmission	Moderate High	7 9
Abiotic Factors (Climate conditions)	Weather related maladies, vector epidemiology	High	8
LIFE STYLE			
Alcohol and Drugs & Substance Abuse	Organ damage to liver, lungs etc,	Moderate	4

	impaired mental health tendency to crime and violence		
Exposure to casual / commercial sex	STIs	Moderate	7
Unprotected sex	STIs. HIV/AIDS	Moderate	8
Cultural practices	Female Gental Mutilation	Low	3
Recreation/stress Management	Hypertension, coronary problems	Very low	6
Waste disposal and Management	Communicable Diseases	High	9
SOCIAL ISSUES			
Inequality	Violence	Moderate	4
Insufficiency of Infrastructure	Poor health preventive and management interventions, insecurity, poor communication	High	7
Poverty/Personal income levels	Variety of diseases and maladies creating vicious cycle of disease and poverty	High	7
Level of crime	Injury fatality	Low	4
Level of Violence	Injury fatality	Moderate	7
Level of Education	Lack of awareness on appropriate	Low to Moderate	4

	preventive and health management practices		
OCCUPATIONAL HAZARDS			
Fishing Activity (Paddling netting)	Inguinal hernias	Moderate	6
Fish Smoking/Processing	Respiratory disorders, eye problems (conjunctivitis)	High in vulnerable population (fish processing womenfolk)	7
OTHERS			
POTABLE WATER INSUFFICIENCY	Water-borne diseases (cholera, typhoid etc.)	Low to moderate	4
MALNUTRITION/FOOD SECURITY	Nutritional maladies in vulnerable population (women/children	Moderate	4
HOUSING AND LIVING ENVIRONMENT	Upper respiratory tract infections. Diseases transmission, risk of fire	Low	3
DEMOGRAPHIC PROFILE	More youthful population liable to	Moderate	6

	high crime. Violence and STI levels		
TRAUMA (INJURIES FROM ACCIDENTS ETC)	Morbidity temporary/permanent death	Moderate	6

Community Perception and Attitude toward the proposed project

The inhabitants are very happy with the operation Harvestfield Agrochemical Company Limited with the view that it will provide their youth with jobs. The population sees additional benefits to the Federal Government and industry resulting from the revenues to be earned from the Aflasafe Plant development at the expense of the host communities who have always been at the receiving end of the positive externalities of such development.

Some proportion of the population however, has positive dispensation to the project. Increased employment expectations, an overall positive benefit on the social environment through the provision of some basic social amenities, increased opportunities for socioeconomic development amongst others were prevalent.

Community Suggestions to Mitigate Potential Negative Impacts

The primary concerns of the communities in the project environment focus on negative activities during the project development period as well as potential negative livelihood impacts, health and environmental hazards during the operation of the company activities. Therefore, their suggestions to improve the project and to lessen the negative impacts on their livelihoods focus on these concerns.

The above bad feelings notwithstanding, the people expect that a memorandum of understanding (MOU) shall be necessary between the company and the project-affected areas (PAAs) to cement a lasting relationship and enhance their welfare. The provision of job opportunities, assisting the communities with overall social issues,

including provision of potable water, health care facility, construction of more educational infrastructures, including furnishings (chairs and desks for pupils) and post primary institution to ease educational pursuit and building of civic gathering places (town hall) are top priorities for the communities.

Conclusion

This survey has revealed that lack of development in the various communities and wide spread unemployment, most especially amongst the youth and women alike, is the major sources of concern of the people. Harvestfield Agrochemical Company Limited shall endeavour to build and foster a good and harmonious working relationship with the neighbouring communities in order to create a conducive working environment, free from suspicion, unrest and sabotage.

CHAPTER FIVE

ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACTS

5.1 Introduction

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

The overall intent of the ESIA study is to identify and characterise all the associated and environmental impacts or effects that will be caused by the proposed Aflasafe Bio-control Plant project. Though there are a number of approaches for the prediction and evaluation of project environmental impacts, the ISO 14001 method was selected for this study. The ISO 14001 method is simple to apply, provides a high level of details and relies on limited data.

5.2 Summary of Environmental Impact Indicators

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

Project Activities

The activities anticipated in the proposed pipeline project and its existing facilities' modifications cover all the anticipated phases including construction, operation/maintenance and decommissioning. The anticipated activities of each of these phases include:

A. Pre-Construction phase activities

- Land take for Plant
- Mobilisation (transport) to site (equipment, personnel and construction modules)
- Energy requirements (provision of energy for construction)
- Labour requirements
- Site Preparation (vegetation and land clearing)
- Excavation of land area

Table 5.1: Environmental Components and Potential Impact Indicators

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

B. Construction phase activities

- Soil Excavation
- Site fabrication (welding) and coating
- Construction of Modules
- Backfilling
- Construction of silos
- Construction of office complex
- Installation of Transformer and Generator
- Commissioning of Plant
- Demobilization

C. The operational phase activities are

- Operations/ maintenance

D. The decommissioning activities include

- Demolition and Evacuation

5.3 Impact Identification and Evaluation

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

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

5.3.1 Impact Identification

The aim of impact identification is to account for the entire potential and associated bio-physical, social and health impacts making sure that both significant and insignificant impacts are accounted for. The anticipated impacts were determined based on the interaction between project activities and environmental sensitivities. The identified

potential impacts during the different phases of the proposed project are as listed in **Table 5.2.**

Table 5.2: Identified Project Impacts of the Proposed Pipeline

Impacts	Phase		
	Pre-Construction and Construction	Operation/Maintenance	Decommissioning
Acceleration of erosion	√		
Acidification of soil and water	√		√
Alteration of local topography	√		
Alteration of soil profile	√		√
Blockage of drainage pattern	√		√
Blockage of roads/motorways	√		√
Burns/injuries from welding sparks	√	√	√
Change in land use	√	√	√
Change in water quality	√		√
Contamination of groundwater	√	√	√
Contamination of surface water and soil	√	√	√
Exposure to welding flash	√	√	√
Impairment of air quality	√	√	√
Improved and increased of bio products supply to customers		√	
Improved livelihood	√	√	√
Increased demand on social infrastructure	√	√	√
Increase in incidence of STI's including HIV	√		√
Increase in income	√	√	
Increase in price of locally sourced materials	√		
Increase in social vices	√		√
Increased opportunity for business and employment	√	√	√
Influx of migrant workers and camp-followers	√		√

Impacts	Phase		
	Pre-Construction and Construction	Operation/Maintenance	Decommissioning
Injuries and death from falling objects	√		√
Interference with road transportation	√		√
Kidnapping of workers and visitors on site	√	√	√
Land utilized for temporary base camps/restriction on land use	√		√
Legal issues	√	√	√
Loss of land	√	√	
Loss of employment/ income			√
Noise and vibration nuisance	√	√	√
Road traffic accidents	√	√	√
Work site accidents	√	√	√

5.3.2 Impact Qualification

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

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

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

5.3.3 Impact Rating

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

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

5.3.3.1 Legal /Regulatory Requirements (L)

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

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

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

5.3.3.2 Risk (R)

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

1=Low risk (green)

3=Intermediate risk (yellow)

5=High risk (red)

5.3.3.3 Frequency of Impact (F)

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

5.3.3.4 Importance of Affected Environmental Component and Impact (I)

The importance of the affected environmental components was determined through consultation and consensus of opinions. This was also further facilitated by information on experiences on the impacts of already existing facilities in the proposed project area. The rating of the importance of impacts is summarized in **Table 5.6.**

Table 5.3: Probability of Occurrence

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

Table 5.4: Consequence Categories

Consequence Category	Considerations			
	Safety / Health	Public Disruption	Environmental Aspects	Financial Implications
I	Fatalities / Serious Impact on Public	Large Community	Major/Extended Duration/Full Scale Response	High
II	Serious Injury to	Small	Serious / Significant	Medium

	Personnel / Limited Impact on Public	Community	Resource Commitment	
III	Medical Treatment for Personnel / No Impact on Public	Minor	Moderate / Limited Response of Short Duration	Low
IV	Minor Impact on Personnel	Minimal to None	Minor / Little or No Response Needed	None

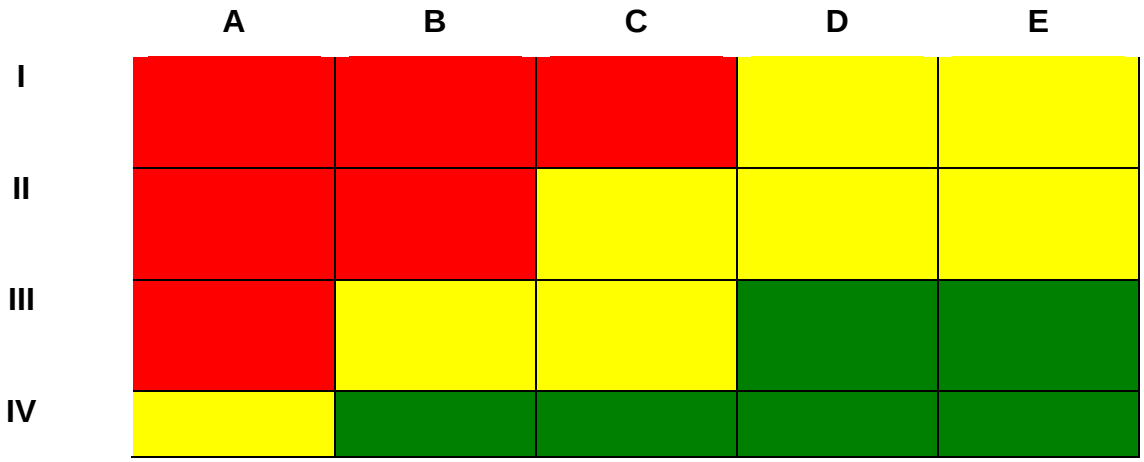

Figure 5.1: Risk Assessment Matrix

5.3.3.5 Public Perception (P)

The consensus of opinions among the project stakeholders were used to determine the public perception on the potential impacts and the criteria applied are as summarized in **Table 5.7**. The combination of the five impact rating weights formed the basis for judging the level of significance of each impact. A matrix displaying the combination based on the ISO 14001 tool.

The final ratings of the identified impacts are presented in **Tables 5.8 - 5.10.** In this study, medium and high significant negative impacts were judged to require mitigation, and all positive impacts required enhancement.

Table 5.5: Frequency Rating and Criteria

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

Table 5.6: Importance Criteria

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

Table 5.7: Public Perception Criteria

Public Perception	Rating	Criteria
Low	1	• No risk to human health, acute and/or chronic • No possibility of life endangerment for residents,

		associated communities • Minor reduction in social, cultural, economic values • Unlikely adverse perception among population
Medium	3	• Limited incremental risk to human health, acute and/or chronic • Unlikely life endangerment for residents, abutting communities • Some reduction in social, cultural, economic value • Possibility of adverse perception among population. • Potential for non-compliance
High	5	• Elevated incremental risk to human health, acute and/or chronic • Possibility of life endangerment for residents, abutting communities • Major reduction in social, cultural, economic value • Continuous non-compliance with statute • Any major public concern among population in study area

Table 5.8: Impact Value and Rating Colour Code

Impact value	**Cut off values**	**Impact Rating**
L+R+F+I+P	<8	Low
L+R+F+I+P	≥8 but <15	Medium
L+R+F+I+P	≥15	High
F + I	>6	
P	= 5	
Positive		Positive

Table 5.9: Potential and Associated Impacts of the Proposed Project – Pre-Construction Phases ***Where L= Legal/Regulatory Requirement, R = Risk, F= Frequency, I = Importance, P = Public Interest/ Perception***

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long-term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
	Land Take for Aflasafe Bio-control Plant	Loss of land		√	√			√	√		3	1	5	1	1	11	6	M
		Change in land use		√	√			√	√		3	1	5	1	1	11	6	M
		Legal issue		√	√		√	√	√		3	1	1	3	3	11	4	M
	Mobilisation (transport) to site (equipment, personnel and construction modules)	Road traffic accidents		√	√		√	√	√		3	3	3	3	3	15	6	H
		Noise nuisance		√	√		√		√		3	3	1	1	1	9	2	M
		Impairment of air quality		√	√		√		√		3	3	1	1	1	9	2	M
		Loss of biodiversity		√	√		√		√		3	3	1	1	1	9	2	M
	Energy consumption (provision of energy for pre-construction activities)	Impairment of air quality		√	√		√		√		3	3	1	1	1	9	2	M
		Noise and vibration nuisance		√	√		√		√		3	3	1	1	1	9	2	M
		Increased opportunity for business and employment	√		√		√		√		-	-	-	-	-	-	-	P
		Contamination of soil by waste oil		√	√		√		√		3	1	3	1	1	9	4	M
	Site Preparation – land clearing, removal of	Acceleration of erosion		√	√		√		√		3	1	3	1	1	9	4	M
		Alteration of local topography		√	√		√		√		3	1	3	1	1	9	4	M
		Alteration of soil profile		√	√	√	√		√		0	1	1	1	1	4	2	L
		Blockage of drainage pattern		√	√	√	√		√		0	1	1	1	1	4	2	L

	vegetation, Land excavation for foundations and Surfacing of feeder roads	Contamination of soil by run-offs		√	√	√	√		√		3	1	1	1	1	7	2	L
		Impairment of air quality		√	√	√	√		√		3	1	3	1	1	9	4	M
		Noise and vibration nuisance		√	√		√		√		3	1	3	1	1	9	4	M
		Worksite accidents		√		√		√	√	√	3	5	3	5	5	21	8	H
		Security/artificial light at night		√	√		√		√		0	1	3	1	1	6	4	L
		Habitat alteration		√	√			√		√	3	5	5	5	5	23	1	H

Table 5.10: Potential and Associated Impacts of the Proposed Project – Construction Phases- ***Where L= Legal/Regulatory, R = Risk, F= Frequency, I = Importance, P = Public Interest/ Perception***

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long-term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
	Transport activities during construction	Road traffic and Marine accidents		√	√		√		√		3	5	5	5	5	23	1	H
		Noise nuisance from steaming engines/ heavy vehicles		√	√		√		√		3	3	3	1	3	13	4	M
		Impairment of air quality – emission from Heavy vehicles		√	√		√		√		3	1	1	1	3	9	2	M
	Casting of the plinths for the modules	Loss of vegetal cover with possible impact on biodiversity loss		√	√	√	√	√	√		3	3	3	3	3	15	6	H
		Noise and vibration nuisance		√	√		√		√		3	5	3	1	3	15	4	H

		Waste generation from excavated materials		√	√		√		√		3	1	3	1	1	9	4	M
		Impairment of air quality		√	√	√	√		√		3	5	3	3	1	15	6	H
		Contamination in the event of oil spills from equipment and machinery		√	√			√	√		5	3	3	5	1	17	8	H
		Waste generation from excavated materials		√	√		√		√		5	1	1	3	1	11	4	M
	Construction of e warehouse, silos and product Storage Facilities	Burns/injuries from welding sparks		√	√			√	√		3	5	3	5	1	17	8	H
		Exposure to welding flash		√	√		√		√		3	5	3	5	1	17	8	H
		Kidnapping of workers		√	√			√		√	3	5	5	5	5	23	1	H
		Noise and vibration nuisance		√	√		√		√		5	1	1	3	1	11	4	M
		Waste Management - The potential effects will be of aesthetics as well as a nuisance of wastes such as metal cuttings		√	√		√		√		5	1	1	3	1	11	4	M
	Coating	Contamination of soil by paints and coating as a result of spillage		√	√		√		√		3	5	3	5	1	17	8	H
		Hazardous waste generation from coating operations such as metals			√	√		√		√	3	5	3	5	1	17	8	H
	Installation of the modules	Noise and vibration nuisance		√	√		√		√		3	1	3	1	1	9	4	M
		Waste generation from		√	√		√		√		3	1	3	1	1	9	4	M

	and Construction of administrative blocks	Installation and construction activities															
		Impairment of air quality		√	√	√	√		√		3	1	3	1	1	9	4	M
		Fall from height/ Worksite accidents		√		√		√	√	√	3	5	3	5	5	21	8	H
		Loss of vegetal cover with possible impact on biodiversity loss		√	√	√	√	√	√		3	3	3	3	3	15	6	H
	Backfilling	Alteration of hydrological patterns resulting in temporary or permanent flooding, soil erosion and destruction of biodiversity			√	√		√		√	3	5	3	5	1	17	8	H
		Worksite accidents			√	√		√		√	3	5	3	5	1	17	8	H
	Site demobilization	Road traffic accidents		√	√			√		√	3	3	3	3	3	15	6	H

Table 5.11: Potential and Associated Impacts of the Proposed Project –Operation (Normal)

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
Operation/ Maintenance	Operation and maintenance of the plant	Air Pollution (1) Fugitive emissions from plant facilities are associated with leaks in the		√	√			√		√	3	5	5	5	5	23	10	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		tubing; valves; connections; flanges; packings; open-ended lines; floating roof storage tank, pump and compressor seals																
		Air Pollution (2) Exhaust gas emissions produced by the combustion or other hydrocarbon fuels in turbines compressors, pumps and other engines for power generation		√	√			√		√	3	5	5	5	5	23	10	H
		Processing wastewater to include storm water which may contain anti-fouling agents		√	√		√		√		5	3	3	5	3	19	8	H
		Noise and vibration nuisance from processing equipment like compressors, pumps, turbines, electric motors.		√	√		√		√		3	3	3	3	3	15	6	H
		Poor disposal of wastes generated during operation and maintenance		√	√	√	√		√		3	3	3	3	3	15	6	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		The threat from major accidents related to the fires and explosions at the facility.		√	√			√		√	3	5	5	5	5	23	10	H
		The threat of Naturally Occuring Radioative Material (NORM) to te environment		√	√			√		√	5	5	5	5	5	25	10	H
		Air emission during Maintenance/servicing of production equipment and ancillaries and generating set		√	√	√	√		√		3	1	1	3	1	9	4	M
	Transport activities during operation	Road traffic accidents		√	√			√		√	3	5	5	5	5	23	10	H

Table 5.13: Potential and Associated Impacts of the Proposed Project – Decommissioning

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
Decommissioning	Demolition and Evacuatio	Interference with road transportation		√	√		√		√		3	3	3	1	3	13	4	M
		Noise and vibration nuisance		√	√		√		√		3	3	3	1	3	13	4	M

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
	n	Impairment of air quality		√	√	√	√		√		3	3	3	3	3	15	6	H
		Contamination of groundwater/ surface water		√	√	√	√		√		3	1	3	3	1	11	6	M
		Contamination of soil		√	√	√	√		√		3	1	3	3	1	11	6	M
		Poor disposal of wastes generated during this phase		√	√	√	√		√		3	3	3	3	3	15	6	H
		Loss of job		√	√			√		√	0	5	5	5	5	20	10	H
		Kidnapping of workers		√	√			√		√	0	5	5	5	5	20	10	H
		Injury/fatalities in workforce /communities		√	√	√	√		√		3	1	3	3	1	11	6	H
		Third Party Agitation due to Employment Issues and Loss of Benefits as Host Communities.		√	√	√	√		√		3	1	3	3	1	11	6	M

5.4 Detailed of Environmental Issues Anticipated from the Refinery

The impact rating of the proposed establishment of Harvestfield Aflasafe Bio-control Plant on the natural environment is moderate, with the likelihood occurrence of most long adverse effects being medium if the Industry were to be rated in isolation of other proposed and existing industries in the region.

The establishment of Harvestfield Aflasafe Bio-control Plant will impact the existing environment in various ways based on the Impact formula of (Chertow, 2011) where Impact is a product of Population, Affluence and Technology. The effect of this Industry on the environment would be felt first and most by the vegetation of the area, with attendant chain effect on other factors of the environment. However, since the size of the plot is not more than five hectares, the impact will be moderate, provided adequate attention is paid to being environmentally conscious in mode of operation and disposal of by-products.

Pre-Construction Phase

Permitting

Permitting is the process of obtaining permission of communities/ individuals and relevant government agencies on issues related to the project.

- *Acceptance of project and cooperation/participation from communities and government.*

Prior to commencement of the project, extensive stakeholder consultations will be carried out with communities, State and Local Government agencies, NGOs/CBOs to enlist their support, cooperation and participation in the project. The occurrence of this rated as medium and the impact positive.

- *Reduction/abatement of threats posed by agitation of communities*

Sometimes there are agitation by communities and other sympathetic third parties over non-disclosure of project activities, employment, contracts, CD, environmental impacts

of projects and other community/third party interests. The impact was described as direct, negative, short-term, local, reversible and rated moderate.

Temporary Land-take for base camp

Land could be required on temporary basis for the construction of a base camp by the contractor. This land will be re-vegetated with indigenous plant species at the end of the project and returned to the owners. The possible impacts from the activity are:

- *Reduction of Access to Land and its Resources*

The vegetation of the required land contains economic plants such as cassava, yams, cocoyam, oil palm, mango and palm trees, etc. Land acquisition in this vicinity could thus eliminate the crops. Similarly, some of the wildlife species identified in the project area were grass cutters, birds. Land take could deny access to these resources, as they would be cleared. The impact was described as direct, negative, short term, local and reversible. It was rated as minor.

- *Third Party Agitations*

Land take sometimes leads to community agitation due either to compensation issues, or stakeholder identification, or incoherence in leadership hierarchy and/or from boundary recognition between communities. The impact was described as direct, negative, short-term, local, reversible and rated moderate.

- *Increased financial flow due to compensations*

Financial and other compensations accruing to the communities and individuals as a result of land acquisition shall yield direct, short term, local, reversible and rated positive.

Recruitment of Workers

- *Creation of opportunities for employment*

This project is manual labour intensive and could create opportunity for temporary employment, contracting and increase in income for the communities. The impact was direct, short term, local, reversible, and rated positive.

- *Conflicts/ Third party agitations over employment issues*

Due to the fact that all available local labour cannot possibly be engaged for the project, conflicts and agitations could arise over distribution of employment slots to individuals and communities. This impact is direct, negative, short term, reversible and rated moderate.

- *Influx of job seekers into communities, thereby exerting pressure on infrastructure*

The influx of job seekers into the communities for employment opportunities could exert additional pressure on limited community resources such as water supply, available food sources and housing. This impact is rated direct, negative, short term, local reversible and moderate.

Mobilization to Site

- Increas*e in usage of roads and waterways with possibilities of accidents.*

Mobilization of workers and equipment to site could result in the increase in traffic in the area and predispose to accidents. This impact is rated as direct, negative, short term, local, reversible/irreversible and moderate

- *Increase in usage of roads and resultant damage to existing roads*

In the same vein, increase in road usage could result in increase in road traffic accidents due to road congestion. This phenomenon is rated as direct, negative, short-term, local and reversible. It is a moderate impact.

***Site Preparation/* clearing for base camp**

The site preparation activity for the project would consist primarily of vegetation clearing the temporary area that would be acquired for the construction of base camp. The potential impacts of this are:

- *Air Quality*

Air quality can be affected by a number of activities associated with the site preparation such as land clearing, earth moving and leveling, transport of materials and workers, mobile generation of electricity, and short-term operation of facilities producing materials (e.g., concrete) used in construction, labour camp. The chief concerns for this phase is dust generation and diesel engine exhaust. The dust from earthwork and vehicle movement could be significant particularly during the dry weather conditions. The exhausts from construction equipment, vehicles will result in release of pollutants such as PM_{10} NO_x, SO_2, CO and VOCs.

Concern for dust generation is much lower in wetter areas and during the rainy season, and during dry seasons dust can be controlled by watering and other management practices. These emissions are short-termed and localized to the immediate site area; though the likelihood of occurrence is high, the overall impact risk is low.

- *Noise*

The heavy equipment used in site clearing activities and excavation, diesel generators used for on-site power generation and the road vehicles used for transportation of material and men to site will have an adverse impact on ambient noise levels. This will be short-term and localized with the likelihood of occurrence high and the overall impact risk is minor.

- *Destruction of Vegetation (Medicinal, Economic and Food)/Loss of Wildlife Habit*

The natural vegetation of the plot will largely be removed in order to create space for construction of the permanent structures. Nevertheless, since not all areas will be put to

secondary use, any remaining vegetation, either for aesthetic beauty or as a green area on the plot will benefit from continuous tendering. These could serve good purpose as indicators of environmental change.

- *Loss of species and their ecosystem services*

This is the primary impact. Many of native species will be cleared from the plot. Some will be lost to trampling. Unless prevented, some species would be lost to soil contamination by agro-chemicals and their precursors. Also, since the land will be under continuous anthropogenic traffic and associated pressure, the sandbank will be lost for the most part. Ecosystem services being currently provided by the species, such as erosion control, modification of hydrological cycle, shelter to wildlife and carbon sequestration will be negatively impacted upon.

Secondary impact includes increase in ambient temperature and heat, weather modification, prevalence of particulate matter suspension in the atmosphere. These might further put any plant species and wildlife in the immediate vicinity of the plot at risk of impaired ecology and physiology, leading to stunted growth and reduced productivity.

The removal of the vegetations on the acquired land will lead to loss of any medicinal, economic or food crops in the area. The wildlife that used this vegetation for habitat would also be deprived of them. The impact will be direct, negative, short term, local, reversible and is rated minor.

- *Exposure of Workers, Community Members to Attack by Poisonous Snakes, Bees, Scorpions, Spiders/Other Wildlife and Contact With Poisonous Plants*

The project area had some dangerous animals like snakes, scorpions, bees etc and plants poisonous plants. Field workers engaged in vegetation clearing could be exposed to attack by these animals and plants. These attacks could result in injuries, poisoning

or even death. The impact was described as direct, negative, short/ long term, local, reversible/ irreversible and rated moderate.

- *Increased Erosion of the Cleared Area*

The project area experiences high level of rainfall annually. These features render the area prone to erosion when the vegetation is cleared. The impact was direct, negative, short term, local and reversible. It was rated minor.

- *Increased access for hunting and logging*

The clearing of vegetation for the construction of base camp could provide access to individuals for hunting of wild life and logging activities. This impact though minor would be direct, negative, short term, local and reversible.

- *Opportunities for Employment*

The site clearing could be done manually using local hands. This could create opportunity for employment, contracting and increase in income for the communities. The impact was direct, short term, local, reversible and rated positive.

- *Injuries during vegetation clearing.*

The process of vegetation clearing is essentially manual, and so workers are exposed to some degree of risk of injuries. This impact is rated as direct, negative, short term, local, reversible and moderate.

- *Increased level of disease vectors*

Disease vectors such as dangerous insects: bees, and mosquitoes etc. could be dislodged from their usual habitat towards the communities and increase the risk of diseases in the communities. This impact could be direct, negative, short term, local, and reversible. It is rated moderate.

- *Traditional occupations (farming and hunting) adversely affected*

Bush clearing/site preparation after land take could affect the farming and hunting activities. This impact is rated as minor, but could be direct, negative, short term and local.

Construction Phase

Building/Civil works

- *Air Quality*

Demolition and construction activities will result in localized high level of dust and vehicular emissions. The dust risings form earthwork and vehicle movement could be significant particularly during dry season and can cause disturbances to the nearby villages. Potential impacts from dust emissions on site will be significantly reduced by careful management and the implementation of mitigation measures to reduce dust generation.

These emissions are short-termed and localized to the immediate site area; though the likelihood of occurrence is high, the consequence is rated a negligible negative. Thus, the overall impact risk level is expected to be low.

- Noise

The heavy equipment used in site clearing activities, excavation and other construction work, diesel generators used for on-site power generation and the road vehicles used for transportation of material and men to site will have an adverse impact on ambient noise levels.

With respect to the ambient noise levels, since noise is attenuated by distance (typically noise levels drop by about 40dBA at 100m distance from source) the activities on-site are unlikely to adversely affect receptors at a significant distance. However, during the nighttime when the ambient noise levels are low, the level of perception to noise by communities may be more acute. Noise from transport vehicles will be only transient for a given location and can be considered as a nuisance during nighttime.

The Nigerian noise standard is 90 dBA for an 8-hour exposure. Hearing impairment could occur from prolonged exposure to high noise level. However, it is envisaged that the facility will be demarcated and an exclusion zone created. Thus, it is unlikely that villagers will be exposed to harmful noise level. The noise impact is rated short-termed

and localized to the immediate site area; with a high likelihood of occurrence, the overall impact is low, reversible and rated minor.

- *Pressure on existing roads with possibilities of accidents*

The activities of building and construction would result in the increase of road usage due to movement of personnel and equipment. The aftermath of this could be accidents as a result of immense pressure put on the roads. This impact is direct, negative, short term, local and reversible. It rated moderate.

- *Pressure on available water for domestic and other uses*

Building and construction works will involve a good number of workers on site, and could put unwarranted pressure on communities' domestic water supply and other resources. This could be direct, negative, short term, local, and reversible. It is rated as moderate.

Labour requirement/recruitment of workforce

- *Increased financial flow, social vices, (drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies, truancy, violence), boom and bust phenomenon associated with temporary labor contracts.*

The increase in financial flow could lead to social vices like violence, alcoholism, attraction of commercial sex workers (CSW), substances abuse, and teenage pregnancies. This could lead to increase in sexually transmissible diseases (HIV/AIDS, and syphilis), injuries, and loss of life or properties. This impact is rated as direct, negative, short term, local, reversible and major.

- *Increased opportunity for contracting and temporary employment*

The project could offer employment for the indigenes at various stages. This could improve income. The impact was described as direct, short term, local/widespread and reversible. It was rated positive.

- *Influx of job prospectors into communities, thereby exerting pressure on social and health infrastructure*

Migrant labour could be attracted to the project area. This increase in population of the area could put pressure on the already deficient infrastructure. These could lead to overcrowding with potential for increase in communicable diseases like malaria, respiratory tract infections and, skin diseases. In other word, the health status of workers can change as a result of this. The impact was direct, negative, short term, local and reversible. It was rated moderate.

- *Conflicts/ Third party agitations over employment issues*

Labour issues are always a source of friction between companies and communities and also among community members. The agitation could be either due to requests for a certain number of labour that could not be met or sharing the labour slots in the community. The impact was described as direct, negative, short term, local and reversible. It was rated major.

- *Increased level of disease vectors (mosquitoes, rats, cockroaches, flies, e.t.c)*

Wastes disposed haphazardly form microenvironments for breeding of disease vectors. The crevices could provide habitats for mosquitoes, rats, cockroaches, flies. The impact is direct, negative, short term, local and reversible with a moderate rating.

- *Increase in disease conditions like diarrhoea/ respiratory tract diseases*.

Consequent on disposal of wastes without proper adherence to sanitary guidelines, discharge of sewage into the water bodies, the preponderance of disease vectors could lead to widespread increase in diarrhoea diseases. The impact was direct, negative, short term, local and reversible. The rating is moderate**.**

- *Increased opportunity for contracting and temporary employment*

The project could offer employment for the indigenes at various stages. This could improve income. The impact was described as direct, short term, local/widespread and reversible. It was rated positive

Waste generation

- *Impairment of the health of terrestrial flora and fauna*

In the aquatic system, eutrophication could result if food wastes are dumped into them. The algal bloom as well as zooplanktons depletes the dissolved oxygen, increasing the BOD. Other wastes could raise the toxicity level (heavy metals) of the water. All organisms linked to the food web including fish and man could be affected. The impact was direct, negative, short term, local and reversible. The rating is moderate.

Operations Phase

The potential impacts of this phase are:

- Air Quality

During the operational phase, the likely sources of air pollution include emission from the production facility, fumes from generated during formulation processes, power generator and vehicular emissions from shipment of materials to and from the production facility, bulk handling and storage of raw materials.

The likelihood of impact occurrence on air quality is high; the overall impact is expected to be low.

- Noise

Noise emissions from continuously and intermittently operating sources such as milling machines, generators, mobile equipment, forklifts, trucks etc will result in increased noise level. Noise emissions will also occur due to equipment faults, inappropriate operation, and damage to equipment supports and fixtures, etc.

The design considerations are expected to reduce noise level to generally low values compared with regulatory limit. The likelihood of occurrence is high, the effect of the noise will be localized and the impact is expected to be moderate.

- Groundwater

The potential sources for groundwater contamination are the discharge of liquid effluents, disposal of solid and hazardous wastes on land and accidental spillages of hazardous materials (oils, chemicals, paints, cleaning solvents, etc.). The liquid effluents include equipment / vehicle wash water, and sanitary wastewater. The likelihood of occurrence is low, since the effect of such spills will be localized, and

properly abated through the implementation of sound facility management principles. The anticipated impact is expected to be low, and insignificant.

- Soil

The potential causes for land contamination are the discharge of liquid effluents, disposal of solid and hazardous wastes on land and accidental spillages of hazardous material. Spill of herbicides, pesticides and fertilizers could result in soil contamination. The likelihood and significance of the impact is high.

Accommodation of workers:

- *Increased social vices, (drug abuse, Commercial sex workers(CSWs), exposure to HIV/AIDS, unwanted pregnancies)*

The increase in population could lead to social vices like violence, alcoholism, attraction of commercial sex workers (CSW), substances abuse and teenage pregnancies. This could lead to increase in sexually transmissible diseases (HIV/AIDS and syphilis, etc), injuries, loss of life or properties. This impact is direct, negative, short term, local and major.

- *Pressure on available water for domestic and other uses, health facilities, schools and other social amenities*

Similarly increase in population could put unwarranted pressure on communities' domestic water supply and other resources in communities with already poor infrastructure. This could be direct, negative, short term, local, and reversible. It is rated as moderate.

- *Pressure on available food with implications for malnutrition in children*

The increase in population of the area could also put pressure on the available food resources in the communities. These could lead to shortages in food supply and with a potential to affect children especially. The impact was direct, negative, short term, local and reversible. It was rated moderate.

Waste generation

- *Contamination of water quality by sewage, resulting in increase in coliforms and thereby diarrhea and other related water borne diseases*

Consequent on disposal of wastes without proper adherence to sanitary guidelines, discharge of sewage into the water bodies, the preponderance of disease vectors could lead to widespread increase in diarrhea diseases. The impact was direct, negative, short term, local and reversible. The rating is moderate.

Transportation of equipment and personnel

- *Increase in usage of roads and waterways with possibilities of accidents*

The project activities involve the deployment of several project vehicles estimated to be about 150. This will result in the increase of road usage due to movement of personnel and equipment. The aftermath of this could be accidents as a result of immense pressure put on the roads. This impact is direct, negative, short term, local and reversible. The impact is rated moderate.

- *Increase in usage and resultant damage to existing roads*

In the same vein, increase in the usage of roads could result in increase in road traffic accidents due to road congestion. This phenomenon is rated as direct, negative, short term, local, reversible and major.

- *Opportunities for contracting, supply of food and supplies*

The use of the indigenes for contracting supply of food for workers could create income generating opportunity for the people of the area. The impact was described as direct, short term, local, reversible and rated positive.

Survey line cutting

Survey line cutting consists primarily of vegetation clearing for survey activities on a temporary land area. The potential impacts of this activity are:

- *Destruction of Vegetation (Medicinal, economic and food)*

The removal of the vegetations on the survey lines could lead to loss of any medicinal, economic or food crops in the area. The wildlife that used this vegetation for habitat would also be deprived of them. The impact was direct, negative, short term, local, reversible and rated moderate.

- *Loss/alteration of wildlife habitat*

The removal of the vegetations during survey cutting could lead to loss/ alteration of wildlife habitat as a result of displacement and destruction of food sources and the wildlife that used this vegetation for habitat would also be deprived of them. The impact was rated direct, negative, short term, local, reversible and rated minor.

- *Increased access for hunting and logging*

The clearing of vegetation for survey cutting could provide access to individuals for hunting of wildlife and logging activities. This impact is rated moderate and would be direct, negative, short term, local and reversible.

- *Reduction of biodiversity*

The removal of the vegetations during survey activities could lead to loss of biodiversity: medicinal, economic or food crops in the area as well as wildlife that used this vegetation for habitat. The impact was described as direct, negative, short-term, local, reversible and rated moderate.

- *Increased opportunity for contracting and temporary employment*

The use of the indigenes in the removal of vegetation on the land section for survey could create income generating opportunity and contracts for the people. The impact was described as direct, short term, local, reversible and rated positive.

- *Possibilities of lines cutting across sensitive locations, property, economic trees, farms, sacred places, public utilities*

The possibility of lines cutting across sensitive locations during operations, properties, economic trees, farms, etc. could arise. This impact is rated as major and is direct, negative, short term, local, reversible.

- *Third party agitation over damage to property, encroachment and compensations*

The third party agitation at this stage could be due to issues of cutting activities across sensitive places and resulting in damage to them: houses and other properties, economic trees, farms, shrines, and public utilities such as water sources. This could lead to agitations for compensations. The impact is considered direct, negative, short term, local, reversible and rated major.

Repairs and maintenance

- *Generation of high intensity welding flash and noise*

The welding activity generates high intensity welding flash. This flash could affect unprotected eyes giving rise to conjunctivitis. The impact is considered direct, negative, short term, local, reversible and rated moderate

- *Burns and injuries from welding sparks/injuries from other maintenance activities*

The sparks generated during welding activities could result in injuries on soft tissues of the body. The impact considered direct, negative, short term, local, reversible and rated moderate.

- *Contamination of surface soil with used lubricant*

Lubricants used for vehicle, heavy equipment and machinery maintenance could result in the contamination of topsoil. This impact is considered direct, negative, short term, local, and reversible with a moderate rating.

Provision of water

- Use of contaminated water
- Third party agitation for provision of water

Decommissioning Phase

- *Air Quality*

Demolition activities will result in localized high levels of dust and vehicular emissions from civil works and vehicle movement. This is expected to be significant particularly during the dry season.

Potential impacts from dust emissions on site will be significantly reduced by implementation of mitigation measures to reduce dust generation.

These emissions are short-termed and localized to the immediate site area; though the likelihood of occurrence is high, the consequence is rated a negligible negative. Thus, the overall impact risk level is expected to be low.

- *Noise*

The heavy equipment used in decommissioning activities and other civil works, diesel generators used for temporary power generation and vehicles used for transportation of material and men to site will have an adverse impact on ambient noise levels.

Noise from transport vehicles will be only transient for a given location and can be considered as a nuisance during nighttime.

The noise impact is rated short-termed and localized to the immediate site area; with a high likelihood of occurrence, the overall impact is low, reversible and rated minor.

- *Solid, Liquid and Hazardous Waste Management*

Decommissioning activities will generate wastes such as, excavated soils and debris wood piles, fuels, lube oils, chemicals and solid wastes from the demolition camp. Leaching from waste oil could result in groundwater contamination. The solid and hazardous waste generated during the decommissioning activities will be managed using the best management practices. The impact from the hazardous waste management will be negative, short term, localized and reversible.

- *Increased opportunity for employment and contracting resulting in increased income level.*

The process of decommissioning will involve the repair of damaged roads, removal of structures, and restoration of campsite. These activities could increase opportunities for employment and contracting. The impact was rated as direct, positive, short term, local and reversible.

- *Nuisance (Noise, emission, Vibration etc) from heavy machinery.*

The process of decommissioning could also result in the generation of noise, vibration etc. from heavy equipment. The impact was rated as direct, negative, short term, local, reversible, and moderate.

- *Third Party Agitation due to Employment Issues and Loss of Benefits as Host Communities.*

As seismic activities come to an end, there could be agitation by the third parties from loss of employment and contracting opportunities. The impact was direct, negative, short term, local, and reversible, with moderate rating.

CHAPTER SIX

MITIGATION MEASURES

6.1 Background Information

This chapter provides mitigation measures that will be taken by Harvestfield against identified impacts to ensure environmental sustainability of its proposed Aflasafe Bio-control Plant in Makun, Obafemi Owode LGA, Ogun State. The impact identification and evaluation process showed that components of the biophysical, health and social environments will be impacted both positively and negatively. A number of measures are hereby proposed to mitigate the impacts of the facility to acceptable residual impact level.

The HSE design and operation objectives of the facilities is to implement all cost-effective measures to reduce the risks and impacts from routine or major hazards including accidents. Thus, the steps taken in the HSE process for the proposed Aflasafe Bio-control Plant include the following:

- design based on codes, standards and regulations
- improved operation based on quantitative risk assessment and
- best international practice

6.2 Criteria for Selection of Mitigation Measures

Selection of mitigation measures for the identified impact is based on the following considerations:

a) Best available technology for sustainable development;
b) FMEnv Regulatory requirements;
c) Environmental laws in Nigeria, with emphasis on permissible limits for waste streams;
d) Social wellbeing; and
e) Industry international best practice (IFC EHS Guidelines, 2016)

6.3 Mitigation Measures

Mitigation measures are actions taken to minimize negative impacts, while also enhance positive ones. Mitigation measures are often implemented on a continuous basis through the project's life span. These measures aim to improve the environmental sustainability of the project. Mitigation measures are recommended for the project identified impacts on:

a) Environment
b) Occupational safety and health
c) Community health and safety.

Typically, a number of mitigation measures have been built into the project design and operating philosophy. These in-built mitigation measures are expected to significantly improve the environmental sustainability of the project. The proposed mitigation measures for the potential impacts associated with the different phases of the project along with the residual impacts are provided in the Environmental and Social Management Plan. The highlights of the mitigation measures for the various phases of the project are as follows:

Permitting

Permitting involves consultations with communities and relevant government bodies to obtain the requisite legal and social licenses to operate. The impacts identified were positive. These are:

1. Acceptance of project and cooperation/participation from communities and government and
2. Reduction/abatement of threats posed by agitation of communities and sympathetic third parties over non-disclosure of project activities, employment, contracts, CD, environmental impacts of projects and other community/third party interests.

In other to enhance these positive impacts, timely consultations and explicit description of project activities, impacts and benefits were recommended.

- **Temporary Land-Take for Base Camp**

Temporary land-take will be required for campsites, fuel dumps/generator house, vehicle parking lots and other land needs. This could result in the following impacts:

1. Third party agitations over compensations, land disputes, wrong stakeholder identification and leadership tussle etc
2. Increased financial flow due to compensations

Third party agitations were rated moderate. The mitigation measures proposed are:

- The relevant stakeholders/legacy issues shall be identified
- Consultations with stakeholders (Community, Government, NGOs, CBOs etc.) shall be carried out
- Adequate and prompt compensation shall be made and
- Project advisory committee (PAC) to guide land acquisition process/ MOU implementation shall be set up

These mitigation measures shall reduce the severity of the impact from moderate to minor.

Encouraging judicious use of income by beneficiaries was recommended for enhancing this positive impact of ***increased financial flow from compensations***.

- **Recruitment of workers**

About 100 local staff (skilled labour – 50%, semi- skilled labour – 30% and unskilled labour – 20%) will be recruited in the cause of the survey activities. The significant impacts identified include:

1. Creation of opportunities for employment
2. Influx of job seekers into communities, thereby exerting pressure on infrastructure
3. Conflicts/ Third party agitations over employment issues

Creation of opportunities for employment was identified as a positive impact, which could be enhanced by encouraging savings and judicious use of income.

A Conflicts/ Third party agitation over employment issues were rated moderate. The mitigation measures that were proffered include:

- Employment of at least 60% of the workforce from the communities
- Prompt communication of employment policy to communities

Influx of job seekers into communities, thereby exerting pressure on infrastructure was rated moderate. The mitigation measure proffered for reducing this impact from moderate to minor is to ensure that the recruitment period is brief and definite

Mobilization to site

About 30 trucks will be mobilized to carry personnel, materials and equipments to site.

Identified impacts from mobilization to site are:

1. Increase in usage of roads with possibilities of accidents
2. Increase in usage and resultant damage to existing roads

Both impacts were rated moderate.

To reduce ***Increase in usage of roads and waterways with possibilities of accidents*** from moderate to minor, measures suggested are:

- Journey management shall be employed to limit the amount of traffic
- Regular maintenance and checks shall be carried out
- Training and retraining of drivers shall be conducted.
- Compliance with speed limits shall be enforced
- Warning signs shall be established where desirable
- Night driving/travels shall be prohibited
- Personal protective equipment (PPE) shall be used during water travels
- Awareness shall be created on the potential of increased traffic
- Harvestfield policy on road and water borne traffic journey management shall be adhered

Increase in usage and resultant damage to existing roads could be reduced from moderate to minor by repairing all identified damaged roads.

Site Preparation/Clearing for Base Camp

Mitigation measures shall include the following:

Air Quality

These emissions are short-termed and localized to the immediate site area. Regular maintenance of vehicle and construction equipment so as to keep the engines in good operating conditions will greatly reduce emission from internal combustion engines. The access road to the site shall be tarred before site preparation, all untarred roads shall be kept damp to minimize dust blow. Lorries transporting friable construction materials shall be covered and vehicle speed shall be limited to 20 Km/Hour on untarred roads.

Noise

Noise intense areas will be clearly marked out during the construction phase with warning signs; areas requiring hearing protection such as earmuffs will also be delineated. Construction noise will be of short duration and restricted mainly to daytime periods, so impacts will be acceptable.

Vegetation Resources

Site clearing and construction activities will severely affect any vegetation resources at the site. Movement of construction equipment and workers shall be restricted to the construction site and laydown areas.

As much as the development of the industry will bring economic returns, the cost to the environment in degradation and aftermath on humans, plants and animals will be invaluable in the long run. It is on this premise that the following mitigation measures are.

1. Selective removal of vegetation
2. Revegetation of unused area of the plot with native plant species. Lawns and ornamental hedges shall be created within the premises of the facility. They shall be properly monitored against abuse such as trampling and littering with garbage. These plants will utilize excess carbon IV oxide (CO_2) being generated in the facility while at the same time ameliorating excessive air temperature through their evaporation and transpiration, and provision of shade.
3. Prevention of chemical spill. Proper waste disposal facilities shall be provided at strategic locations in order to prevent escape of injurious and toxic

substances into the ecosystem. The power generators shall be located such that spent oil and leaked fuel could drain into a concrete drain where it can be treated or removed from the site. Since the water table of the plot is very high, it is mandatory for the industry to ensure that there is a good network of close drainage system, where there is no risk of seepage to the ground water of run-off to the ocean/lagoon.

4. Mandatory use of non-persistent, biodegradable chemicals. In order to prevent a repeat of the DDT syndrome – due to bioaccumulation and biomagnifications of the persistent toxic DDT, the use of which Rachael Carson fought against in the 1960s (Carson, 1962/2002), the company must be regulated to use easily biodegradable, non-persistent, environmentally friendly chemical inputs. Any fume emanating shall be regulated within limits permissible by the FEPA Act.
5. There shall be regular monitoring of the vegetation, air, water and soils in the premises of the industry as well as the surroundings in general. This is a joint responsibility of the Ministry of Environment, Ogun State, Federal Ministry of Environment, NAFDAC, Ministry of Agriculture and Water Resources, and Standards Organization of Nigeria.

A parcel of land will be cleared for the base camp. Identified impacts include:

1. Creation of opportunities for employment
2. Attack of workers and community members by poisonous snakes, bees, plants etc
3. Injuries during vegetation clearing.
4. Increased level of disease vectors

To enhance the beneficial effects of ***Creation of*** o***pportunities for employment,*** Harvestfield shall ensure that at least 60% of the workforce is employed from the communities.

To reduce ***Attack of workers and community members by poisonous snakes, bees, plants etc*** from moderate to minor:

- Harvestfield shall provide and enforce usage of PPE by field workers
- First aid /Anti- venom shall be provided on site
- Designated staff shall be trained to control poisonous plants and animals

- Awareness shall be created among site workers and nearby communities on the likelihood of exposure to wildlife

To reduce ***Injuries during vegetation clearing*** from moderate to minor:

- Harvestfield shall provide and enforce usage of PPE by field workers
- First aid shall be provided on site
- Compliance with HSE procedures shall be enforced
- MEDEVAC shall be provided on site

To reduce ***increased level of disease vectors*** from moderate to minor:

- Affected areas shall be drained to eliminate breeding sites of disease vectors
- Area shall be fumigated to eliminate disease vectors

Construction of base camp

Construction works for the base camp include the installation of the *portakabins* and building of a workshop, restaurant, generator house and sheet fence. Other construction works include plumbing, electrification, communication, recreation. The impacts identified include:

1. Pressure on existing roads with possibilities of accidents
2. Pressure on available water for domestic and other uses

Both impacts were rated moderate.

To reduce ***Pressure on existing roads with possibilities of accidents*** from moderate to minor:

- Journey management shall be employed to limit the amount of traffic
- Repair of roads, tracks and farm roads shall be carried out
- Warning signs shall be established where desirable
- Compliance with speed limits shall be enforced
- Regular maintenance and checks shall be carried out
- MEDEVAC shall be provided
- Awareness shall be created on the potential of increased traffic
- Harvestfield policy on road and water borne traffic journey management shall be adhered to

Pressure on available water for domestic and other uses could be reduced from moderate to minor by providing additional water to affected communities during construction activities.

Labour requirement/recruitment of workforce for Construction

The recruitment of workforce for construction could result in:

1. Increase in financial flow resulting in social vices such as drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies, truancy, violence), boom and bust phenomenon associated with temporary labor contracts etc
2. Increased opportunity for contracting and temporary employment
3. Influx of job seekers into communities, thereby exerting pressure on social and health infrastructure

The following mitigation measures were proffered to reduce ***Increase in financial flow resulting in social vices*** from major to minor:

- Awareness campaign shall be carried out to enlighten the communities/field workers on the implications of casual and unprotected sex, prostitution, (HIV/AIDS), drug and alcohol abuse
- Alternative recreational facilities shall be provided at camp sites
- Harvestfield alcohol and drug policy shall be implemented to encourage healthy lifestyle
- Conflicts/ Third party agitations over employment issues

The following mitigation measures were recommended to enhance the beneficial effects of

Increased opportunity for contracting and temporary employment:

- At least 60% of the workforce shall be employed from the communities
- Indigenous contractors shall be used

Influx of job seekers into communities, thereby exerting pressure on social and health infrastructure was rated moderate. Its negative effects could be reduced from moderate to minor by ensuring that the recruitment period is brief and definite.

Conflicts/ Third party agitations over employment issues could be mitigated by ensuring that at least 60% of the workforce is employed from the communities and ensuring that the communication of the employment policy to communities is prompt

Waste generation- Construction:

Solid, liquid and gaseous waste that could be generated from the construction works include wood chippings, cement bags, PVC pipes, paint, lubricants, fencing sheets

off cuts, exhaust from cranes/heavy equipment, domestic waste, and plumbing accessories.

Significant identified impacts from the generation of solid, liquid and gaseous waste include:

1. Nuisance noise, dust, emissions, lighting,etc
2. Increased opportunity for contracting and temporary employment

The following mitigation measures shall reduce ***Nuisance noise, dust, emissions, lighting*** from moderate to minor:

- Machinery with noise levels within acceptable limits (85 dB (A)) shall be used
- Site construction shall be done within the shortest possible time
- Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits
- High sound energy equipment shall be enclosed in noise insulators in line with Harvestfield policy
- Harvestfield HSE policy of wearing ear muffs/ plugs shall be applied in all construction sites
- Sufficient separation distances shall be provided for sources of high energy sound to reduce noise levels
- Workers with existing hearing impairment shall not be deployed to site.

The following mitigation measures shall enhance the beneficial effects of ***increased opportunity for contracting and temporary employment:***

- At least 60% of the workforce shall be employed from the communities
- Indigenous contractors shall be used

Accommodation of workers

Some of the 100 workers that will be recruited will be accommodated. The identified impacts of accommodation of workers include:

1. Increased social vices, (drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies)
2. Pressure on: available water for domestic and other uses, food, health facilities and other social amenities
3. Opportunities for contracting, supply of food and other supplies

4. Contamination of water by sewage, resulting in increase in diarrhea and other water borne diseases

5. Third party agitation over waste disposal

To bring the effect of ***increased social vices,*** (drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies) from major to minor, the following mitigation measures were proffered:

- Awareness campaign shall be carried out to enlighten the communities/field workers on the implications of casual and unprotected sex, prostitution, (HIV/AIDS), drug and alcohol abuse
- Alternative recreational facilities shall be provided at camp sites
- Harvestfield alcohol and drug policy shall be implemented to encourage healthy lifestyle

The potential for increment in ***Pressure on available water for domestic and other uses, food, health facilities and other social amenities*** could be reduced from moderate to minor by the following measures:

- Harvestfield shall provide water and food at campsite to prevent pressure on community resources
- Harvestfield shall provide health and recreational facilities on campsite to prevent pressure on community facilities.

By involving indigenous contractors in the supply of food, the beneficial effects of ***Increased opportunity for contracting*** shall be enhanced. In addition, ***employing at least 60% of the workforce from the communities could enhance opportunities for employment.***

Contamination of water by sewage, resulting in increase in water borne diseases was rated moderate. To reduce this impact to minor:

- Effluents from facilities shall be treated prior to disposal into surface water
- Sanitary toilets shall be provided at campsite
- Sanitary waste shall be treated biologically or by use of septic tanks

Third party agitation over waste disposal, could be abated from a moderate impact to minor by providing an alternative source of drinking water to communities where applicable

Transportation of equipment and personnel

During the survey activities, equipment and personnel will be transported from one location to the other within Harvestfield project area. Identified impacts include:

1. Increase in usage of roads and waterways with possibilities of accidents
2. Increase in usage and resultant damage to existing roads
3. Nuisance (Noise, emission, Vibration etc) from heavy machinery.

These impacts were all rated moderate. Measures proffered for reducing ***Increase in usage of roads and waterways with possibilities of accidents*** from moderate to minor are:

- Repair of roads, tracks and farm roads shall be carried out
- Harvestfield 's journey management policy on road and water shall be employed to limit the amount of traffic
- Warning signs shall be established where desirable
- Compliance with speed limits shall be enforced
- Regular maintenance and checks shall be carried out
- MEDEVAC shall be provided
- Awareness shall be created on the potential of increased traffic

Increase in usage and resultant damage to existing roads was rated major. This could be reduced from to minor by repairing all identified damaged roads.

In other to reduce ***Nuisance (Noise, emission, Vibration etc) from heavy machinery*** from moderate to minor:

- Machinery with noise levels within acceptable limits (85 dB (A)) shall be used
- Survey activities shall be done within the shortest possible time

Survey line cutting

Survey line cutting involves the clearing of vegetation of a maximum of one meter a grid that transects the project area. Identified impacts are:

1. Destruction of vegetation resulting in loss/alteration of wildlife habitat, medicinal, economic and food materials and reduction of biodiversity.
2. Increased access for hunting and logging

3. Increased opportunity for contracting and temporary employment Possibility of lines cutting across sensitive locations, property, economic trees, farms, sacred places, public utilities

To mitigate the ***Destruction of vegetation resulting in loss/alteration of wildlife habitat, medicinal, economic and food materials and reduction of biodiversity*** from moderate to minor:

- Clearing shall be minimized and confined to the 1 meter width
- Re-vegetation of cleared line shall be undertaken after survey where desirable

Measures to reduce increased access for hunting and logging from moderate to minor include:

- Awareness campaign of the adverse effects of hunting and logging.
- Support of programmes aimed at sustainable use of forest resources by Harvestfield
- Discouraging hunting by workers and community during the survey

Employing at least 60% of the workforce from the communities and involving indigenous contractors could enhance increased opportunity for contracting and temporary employment.

Third party agitation over damage to property, encroachment and compensations was rated major. In order to reduce this impact to minor:

- Appropriate beneficiaries of damaged property shall be identified and the loss evaluated.
- Consultations with the relevant communities and property owners shall be carried out and adequate and prompt compensation shall be made.
- Project advisory committee (PAC) including representatives of government, Harvestfield,

NGOs and communities shall be constituted to guide the compensation process.

Repairs and maintenance

Repairs and maintenance encompass welding, motor vehicle repairs, maintenance and servicing of facilities in the proposed workshop. The impacts identified include:

1. Generation of high intensity welding flash and noise

2. Burns and injuries from welding sparks/injuries from other maintenance activities

Both impacts were rated moderate. Mitigation measures proffered for them include:

- Awareness sessions on health risks and safety precautions of welding operations shall be carried out for workers
- Pre-employment medical certification shall be carried out for the welders
- Harvestfield shall enforce the use of welder's mask, earmuffs, jackets, gloves, boots and coveralls by welders during welding.

Provision of water

Workers in the camp and on the field will need a large quantity of drinking water. ***Use of contaminated water*** was identified as a potential outcome rated as moderate which could be mitigated to minor by Harvestfield providing its workforce with potable water and discouraging use of water from other sources. In addition, there could be ***Third party agitation*** as a result of communities demanding for water, which could be reduced from moderate to minor by provision of water to communities where applicable.

Decommissioning

Decommissioning involves the removal and abandonment of structures as well as repair of damaged roads.

The Mitigation measures on the impacts of decommissioning shall include the following:

Air Quality

These emissions are short-termed and localized to the immediate site area. Regular maintenance of vehicle and construction equipment so as to keep the engines in good operating conditions will greatly reduce emission from internal combustion engines. The site shall be dampened with water to reduce dust generation. Also workers on site shall use nose and eye protector to reduce impact of dust on the workers. Lorries transporting materials from construction site shall be covered and vehicle speed shall be limited to 20 Km/Hour on untarred roads.

Noise

Noise intense areas will be clearly marked out during the decommissioning phase with warning signs; areas requiring hearing protection such as earmuffs will also be delineated. Construction noise will be of short duration and restricted mainly to daytime periods, so impacts will be acceptable.

Solid, Liquid and Hazardous Waste Management

Decommissioning activities will generate wastes such as, excavated soils and debris wood piles, fuels, lube oils, chemicals and solid wastes from the demolition camp. Leaching from waste oil could result in groundwater contamination. The solid and hazardous waste generated during the decommissioning activities will be managed using the best management practices.

Increased opportunity for employment and contracting resulting in increased income level.

The process of decommissioning will involve the repair of damaged roads, removal of structures, and restoration of campsite. These activities could increase opportunities for employment and contracting. Harvestfield shall use indigenous contractors and engage at least 60% of the workforce from the communities

6.3.1 Recommendations for Community Health and Safety

Emergency planning to be adopted by Harvestfield, to prevent major hazards to the community will include, at a minimum,

- ✓ the preparation and implementation of an Emergency Management Plan, prepared with the participation of local authorities and potentially affected communities
- ✓ periodic environmental and health surveillance
- ✓ develop and implement mechanism for monitoring and correcting community complaints and grievances

The comprehensive mitigation measures encapsulating the project phases from pre-construction to construction, operation and decommissioning is presented in ***Table 6.1*** below. Following adoption of mitigation measures, residual impacts are also presented.

Table 6.1: Mitigation Measures of the Proposed Project Activities – Pre-Construction Phase

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
Land Take for Aflasafe Bio-control Plant	Loss of land Change in land use Legal issue	M	This impact, although negative is reversible, the probability of the impact arising is also low considering the fact that Harvestfield already has an allocation, where the project will be situated. The percentage of environmental significance is less than 25%, therefore the impact significance is described as low. However, Harvestfield shall ensure that: ✓ continuous consultation and engagement with host communities and other stakeholders be maintained to forestall unrest in line with the company's grievance mechanism. ✓ that proper land acquisition procedure is followed and payment of all land dues to government and any concerned stakeholder ✓ that all necessary document and permit relating to the acquired land are obtained from the right quarters.	**L**
Mobilisation (transport) to site (equipment, personnel and construction modules)	Road and traffic accidents	H	Harvestfield shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic, and the need for extra precautions through public enlightenment • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, carry out job hazard	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			analysis • minimize movement at the peak hours of the day • ensure that all traffic rules are obeyed by the drivers • Large and slow-moving vehicles shall be scheduled during off peak periods • Involve Harvestfield security in traffic control in traffic management • Defensive driving course for Harvestfield and contractor drivers • First aid training of workforce and provision of first aid boxes in operational vehicles • Visible warning signs on roads and vehicles • Speed breakers at sections traversing communities	
	Noise nuisance	M	Harvestfield shall ensure: • regular maintenance of vehicles • Vehicles are turned off when not in use • Vehicles are fitted with effective silencers.	L
	Impairment of air quality	M	Harvestfield shall ensure: • Engine to comply with international standards for exhaust gases; Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • that water shall be sprayed on construction sites to reduce dust levels especially during dry season.	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	Loss of biodiversity	M	▪ Strictly regulating heavy equipment traffic ▪ Restricting the number of traffic lanes and limiting the movement of the machinery to the work site and to the marked access way ▪ Implement good housekeeping practice on-site. ▪ Storing and handling of hazardous waste in accordance to approved WMP ▪ Selecting vehicles suited for erodible soil ▪ Limiting activities in erodible soil	L
Energy consumption (provision of energy for pre-construction activities)	Impairment of air quality	M	Harvestfield shall ensure that: • there is regular maintenance of the generators; • generators are switched off when not in use • dust control and dust recovery machinery are used	L
	Noise and vibration nuisance	M	Harvestfield shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of the generators; • noise barrier are erected • generators are switched off when not in use; • soundproof electric power generators are engaged	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	Increased opportunity for business and employment	P	Harvestfield shall ensure: • local contractors are engaged; • prompt payment to engaged labour • that Indigenes are considered first • that alternative will be made and vehicular traffic will be reduced • that they agree with community before mobilization on modalities of promoting Local entrepreneurship in the provision of housing and transport.	P
	Contamination of soil	M	Harvestfield shall ensure: • Soil disturbance shall be kept to minimum required for operation and safety • Oil spill containment shall be provided to prevent oil spill from getting to the soil. • Implement good housekeeping practice on-site. • Storing and handling of hazardous waste in accordance to approved WMP.	L
Site Preparation – clearing, excavation and landscaping	Acceleration of erosion	M	Harvestfield shall: • Stabilize soil within the well location and campsite mechanically using compactors to reduce erosion potential • Mechanically stabilize the soil in order to reduce potential for erosion	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• Avoid excavation and burial in steeply sloped ground and avoid creation of great breaks • Provide for the placement of siltation ponds in areas subject to heavy erosion • Select vehicles suited for erodible soil • Limiting activities in erodible soil	
	Alteration of local topography	M	• Harvestfield shall ensure: • re-grading of the sites, then replacing the layer of top soil that was previously put. • restoring the operational site by restoring the original profile of the topography and the soil • strictly regulating heavy equipment traffic • restricting the number of traffic lanes and limiting the movement of the machinery to the work site and to the marked access way	L
	Alteration of soil profile	M	Harvestfield shall: • ensure that stripping and excavation of topsoil is strictly limited to areas acquired for the activities. • ensure proper re-vegetation of all other areas with indigenous species from adjoining forest after activities • stabilize soil within the well location and campsite mechanically using compactors to reduce erosion potential	L
	Blockage of drainage pattern	M	Harvestfield shall ensure that: • strict environmental policy shall be ensured • Regular cleaning of the drainage shall be ensured	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• The drainage network shall be covered	
	Contamination of soil	M	Harvestfield shall: • Ensure that soil disturbance shall be kept to minimum required for operation and safety • Ensure that oil spill containment are provided to reduce oil spill from getting to the soil • Implement good housekeeping practice on-site. • Store and handle hazardous waste in accordance to approved WMP. • Place filtration berms and sediment barriers. • Use methods that minimize perturbation to aquatic environment. • Avoid spills prohibiting refueling near waterway	L
	Impairment of air quality	M	Harvestfield shall ensure that: • only pre-mobbed equipment are used; • all equipment are controlled; • equipment engines are turned off when not in use • Harvestfield shall ensure that all construction equipment shall be in proper operating condition and fitted with factory standard silencing features if appropriate • Harvestfield shall provide and enforce the use of PPE (e.g. nose masks and ear muffs) • Harvestfield shall construct sound proofing walls around stationary power generating sources • Use of the cleanest fuel economically available shall be adopted	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance; • Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors; • Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust;	
	Noise and vibration nuisance	M	Harvestfield shall ensure that: • equipment are fitted with effective silencers; • there shall be regular maintenance of equipment; • equipment are switched off when not in use; • Vibration containment be made for equipment which are likely to cause vibration • noise barriers are erected	L
	Work site accidents	H	Harvestfield shall ensure that: • workers and visitors are properly kitted (use of appropriate PPEs) • use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site	L
	Security/artificial light at	L	Harvestfield shall ensure that:	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	night		• work at night shall be done without impacting the visual element of the area by reducing luminosity of night light. • As far as possible, the operation of heavy equipment shall be conducted in day light hour in locations that are not close to residential areas • Job shift is encouraged	
	Habitat Alteration	H	Harvestfield shall: ▪ Use methods that minimize perturbation to aquatic environment. ▪ Avoid spills prohibiting refueling near waterway ▪ Minimize destruction or modification of the vegetation cover by restoring vegetation at the end of the work	L

Table 6.2: Mitigation Measures of the Proposed Project Activities– Construction Phase

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
Transport activities during construction	Road traffic accidents	H	Harvestfield shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic, and the need for extra precautions through public enlightenment • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, • to carry out job hazard analysis • minimize movement at the peak hours of the day • ensure that all traffic rules are obeyed by the drivers • Large and slow-moving vehicles shall be scheduled during off peak periods • Involve Harvestfield security in traffic control in traffic management	L

			• Defensive driving course for Harvestfield and contractor drivers • First aid training of workforce and provision of first aid boxes in operational vehicles • Visible warning signs on roads and vehicles • Speed breakers at sections traversing communities	
	Noise nuisance	M	Harvestfield shall ensure: • regular maintenance of vehicles • Vehicles are turned off when not in use • Vehicles are fitted with effective silencers.	L
	Impairment of air quality – emission from trucks	M	Harvestfield shall ensure: • Engine to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • Use of the cleanest fuel economically available shall be adopted	L

			• Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance; • Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors; • Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust	
Excavation of land area and Casting of the plinths	Loss of vegetal cover with possible impact on biodiversity loss	H	Harvestfield shall: ▪ Provide siltation pond in areas of heavy erosion ▪ Place filtration berms and sediment barriers. ▪ Use methods that minimizes perturbation to aquatic environment. ▪ Avoid spills prohibiting refueling near waterway ▪ Minimize destruction or modification of the vegetation cover	L

			by restoring vegetation at the end of the work	
	Impairment of air quality	H	Harvestfield shall ensure: • there is regular maintenance of the engines; • engines are switched off when not in use • engines to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; • that nose masks and ear muffs are worn by site workers during excavation • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance;	L
	Noise and vibration nuisance	H	Harvestfield shall ensure that: • Machine engines are fitted with effective silencers; • regular maintenance of machine/ engines are performed; • engines are switched off when not in use;	L

			• soundproof electric power generators are engaged • the use of PPEs is encouraged • vibration containment shall be made for generators and machines	
	Contamination in the event of oil spills from equipment and machinery	H	• Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface • there shall be regular maintenance of the equipment and machineries	L
	Waste generation from excavated materials	M	Harvestfield shall ensure that: • all other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner. • generation of all wastes are minimize as much as practically possible • Unsuitable excavated materials shall be systematically carried away from areas prone to erosion; • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or	L

			removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials must not be burned; • Optimize the reuse of spoil and construction waste; • All the construction camps and facilities shall be dismantled and removed from the site, unless otherwise desired by the local public; • site shall be restored to a condition in no way inferior to the condition prior to the commencement of work. • safety measures while disposing wastes are followed; • introduction of foreign soil and synthetic materials is avoided; • disposal of construction and related waste materials at designated and approved waste dump site; • waste management plan in road planning and contract specifications is incorporated; • there is collaboration with relevant waste management agencies to enforce appropriate sanitation and other bye laws.	
Constructio	Burns/injuries from	H	• Harvestfield shall ensure that workers and visitors are properly	L

n of e warehouse, silos and product Storage Facilities	welding sparks		kitted • Use of experienced/competent workers • Pipe joining techniques such as welding shall meet international standards	
	Exposure to welding flash	H	• Harvestfield shall ensure that workers and visitors are properly kitted (appropriate PPEs are used)	L
	Noise and vibration nuisance	M	Harvestfield shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of the generators; • generators are switched off when not in use; • soundproof electric power generators are engaged • the use of PPEs shall be encouraged	L

	Kidnapping of workers and visitors on site	H	• Harvestfield shall ensure that both contractor and Harvestfield personnel develops a high level of security consciousness both within and outside the work area • Daily security reports shall be reviewed by the Harvestfield Project Manager • Special security force shall be established and deployed for the project. This shall include deploying some of Harvestfield police to strengthen security in the area • Harvestfield shall ensure that a liaison to foster partnership with the community so as to guarantee security for the project is established and sustained • In order to beef up security for the project, Harvestfield shall support government authorities by providing assistance with equipment e.g. patrol vehicles, to ensure improved security • Harvestfield shall ensure that safety workshops to identify, evaluate and recommend contingency plans for all security risks are regularly organized	M

	Waste Management - The potential effects will be of aesthetics as well as a nuisance. Wastes shall mainly come from discarded packaging materials such as metal cuttings and empty plastic containers. Poor disposal methods can lead to environmental problems due to their non-biodegradable nature. Most of the packaging wastes are expected to be reused	H	Harvestfield shall ensure that: • toilets are created at the site. • site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment • Minimum wastes are generated • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials shall not be burned; • safety measures are followed while disposing wastes;	L

Coating	Contamination of surface water and soil by paints and coating as a result of spillage	H	• Using of engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard; • Implementing of management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures. • Safe ventilation for storage of volatile materials shall be provided; • Access to areas containing paint substances shall be restricted and controlled; • Paints shall be stored on impervious ground under cover; the area shall be constructed as spill tray to avoid spread of accidental spills	L

	Hazardous waste generation from coating operations such as metals	H	• Good housekeeping shall be instituted and maintained • hazardous wastes shall be collected, stored and disposed appropriately in line with FMEnv standard at an approved disposal site.	L
Backfilling	Alteration of hydrological patterns resulting in temporary or permanent flooding, soil erosion and destruction of biodiversity	H	• Mechanically stabilising the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodible soil • At the completion of the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.	L
	Worksite accidents	H	Harvestfield shall ensure that: • workers and visitors are properly kitted (use of appropriate PPEs)	L

			• use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site	
	Increase in communicable disease (including STDs and HIV/AIDS)	M	• Health awareness lectures shall be given to workers on the mode of transmission of STIs (including HIV/AIDS) • As much as possible provide psychological support to persons living with the HIV virus • Harvestfield shall insure immunization of workforce against as appropriate • Regular spraying of work sites Provision of insecticide treated nets to field workers to reduce incidence of malaria • Awareness campaign shall be carried out to enlighten the communities /field workers on the common communicable diseases and the health implications of drug and alcohol abuse, unprotected sex, prostitution and the need to sustain cultural values • Harvestfield shall assist the activities of the state action committee on STIs/HIV/AIDS as part of her stakeholders' engagement plan.	L

			• Harvestfield shall ensure site clinic is provided to take care of minor illnesses for all construction workers	
Installation of modules and Construction of administrative blocks	Loss of vegetal cover with possible impact on biodiversity loss	H	• Ensure prompt landscaping/reclamation of degraded lands. • Rehabilitate Excavation sites by filling. • Ugly scars left around sites shall be leveled and landscaped. • Plant shrubs/grasses to be planted to check erosion. • Develop embankment on steep slopes to protect them from erosion. • Stone pitch to protect slopes where necessary • New structures such as signboards, bill boards for the project shall be removed after construction. Those required such as direction or warning signs shall be properly placed.	L
	Noise and vibration nuisance	H	Harvestfield shall ensure that: • Machine engines are fitted with effective silencers; • regular maintenance of machine/ engines are performed; • engines are switched off when not in use; • soundproof electric power generators are engaged • the use of PPEs is encouraged • vibration containment shall be made for generators and machines	L

	Waste generation from Installation and construction activities	H	Harvestfield shall ensure that: • all other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner. • generation of all wastes are minimize as much as practically possible • Unsuitable excavated materials shall be systematically carried away from areas prone to erosion; • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials must not be burned; • Optimize the reuse of spoil and construction waste;	L

	Impairment of air quality	M	Harvestfield shall ensure: • Engine to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance; • Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors; • Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust	L

	Fall from height/ Worksite accidents	H	Harvestfield shall shall ensure and require that contractors implement the following fall prevention and protection measure for all workers exposed to the hazard of falling while working: • Test structures for integrity prior to undertaking work • Implement a fall protection program that includes training in climbing techniques and use of fall protection measures; inspection, maintenance, and replacement of fall protection equipment; and rescue of fall-arrested workers, among others • Provide adequate work-positioning device system for workers. • Contractors working at site must use appropriate PPE • workers and visitors are properly kitted (use of appropriate PPEs) • use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site	L
Site demobilization	Road traffic accidents	H	Harvestfield shall ensure: • enforcement of the use of PPEs • daily pep talk is carried out • job hazard analysis is carried out • compliance with journey management policy	L

Table 6.3: Mitigation Measures of the Proposed Project Activities – Operation/Maintenance

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
Operations and Maintenance	Air Pollution (1) Fugitive emissions from plant facilities are associated with leaks in the tubing; valves; connections; flanges; packings; open-ended lines; floating roof storage tank, pump and compressor seals	H	Harvestfield shall ensure: • Regular monitoring of fugitive emissions from valves, seals, tanks, and other infrastructure components with vapor detection equipment, and maintenance or replacement of components as needed in a prioritized manner • Maintain stable tank pressure and vapor space by: o Coordinating filling and withdrawal schedules, and implementing vapor balancing between tanks, (a process whereby vapor displaced during filling activities is transferred to the vapor space of the tank being emptied or to other containment in preparation for vapor recovery); o Using white or other color paints with low heat absorption properties on exteriors of storage tanks for lighter distillate such as gasoline, ethanol, and methanol to reduce heat absorption; • Where vapor emissions contribute or result in ambient air	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			quality levels in excess of health-based standards, installation of secondary emissions controls, such as vapor condensing and recovery units, catalytic oxidizers, vapor combustion units, or gas adsorption media.	
	Air Pollution (2) Exhaust gas emissions produced by the combustion or other hydrocarbon fuels in turbines compressors, pumps and other engines for power generation	H	Harvestfield shall ensure that: • Emissions related to the operation of power sources shall be minimized through the adoption of a combined strategy which includes a reduction in energy demand, use of cleaner fuels, and application of emissions controls where required	L
	Processing wastewater to include storm water which may contain anti-fouling agents	H	Harvestfield shall ensure: • Use of heat recovery methods (also energy efficiency improvements) or other cooling methods to reduce the temperature of heated water prior to discharge to ensure the discharge water temperature does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone that takes into account	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			ambient water quality, receiving water use, assimilative capacity , etc.; • Minimizing use of antifouling and corrosion-inhibiting chemicals through proper selection of depth for placement of water intake and use of screens; selection of the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential; and dosing according to local regulatory requirements and manufacturer recommendations; and • Where liquids are handled, segregate contaminated and non-contaminated stormwater, implement spill control plans, and route stormwater from process areas into the wastewater treatment unit	
	Noise and vibration nuisance from processing equipment like compressors, pumps, turbines, electric motors.	H	• Selecting equipment with lower sound power levels • Installing silencers for fans • Installing suitable mufflers on engine exhausts and compressor components • Installing acoustic enclosures for equipment casing radiating	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			noise • Improving the acoustic performance of constructed buildings, apply sound insulation • Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m^2 in order to minimize the transmission of sound through the barriers. • Barriers shall be located as close to the source or to the receptor location to be effective • Installing vibration isolation for mechanical equipment • Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas • Encourage the use PPEs	
	Poor disposal of wastes generated during operation and maintenance	H	Harvestfield shall ensure: • Toilets are created at the site. • Site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment • Minimum waste are generated • Reuse waste materials wherever possible and use designated • Nonhazardous wastes are segregated, stored and disposed through an approved state waste collector	
	Threat from major accidents related to the fires and explosions at the facility and potential accidental releases of raw materials or finished products during their transport outside of the processing facility.	H	Harvestfield shall ensure: • Limiting the inventory that may be released by isolation of the process operations in the facility from large storage inventories; • Avoiding potential sources of ignition (e.g., by configuring the layout of piping to avoid spills over high temperature piping, equipment, and / or rotating machines); • Controlling the potential effect of fires or explosions by segregation of process, storage, utility, and safe areas by	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			designing, constructing, and operating them according to international standards for the prevention and control of fire and explosion hazards, including provisions for distances between tanks in the facility; • Limiting the areas that may be potentially affected by accidental releases by: ○ Defining fire zones and equipping them with a drainage system to collect and convey accidental releases of flammable liquids to a safe containment area including secondary containment of storage tanks; ○ Installing fire / blast partition walls in areas where appropriate separation distances cannot be achieved.	
	Air emission during maintenance/servicing of production equipment and ancillaries	M	Harvestfield shall ensure • Regular maintenance or servicing of production equipment as at when due • Prompt attention shall be given to any faulty production equipment • Use of original part to replace the faulty ones	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• Experts and professional must always be used to handle any repairs of production equipment and ancillaries • Harvestfield shall treat and dispose all waste oil and lubricants in accordance with regulatory requirements • and best practice using approved contractors • Harvestfield shall ensure that none of these wastes are disposed into any water body or on land	
	The threat of Naturally Occuring Radioactive Material (NORM) to the environment (Soil, water and air)	H	Harvestfield shall ensure: • Regular maintenance or servicing of production equipment as at when due; • Regular NORM monitoring programs to detect materials and equipment with NORM; • a surface contamination survey in a workshop to confirm that NORM contamination controls are working; • sampling and analysis of waste streams to confirm that they remain within regulatory limits; • materials used in NORM control procedures, such as gloves, plastic sheeting, disposable coveralls etc. if an area,	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			materials or equipment is affected by NORM.	
	Road and traffic accidents as a result of transportation activities during facility operation	H	Harvestfield shall ensure: • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, carry out job hazard analysis • ensure that all traffic rules are obeyed by the drivers	L

Table 6.4: Mitigation Measures of the Proposed Project Activities – Decommissioning

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
Demolition and Evacuation	Interference with road transportation	M	• Harvestfield shall monitor the no of trucks per day to know if there is need to create other accessible roads • Harvestfield shall develop a transport management plan specifying routes, speeds, times of travel and key roads/waterway in terms of local services; • Consideration shall be given to avoid reliance on public transport and contractors shall be required to use private vehicles	L
	Noise and vibration nuisance	M	Harvestfield shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of vehicles and generators; • generators and vehicles are switched off when not in use; • soundproof electric power generators are engaged • PPEs are used	L
	Impairment of air quality	H	Harvestfield shall ensure: • Engine to comply with international standards for exhaust gases; Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • that water shall be sprayed on construction sites to reduce	L

			dust levels especially during dry season.	
	Contamination of surface and Groundwater & soil	M	Harvestfield shall ensure: • Soil disturbance shall be kept to minimum required for operation and safety • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface/ groundwater • Follow FMEnv guidelines on waste management • Cleanup in compliance with relevant national and International guidelines, involving the removal of the waste, etc. • Restore the to a condition in no way inferior to the condition prior to the commencement of work.	L
	Solid waste generation and impact on disposal facility	H	• Harvestfield shall treat and dispose all wastes in accordance with regulatory requirements and best practice using approved contractors • Harvestfield shall ensure that none of these wastes are disposed into any water body or on land • follow safety measures while disposing wastes • Harvestfield shall keep all waste consignment, treatment and disposal records for regulatory verification • Proper disposal of solid waste from labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water to the environment • All other wastes generated including environmentally deleterious materials generated by construction activities will	L

			be disposed offsite in an appropriate, legal, and safe manner. • There is minimum generation of waste • Unsuitable excavated materials shall be systematically carried away from areas prone to erosion; • Reuse waste materials wherever possible • Wastes shall be segregated, stored and disposed by an accredited state waste collector	
	Loss of job	H	Harvestfield shall • Counsel worker who losses job. • Give enough notice • Assist staff that are likely to loss job in skill acquisition • Assist in setting small scale business	L
	Injury / fatalities in workforce /communities	H	Harvestfield shall • Ensure Safety awareness training for workforce • Emergency response procedures shall be put in place and enforced • ensure use of PPE • provide first aid and clinic on site	L
	Kidnapping of workers and visitors on site	H	• Harvestfield shall ensure that both contractor and Harvestfield personnel develops a high level of security consciousness both within and outside the work area • Daily security reports shall be reviewed by the Harvestfield Project Manager • Special security force shall be established and deployed for the project. This shall include deploying some of Harvestfield police to strengthen security in the area • Harvestfield shall ensure that a liaison to foster partnership	M

			with the community so as to guarantee security for the project is established and sustained • In order to beef up security for the project, Harvestfield shall support government authorities by providing assistance with equipment e.g. patrol vehicles, to ensure improved security	
	Third Party Agitation due to Employment Issues and Loss of Benefits as Host Communities.	M	• Assist staff that are likely to loss job in skill acquisition • Assist in setting up small scale business	L

6.3 Summary of Residual Impacts after Mitigation

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

Overall, on balance, with the provision of the proposed mitigation measures as outlined in Tables 6.1 to 6.3, the positive impacts of the scheme will considerably outweigh the negative impacts. The public as a whole will benefit from the completion of the project. Once the mitigation measures outlined are implemented, the residual impact of construction and operation on the different elements identified will not be significant.

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

CHAPTER SEVEN

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

7.1 Background Information

Harvestfield Refineries has established and will continually maintain a comprehensive Environmental and Social Management Plan (ESMP) to fulfil its regulatory compliance requirements to FMEnv and to achieve its corporate health, safety and environment (HSE) policy objectives.

This ESMP, developed in line with the framework provided by FMEnv, is a component of the project's overall Environment Management System (EMS) which is the programme used to ensure environmental, social, and health performance. The ESMP provides the procedures and processes that will be incorporated into Harvestfield's activities to check and continuously monitor effectiveness of the recommended mitigation and enhancement measures. With respect to the significant impacts identified by the ESIA, the ESMP identifies the linkage between each significant impact, relevant mitigation measures and monitoring approach.

7.2 Objectives of the ESMP

The objectives of the ESMP are to:

- ensure compliance with regulatory requirements and the company policy;
- achieve, enhance and demonstrate sound environmental performance built around the principle of continuous improvement;
- integrate environment fully into the business;
- rationalise and streamline existing environmental activities to add value in efficiency and effectiveness;
- encourage and achieve the highest performance and response from individual employees and contractors;
- provide standards for overall planning, operation, audit and review;
- enable management to establish environmental priorities;

- ensure early consultation is held with communities and regulating authorities to ensure hitch free operations;
- establish a structure that will ensure compliance by Harvestfield and its Contractors with the ESMP.

7.3 Features of the ESMP

In order to accomplish its objectives, the ESMP considered each environmental, social and health impact of the project as well as the parameters for their monitoring. The ESMP translates recommended mitigation and monitoring measures into specific actions that will be carried out by Harvestfield. For the development of this ESMP, Harvestfield recognised that sound environmental management of the proposed project can only be guaranteed through the integration of the provisions of the plan as an integral part of business quality management. To this end Harvestfield Refineries Limited shall put in place measures to enforce compliance by the project team on a daily basis throughout the duration of the project. It outlines the actions necessary to attain this goal, and describes the means, time frames, and designation of responsibility required for compliance and conformance.

The Harvestfield Refineries ESMP:

- identifies and discusses the management and implementation of commitments to stakeholders, as identified in the report;
- discusses how to implement the mitigating/amelioration measures, as identified in the report;
- designed and implement an appropriate post-ESIA monitoring;
- identified the action parties and provide time frame for implementation of issues identified
- is accompanied with fiscal plan for implementation of mitigating measures and monitoring; and
- puts in place a systematic procedure of obtaining all necessary regulatory approvals/permits for all the aspects of the project

7.4 Management Commitments and Responsibility

The Management's commitment and responsibility are detailed in the company's Health, Safety and Environmental (HSE) policy. The company operates in strict compliance with all the provisions of this HSE policy which specifies the need for adherence to national standards and guidelines by every member of staff and contractors. The HSE policy of Harvestfield states that projects are planned and executed in a manner that achieves the following:

- preserves the health, safety and security of its employees, contractors, and all members of the public who may be affected by its operations;
- minimizes the impact of its operations on the environment; and
- be sensitive to the needs and concerns of Harvestfield host communities

The primary vehicles through which Harvestfield shall meet the commitments in the HSE Policy are a comprehensive Health, Safety and Environment Management System (HSE-MS) and the associated planning documents which include the following which are also specific to the ESMP:

- HSE Management Plan (Safety Plan)
- Waste Management Plan;
- Security Plan;
- Labour Plan (including Job Rules);
- Community Relations Plan;
- Influx Management Plan;
- Community Development Plan; and
- Transportation and Journey Management Plan.

7.4.1 Organisation Structure

The organizational structure of Harvestfield Agrohao Industries Ltd contains flow of authority, responsibilities and interrelationship of those who ensure that operations at all base stations nation-wide run smoothly.

In Harvestfield Agrohao Industries Ltd, the Managing Director/CEO is responsible for compliance with the Environmental Regulations while the HSE manager is responsible for the implementation of the Environmental Management Systems & Plans, the maintenance of environmental and social records, internal reviews, and preparation of annual environmental audit reports.

Harvestfield Agrohao Industries Ltd has an Environmental and Safety Unit that oversees the environmental issues of the site. An HSE manager heads the unit.The Managing Director provides resources for Environmental Management and running of the Ltd. The resources include; human, financial, material, technology and specialized skills.

The HSE manager works directly with the Head of manufacturing whose duty is to ensure QA/QC and to supervise the laboratory activities. He is also involved in the formulation and packaging. (**Figure 7.1**).

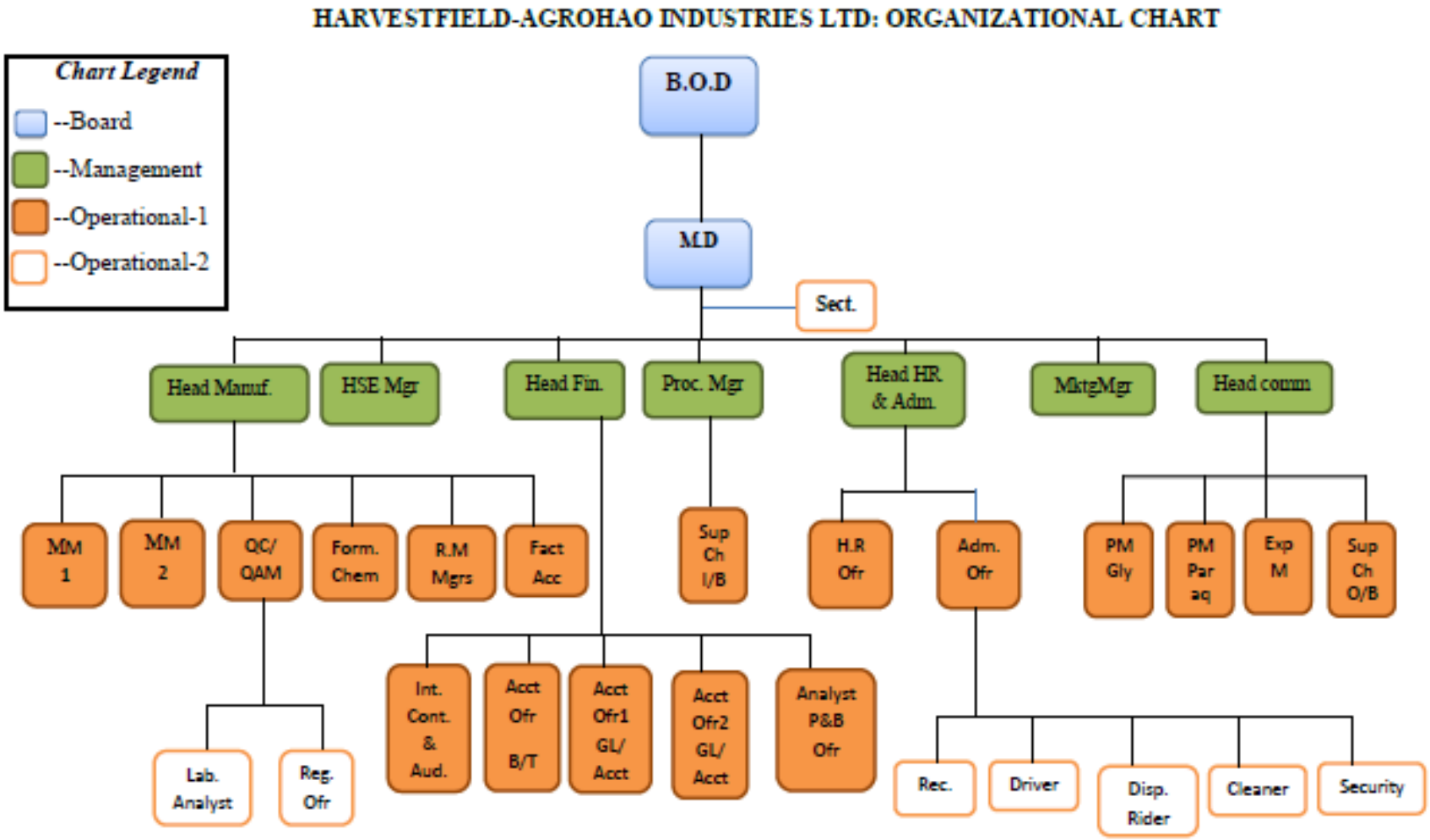

Figure 7.1: Harvestfield Organizational Chart

7.4.2 Contractor Management Plan

Harvestfield will engage contractors to carry out the various project activities. The contractors are responsible for performing all work in compliance with relevant national and international HSE legislation and regulations, and with other requirements to which Harvestfield subscribes; and in conformance with Harvestfield's HSE MS requirements; and in accordance with Harvestfield's technical and quality specifications.

Harvestfield will provide specifications for environmental compliance and performance (through this ESIA and ESMP and the associated plans) and, as a contractual requirement, the Contractor must develop and provide to Harvestfield its own specific management plans, incorporating:

- Health, Safety and Environment Policy Statements, Programs, and Management Systems;
- Health, Safety, and Environment Organization;
- Health, Safety, and Environment Responsibilities;
- HSE Procedures;
- Employee HSE Training Programs;
- Waste Management Plans;
- Emergency Response/Evacuation Plans;
- Transportation Safety Management System;
- Hazardous Materials Management Program;
- Industrial Hygiene and Medical Protection Plans.

The Contractors must also provide documentation detailing their plans for implementing the measures required in the ESIA and this ESMP; Local Content; Logistics; Security; and Community Relations. The Contractor's management plans must conform to the requirements of Harvestfield's overarching plans. Contractor's plans will be reviewed and approved by Harvestfield and incorporated into, and form part of, Harvestfield's overall ESMP. Contractors will be required to self-monitor against their plan and the contractor's compliance with the plan will be routinely

monitored by Harvestfield directly or by third-parties and in conjunction with environmental regulators. Contractors will be required to submit regular reports of monitoring activities and Harvestfield will review these on a regular basis.

As a contractual requirement, the Contractor will provide sufficient resources to manage HSE aspects of the work to be performed. This includes providing resources to ensure sub-contractor compliance and a process for emergency stop-work orders in response to monitoring triggers.

7.5 Implementation

7.5.1 Training

Harvestfield shall identify, plan, monitor, and record training needs for personnel whose work may have a significant adverse impact on the environment or social conditions. It recognizes that it is important that employees at each relevant function and level are aware of Harvestfield's environmental, social, and health policy; potential impacts of their activities; roles and responsibilities in achieving conformance with the policy and procedures.

This will be achieved through a formal training process. Employee training will include awareness of and competency with respect to:

- environmental and social impacts that could potentially arise from their activities;
- necessity of conforming to the requirements of the ESIA and ESMP, in order to avoid or reduce those impacts; and
- roles and responsibilities to achieve that conformity, including with regard to change management and emergency response

The HSE Manager is responsible for coordinating the training, maintaining employee-training records, and ensuring that these are monitored and reviewed on a regular basis. The HSE Manager will also periodically verify that staff are performing competently through discussion and observation. Employees responsible for

performing site inspections shall receive training drawing on external resources as necessary.

Training will be coordinated by the HSE Manager and/or Community Relations Manager prior to the beginning of field activities. Upon completion of training and once deemed competent in the requirements, staff will be allowed to train other people.

Similarly, Harvestfield shall require that each of the Contractors institute training for its personnel. Each Contractor is responsible for site HSE awareness training for personnel working on the job sites. The Contractor is also responsible for identification of any additional training requirements to maintain required competency levels.

The Contractor training program will be subject to approval by Harvestfield and it will be audited to ensure that:

- training programs are adequate;
- all personnel requiring training have been trained; and
- Contractor has periodically verified that personnel perform competently after training

7.5.2 Documentation

Harvestfield will control HSE documentation, including plans (e.g., the ESMP); associated procedures; and checklists, forms, and reports, through a formal company procedure. The document control procedure also describes the processes that Harvestfield and the Contractor will employ for official communication of both hardcopy and electronic (through the intranet) document deliverables. In addition, it describes the requirement for electronic filing and posting and for assignment of a document tracking and control number (including revision codes).

The Harvestfield Document Control Officer is responsible for maintaining a master listing of applicable documents, including HSE documents, and making sure that this list is communicated to the appropriate parties. The Harvestfield HSE Manager is responsible for providing notice to the affected parties of changes or revisions to documents, for issuing revised copies and for checking that the information is communicated within that party's organization appropriately.

The Contractor shall be required to develop a system for maintaining and controlling its own HSE documentation and describe these systems in their respective HSE Plans and Site-Specific HSE Plans.

7.5.3 Operational Control Procedures

Each potentially significant impact identified in this ESMP shall have an operational control associated with it that specifies appropriate procedures, work instructions, best management practices, roles, responsibilities, authorities, monitoring, measurement, and record keeping for avoiding or reducing impacts. Operational controls are monitored for compliance and effectiveness on a regular basis through a monitoring and auditing procedure described in the ESMP.

Operating control procedures shall be reviewed and, where appropriate, amended to include instructions for planning and minimizing HSE impacts, or to at least reference relevant documents that address HSE impact avoidance and mitigation. To be comprehensive, suitable, adequate, and effective, the ESMP shall ensure that operational controls for avoiding and minimizing impacts are properly maintained for the project's life-cycle.

7.5.4 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. 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 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.

7.5.5 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.

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 Harvestfield contractor. Monitoring by the Harvestfield 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 Harvestfield contractor; therefore, Harvestfield will pay attention to applying appropriate contractor control, mitigation and monitoring activities for contractors. Harvestfield expects contractors to have HSE systems in place consistent with Ogun State Government guidelines. Personnel working in the area shall work in accordance with job specifications developed by Harvestfield. 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 consider 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 Harvestfield. This data will be provided in a timely manner such that facility-specific training can be given to personnel prior to start-up.

7.5.6 Worker Safety and Health Plan

Operations within the work site shall be subject to the OHSA 18001 (Occupational Health and Safety) Standard and the World Bank Group's Environmental, Health, and Safety Guidelines. All Harvestfield 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 to 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 plant (fire hazard) areas.

Integrity of Workplace Structures

- All plant surfaces, structures and installations would be design to enable easy cleaning and repair, and limit the accumulation of hazardous compounds;
- Plant buildings will be structurally safe, provide appropriate protection against climate change and have acceptable light and noise conditions;
- Plant 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
- Plant heavy oscillating, rotating equipment would be in dedicated buildings or structurally
- isolated sections within the plant site.

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

- Harvestfield shall equip the plant 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 Harvestfield 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 plant and office areas would, during service hours, be maintained at a level appropriate to the facility;
- Fall prevention and protection measures would be implemented whenever a worker is exposed to the hazard of falling from height.

7.5.7 Emergency Response Plan (ERP)

Harvestfield has developed plans and procedures to identify the potential for and response to environmental accidents and health and safety emergency situations and for preventing and mitigating potentially adverse environmental and social impacts that may be associated with them.

The objective of the ERP is to ensure that any emergency affecting the place of operational activities is dealt with in an efficient and professional manner so that the safety of personnel is not compromised in any way, the environmental pollution risks are prevented or minimized and that all other losses which may arise from emergencies are prevented or minimized. The ERP addresses emergency response procedures for the Contractor, Subcontractors and all personnel working for the Project.

It is the responsibility of management to familiarize itself with the emergency procedures, which apply to the project. The ERP will include as a minimum the following:

- Emergency Communication Procedures: These include a description of the communication procedure and command hierarchy to define who is responsible for directing the activities of the various respondents, and the means of maintaining communication between the facility operators, Emergency Response Contractor, Company and Local Emergency Services.
- Identification of potential scenarios (fire, severe injury, road traffic accident, Incident, spills etc.) and action plans.
- Site Specific ERP Orientation: Training for site personnel and visitors.
- Emergency Events Log: The Contractor is required to log all emergency events and report them to the Company and appropriate regulatory authorities.
- Emergency Contact List: listing of Contractor personnel, Emergency Response Contractor(s), and Emergency Services to contact with primary and secondary contact information.

- Emergency Equipment List and Alarms.
- Emergency Response Team: description of the roles of Contractor and Subcontractor field and support personnel during an emergency.
- Emergency Support Services: Description of emergency conditions requiring procedures for implementing additional help from Company and Contractor.

Work shall be conducted in accordance with ERP requirements. Field HSE Manager shall ascertain the effectiveness of Emergency Response plan by conducting audits and organizing exercises/drills to the work force regularly. All personnel involved in the emergency response group shall also be familiarized with their roles and responsibilities by regular exercises/drills.

Field HSE Manager will issue the performance report of each exercise/drill conducted at site to the Project Management team (PMT) containing the information on recommendations to be taken for improvement. Following are potential foreseen types of emergency expected but not limited to:

- Fire and explosion
- Oil, Chemical spills and release
- Medical Evacuation (MEDEVAC)
- Vehicle accidents

7.5.9 Fires

If you see a fire or smoke, take the following steps:

- Activate the alarm to begin evacuating the building.
- If you are not in immediate danger, report the fire to the Plant Manager. Provide information on the approximate location of the fire, the size and type of fire.
- If you are formally trained in fire fighting techniques or if you are not in imminent danger, you may attempt to fight a fire that is small and controllable. Do not place yourself or others in unnecessary danger.
- Exit the building by following posted evacuation routes. Proceed to the designated assembly location.

- Employees must receive permission from their supervisor or the emergency response coordinator before re-entering the building.

Fire & Gas detection system with Fire Alarm panel in the Fire Control room will be used for quick emergency response. Emergency Sirens and Public Address systems are installed to alert all the Refinery personnel during major Emergency. Mobile firefighting equipment for the Plant complex shall be provided. The various mobile fire appliances to be used are: Portable fire extinguishers, Dry Chemical Powder (DCP) and Carbon dioxide (CO_2) will be provided. Traveling distance of 15m. At least one fire extinguisher shall be provided for every 250 m^2 of hazardous operating area. Higher Capacity DCP fire extinguishers will be provided for every 750 m^2 of hazardous operating area. CO_2 extinguishers will be located in sub-stations, Office buildings and Control rooms. Also Hose Stations with fire hoses and branch pipes will be provided in the plant and non-plant buildings.

7.5.10 Emergency Incident Reporting

In a situation of a fire outbreak or other emergency that poses immediate danger to people or property, employee should sound the fire alarm if they can do so safely before evacuating. Follow emergency evacuation procedures. Employee should calmly notify others, and respond to the emergency as appropriate. Procedures for responding to specific types of emergencies are described below. Do not attempt to handle emergency duties – e.g., firefighting – for which you do not have training. The following numbers should be posted near telephones and in other conspicuous locations:

- Outside emergency services (police, fire department, ambulance service)
- Hospital
- Emergency Response Coordinator

7.5.11 Community Engagement Policy

Introduction

Community is made up of the people who live, work, visit or invest in the Makun Community where the proposed project will be situated. Community Engagement is the process through which the community are informed about and/or invited to contribute, through consultation or involvement, to proposals or policy changes relating to Makun community, events, strategic plans, issues and projects.

Purpose

The Harvestfield Engagement Plan will ensure that:

- Harvestfield has the opportunity to consider the input of a wide range of community members before making decisions;
- Community members are given the opportunity to contribute to the planning and development process.

The plan will:

- Establish a standard process for community engagement;
- Ensure that the process is implemented by Harvestfield staff and some key members of the community;
- Ensure that inclusive and efficient consultation is undertaken at all times;
- Ensure that the community is kept informed of decisions emanating from community engagement.

The Plan contains three key strategies:

1. Inform
2. Consult
3. Involve

Each strategy has a specific goal, a commitment to the community and a set of methodologies.

Scope

This Community Engagement Plan relates to many activities undertaken by the Harvestfield which will have effect on the community with the exception of notifications in relation to statutory notifications. Where legislative requirements exist which address specific information / consultation processes, the legislative requirements take precedence.

Benefits

There are a number of benefits from having a Community Engagement Plan, including:

- Commits Harvestfield to being open and accountable;
- Assists Harvestfield to plan services that better meet community needs;
- Enables the Harvestfield to prioritise services and make better use of resources
- Allows a broader range of views to be expressed and more information to be assembled prior to making decisions;
- Sees the Harvestfield and the community working together to achieve balanced decisions;
- Offers opportunities for the community to contribute to and influence outcomes which directly affect their lives;
- Ensures an open and familiar process which becomes easier for community members to participate in.

Community Engagement Strategy 1: Inform

Information dissemination is the primary form of community engagement. In order to be able to actively engage in their community and in Harvestfield's decision making processes, the community requires information in a variety of ways to reach all sections of the community.

Goal

To provide the community with appropriate information regarding Harvestfield services, events, strategic plans, issues and projects.

Commitment to the Community

We will keep you informed, ensuring that information is easy to access, relevant to the issue and easy to understand using clear, jargon-free language.

Methodology: How

By making up-to-date information available on the Harvestfield's processes, meeting agendas / minutes, services, projects and on how residents may feedback any issues, concerns and suggestions for service improvements and ensuring that all information is in a form that is accessible to all groups in the Community ie. people with disabilities, people with computer literacy difficulties, young people, the aged and, people from diverse cultural backgrounds.

Methods can include;

- **Advertising - Newspapers** - both local and state. Other publications can be considered dependent on the target group.
- **Advertising - Radio** - both local and regional.
- **Public Meetings / Forums** - at various locations / localities, as appropriate.

When

Ongoing, as Harvestfield events, strategic plans, issues and projects are scheduled.

Who

Entire community, noting that community members need to be aware of the methods that are in use.

Community Engagement Strategy 2: Consult

Consultation takes place when feedback is required in relation to:

- *The development of new policies, strategies and plans;*
- *The review and evaluation of existing policies, strategies and plans;*
- *The planning and development of new services and infrastructure;*
- *The review and evaluation of existing services and infrastructure;*

- *Issues which impact on or are of concern to the community, including:*

Broad community issues ie. Community Safety; Specific community issues ie. Seniors and Youth; and Area issues ie. traffic management and land use changes

Goal

To capture community input on strategic plans, directions, issues, priorities and projects.

Commitment to the Community

We will listen to you, consider your ideas and keep you informed about what input was received, an analysis of this input and the final decision/s reached.

Methodology: How

Consultation mechanisms will be chosen that take account of the primary stakeholders and are accessible to the community. Community consultation techniques will vary depending on who is being consulted and the nature and complexity of the issue. Available resources will also determine the type of techniques that can be utilised ie. the timeframe, funds and staff available.

A range of consultation techniques will be utilised to ensure greater participation levels. These will include;

- **Consultative Workshops:** open to the community with the aim of briefing interested residents on specific projects and getting their feedback.
- **Focus Groups:** open by invitation to specific groups with relevant experience of the issue at hand.
- **Surveys/Questionnaires:** a series of relevant questions regarding a subject, with the collated replies available for consideration and distribution. These may be conducted via mail, email / web or in person, for example venues could include but are not limited to homes / schools / businesses / community meetings to ensure the inclusion of community members who may not normally be able to participate in community engagement.

When

Harvestfield will ensure that the community is consulted on issues which impact on or are of concern to the community in a timely manner to allow adequate community comment to occur and be analysed in order to inform decision making processes.

Who

All community members who are identified as being directly impacted will be consulted, with the whole community being informed. Stakeholders will vary according to the issue, but could include residents, ratepayers, businesses, volunteers, those who visit or work in the municipality, other service providers/agencies, community groups, other levels of government, peak bodies, etc. It could also include particular groups within the community, ie. older people, families, children, youth, different ethnic groups, business people, people with a disability, etc.

7.6 Checking and Corrective Action

The objective of the inspection and monitoring activities described in this section is to verify compliance with the ESMP. The inspection and monitoring approach will also be reflected in Contractor's HSE procedures. Contractors will be responsible for implementing Harvestfield's environmental and social commitments in the field on a daily basis. Auditing of the monitoring and inspection activities by the Contractor and by Harvestfield provide the mechanism by which Harvestfield ensures that it remains compliant with regulatory commitments as well as its own HSE standards and policies.

The *inspection* activities described in this ESMP refer to qualitative monitoring, e.g., visual inspections. The *monitoring* activities described in this ESMP refer to empirical monitoring (e.g., measurements).

7.6.1 Inspection

Inspections shall be conducted by Staff, Contractor's HSE department on a daily basis. The results of the inspection and monitoring activities shall be made available to Harvestfield on a weekly basis or more frequently if requested by the Harvestfield Head HSE.

7.6.2 Monitoring

Monitoring will be conducted to ensure compliance with regulatory requirements as well as to evaluate the effectiveness of operational controls and other measures intended to mitigate potential impacts. With respect to the significant impacts identified in the ESIA, Harvestfield has developed a program to monitor the effectiveness of the mitigation measures. The program describes what effect is to be measured and the frequency.

In conjunction with monitoring of the effectiveness of specific mitigation measures, Harvestfield has developed a program to monitor for compliance with relevant regulatory standards. This program also ensures that staffs are meeting contractual obligations with respect to work practices and design specifications. Monitoring is carried out by Harvestfield HSE department and/or by Supervisors and Contractors pursuant to their contractual obligations. The parameters to be measured during the Harvestfield Aflasafe Bio-control Plant activities along with the frequency of monitoring are provided in **Tables 7.1 – 7.5** below.

Table 7.1: Environmental and Social Management Plan (ESMP) of the Aflasafe Bio-control Plant – Pre-Construction Phase

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation			
Land Take for Aflasafe Bio-control Plant	Loss of land, Change in land use and Legal issue	M	This impact, although negative is reversible, the probability of the impact arising is also low considering the fact that Harvestfield already has an allocation, where the project will be situated. The percentage of environmental significance is less than 25%, therefore the impact significance is described as low. However, Harvestfield shall ensure that: ✓ continuous consultation and engagement with host communities and other stakeholders be maintained to forestall unrest in line with the company's grievance mechanism. ✓ that proper land	**L**	Stakeholder engagement document	Harvestfield	During Pre-Construction

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**			
			acquisition procedure is followed and payment of all land dues to government and any concerned stakeholder ✓ that all necessary document and permit relating to the acquired land are obtained from the right quarters.				
Mobilisation (transport) to site (equipment, personnel and construction modules)	Road and traffic accidents	H	Harvestfield shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic, and the need for extra precautions through public enlightenment • compliance with journey management policy • Vehicles are pre-mobbed and pre-	L	Site inspection report Compliance monitoring report	Harvestfield	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation			
			mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, carry out job hazard analysis • minimize movement at the peak hours of the day • ensure that all traffic rules are obeyed by the drivers • Large and slow-moving vehicles shall be scheduled during off peak periods • Involve Harvestfield security in traffic control in traffic management • Defensive driving course for Harvestfield and contractor drivers • First aid training of				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation			
			workforce and provision of first aid boxes in operational vehicles • Visible warning signs on roads and vehicles • Speed breakers at sections traversing communities				
	Noise nuisance	M	Harvestfield shall ensure: • regular maintenance of vehicles • Vehicles are turned off when not in use • Vehicles are fitted with effective silencers.	L	Site inspection report Compliance monitoring report	Harvestfield	During Pre-Construction
	Impairment of air quality	M	Harvestfield shall ensure: • Engine to comply with international standards for exhaust gases; Maintenance of engines	L	Site inspection report	Harvestfield	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation			
			and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • that water shall be sprayed on construction sites to reduce dust levels especially during dry season.		Compliance monitoring report		
	Loss of biodiversity	M	▪ Strictly regulating heavy equipment traffic ▪ Restricting the number of traffic lanes and limiting the movement of the machinery to the work site and to the marked access way ▪ Implement good housekeeping practice on-site. ▪ Storing and handling of hazardous waste in accordance to	L	Site inspection report Compliance monitoring report	Harvestfield	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation			
			approved WMP ▪ Selecting vehicles suited for erodible soil ▪ Limiting activities in erodible soil				
Energy consumption (provision of energy for pre-construction activities)	Impairment of air quality	M	Harvestfield shall ensure that: • there is regular maintenance of the generators; • generators are switched off when not in use • dust control and dust recovery machinery are used	L	Site inspection report Compliance monitoring report	Harvestfield	During Pre-Construction
	Noise and vibration nuisance	M	Harvestfield shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of the generators; • noise barrier are erected • generators are switched off	L	Site inspection report Compliance monitoring report	Harvestfield	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation			
			when not in use; • soundproof electric power generators are engaged				
	Contamination of soil	M	Harvestfield shall ensure: • Soil disturbance shall be kept to minimum required for operation and safety • Oil spill containment shall be provided to prevent oil spill from getting to the soil. • Implement good housekeeping practice on-site. • Storing and handling of hazardous waste in accordance to approved WMP.	L	Site inspection report	Harvestfield	During Pre-Construction
Site Preparation – clearing, excavation and	Acceleration of erosion	M	Harvestfield shall: • Stabilize soil within the well location and campsite mechanically using compactors to	L	Site inspection report	Harvestfield	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation			
landscaping			reduce erosion potential • Mechanically stabilize the soil in order to reduce potential for erosion • Avoid excavation and burial in steeply sloped ground and avoid creation of great breaks • Provide for the placement of siltation ponds in areas subject to heavy erosion • Select vehicles suited for erodible soil • Limiting activities in erodible soil				
	Alteration of local topography	M	• Harvestfield shall ensure: • re-grading of the sites, then replacing the layer of top soil that was	L	Compliance monitoring report	Harvestfield	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation			
			previously put. • restoring the operational site by restoring the original profile of the topography and the soil • strictly regulating heavy equipment traffic • restricting the number of traffic lanes and limiting the movement of the machinery to the work site and to the marked access way				
	Alteration of soil profile	M	Harvestfield shall: • ensure that stripping and excavation of topsoil is strictly limited to areas acquired for the activities. • ensure proper re-vegetation of all other areas with indigenous species from adjoining forest after activities	L	Compliance monitoring report	Harvestfield	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation			
			• stabilize soil within the well location and campsite mechanically using compactors to reduce erosion potential				
	Blockage of drainage pattern	M	Harvestfield shall ensure that: • strict environmental policy shall be ensured • Regular cleaning of the drainage shall be ensured • The drainage network shall be covered	L	Site inspection report Compliance monitoring report	Harvestfield	During Pre-Construction
	Contamination of soil	M	Harvestfield shall: • Ensure that soil disturbance shall be kept to minimum required for operation and safety • Ensure that oil spill containment are	L			

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation			
			provided to reduce oil spill from getting to the soil • Implement good housekeeping practice on-site. • Store and handle hazardous waste in accordance to approved WMP. • Place filtration berms and sediment barriers. • Use methods that minimizes perturbation to aquatic environment. • Avoid spills prohibiting refueling near waterway				
	Impairment of air quality	M	Harvestfield shall ensure that: • only pre-mobbed equipment are used; • all equipment are controlled; • equipment engines are	L	Site inspection report	Harvestfield	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation			
			turned off when not in use • Harvestfield shall ensure that all construction equipment shall be in proper operating condition and fitted with factory standard silencing features if appropriate • Harvestfield shall provide and enforce the use of PPE (e.g. nose masks and ear muffs) • Harvestfield shall construct sound proofing walls around stationary power generating sources • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation			
			technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance; • Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors; • Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation			
			designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust;				
	Noise and vibration nuisance	M	Harvestfield shall ensure that: • equipment are fitted with effective silencers; • there shall be regular maintenance of equipment; • equipment are switched off when not in use; • Vibration containment be made for equipment which are likely to cause vibration • noise barriers are erected	L	Stakeholder engagement document	Harvestfield	During Pre-Construction
	Work site accidents	H	Harvestfield shall ensure that: • workers and visitors are properly kitted (use of appropriate PPEs)	L	Site inspection/ stakeholder	Harvestfield	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation			
			• use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site		engagement report Inventory of approved journey management forms		
	Habitat Alteration	H	Harvestfield shall: ▪ Use methods that minimize perturbation to aquatic environment. ▪ Avoid spills prohibiting refueling near waterway ▪ Minimize destruction or modification of the vegetation cover by restoring vegetation at the end of the work	L	Site inspection report Compliance monitoring report	Harvestfield	During Pre-Construction

Table 7.2: Environmental and Social Management Plan (ESMP) of the Aflasafe Bio-control Plant – Construction Phase

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Transport activities during construction	Road traffic accidents	H	To prevent road accident, Harvestfield shall ensure: • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, carry out job hazard analysis • ensure that all traffic rules are obeyed by the drivers • Speed breakers at sections traversing	L	Site inspection/ stakeholder engagement report Inventory of approved journey management forms	Harvestfield/ Ogun State Ministry of Environment/FMEnv	During Construction

			communities				
	Noise nuisance	M	Harvestfield shall ensure: • regular maintenance of vehicles • Vehicles are turned off when not in use • Vehicles are fitted with effective silencers.	L	Site inspection report Compliance monitoring report	Harvestfield/Ogun State Ministry of Environment/FMEnv	During Construction
	Impairment of air quality – emission from trucks	M	Harvestfield shall ensure: • Engine to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • Use of the cleanest fuel economically available	L	Site inspection report Compliance monitoring report	Harvestfield/Ogun State Ministry of Environment/FMEnv	During Construction

			shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance; • Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors; • Use of water spray systems to reduce the formation of fugitive dust				

			from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust				
Excavation of land area and Casting of the plinths	Loss of vegetal cover with possible impact on biodiversity loss	H	Harvestfield shall: • Provide siltation pond in areas of heavy erosion • Place filtration berms and sediment barriers. • Use methods that minimise perturbation to aquatic environment. • Avoid spills prohibiting refuelling near waterway • Minimise destruction or modification of the	M	Site inspection report Compliance monitoring report	Harvestfield/Ogun State Ministry of Environment/FMEnv	During Construction

			vegetation cover by • Restoring vegetation at the end of the work				
	Impairment of air quality	H	Harvestfield shall ensure: • there is regular maintenance of the engines; • engines are switched off when not in use • engines to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; • that nose masks and ear muffs are worn by site workers during excavation • Use of the cleanest fuel economically available shall be adopted • Combustion technology	L	Compliance monitoring report	Harvestfield/Ogun State Ministry of Environment/FMEnv	During Construction

			and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance				
	Noise and vibration nuisance	H	Harvestfield shall ensure that: • Machine engines are fitted with effective silencers; • regular maintenance of machine/ engines are performed; • engines are switched off when not in use; • soundproof electric power generators are engaged • the use of PPEs is encouraged • vibration containment	L	Site inspection report Compliance monitoring report	Harvestfield/Ogun State Ministry of Environment/FMEnv	During Construction

			shall be made for generators and machines				
	Contamination in the event of oil spills from equipment and machinery	H	• Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface • there shall be regular maintenance of the equipment and machineries	M	Site inspection report	Harvestfield	During Construction
	Waste generation from excavated materials	M	Harvestfield shall ensure that: • all other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner. • generation of all wastes	L	Site inspection report Waste Management Policy/ tracking sheet report	Harvestfield	During Construction

			are minimize as much as practically possible • Unsuitable excavated materials shall be systematically carried away from areas prone to erosion; • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials must not be burned; • Optimize the reuse of				

			spoil and construction waste; • All the construction camps and facilities shall be dismantled and removed from the site, unless otherwise desired by the local public; • site shall be restored to a condition in no way inferior to the condition prior to the commencement of work. • safety measures while disposing wastes are followed; • introduction of foreign soil and synthetic materials is avoided; • disposal of construction and related waste				

			materials at designated and approved waste dump site; • waste management plan in road planning and contract specifications is incorporated; • there is collaboration with relevant waste management agencies to enforce appropriate sanitation and other bye laws.				
Construction of e warehouse, silos and	Burns/injuries from welding sparks	H	• Harvestfield shall ensure that workers and visitors are properly kitted • Use of experienced/competent workers • Pipe joining techniques such as welding shall meet	M	Site inspection report Daily Progress report	Harvestfield	During Construction

product Storage Facilities			international standards				
	Exposure to welding flash	H	• Harvestfield shall ensure that workers and visitors are properly kitted (appropriate PPEs are used)	L	Site inspection report Daily Progress report	Harvestfield	During Construction
	Surface water may be polluted due to increased erosion, run off from construction site, and contamination in	H	Harvestfield shall ensure that: • Soil disturbance shall be kept to minimum required for operation and safety to reduce erosion • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface • there shall be regular maintenance of the equipment and machineries • Mechanically stabilizing	M	Site inspection report Compliance monitoring report	Harvestfield	During Construction

	the event of oil spills from equipment and machinery		the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodible soil • At the completion of the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.				
	Waste	M	Harvestfield shall ensure that:	L	Site inspection	Harvestfield	During

	generation from construction activities such as metal cuttings		• toilets are created at the site. • site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment • Minimum wastes are generated • Reuse waste materials		report Waste Management Policy/ Waste tracking sheet report		Construction

			wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials shall not be burned; • safety measures are followed while disposing wastes				

Backfilling	Alteration of hydrological patterns resulting in temporary or permanent flooding, soil erosion and destruction of biodiversity	H	• Mechanically stabilizing the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodible soil • At the completion of the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.	L	Site inspection report Compliance monitoring report	Harvestfield	During Construction

	Habitat alteration	M	Harvestfield shall: • Implement good housekeeping practice on-site. • Store and handle hazardous waste in accordance to approved WMP. • Harvestfield shall ensure the use of appropriate PPEs • Harvestfield shall ensure that backfilling is followed by mechanical compaction so as to retain the original level and avoid alterations • Harvestfield shall re-vegetate the soil with indigenous grasses, sedges etc to check	L	Site inspection report Compliance monitoring report	Harvestfield	During Construction

			incidence of flooding				
	Kidnapping of workers and visitors on site	H	• Harvestfield shall ensure that both contractor and Harvestfield personnel develops a high level of security consciousness both within and outside the work area • Daily security reports shall be reviewed by the Harvestfield Project Manager • Special security force shall be established and deployed for the project. This shall include deploying some of Harvestfield police to strengthen security in the area • Harvestfield shall ensure	M	Daily/weekly security report	Harvestfield/Nigerian Police Force	During Construction

			that a liaison to foster partnership with the community so as to guarantee security for the project is established and sustained • In order to beef up security for the project, Harvestfield shall support government authorities by providing assistance with equipment e.g. patrol vehicles, to ensure improved security • Harvestfield shall ensure that safety workshops to identify, evaluate and recommend contingency plans for all security risks are regularly organized				
	Worksite	H	Harvestfield shall ensure that:	M	Site inspection	Harvestfield	During

	accidents		• workers and visitors are properly kitted (use of appropriate PPEs) • use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site		report		Construction
	Increase in communicable disease (including STDs and HIV/AIDS)	M	• Health awareness lectures shall be given to workers on the mode of transmission of STIs (including HIV/AIDS) • As much as possible provide psychological support to persons living with the HIV virus • Harvestfield shall insure immunization of workforce	L	Site inspection report	Harvestfield	During Construction

			against as appropriate • Regular spraying of work sites Provision of insecticide treated nets to field workers to reduce incidence of malaria • Awareness campaign shall be carried out to enlighten the communities /field workers on the common communicable diseases and the health implications of drug and alcohol abuse, unprotected sex, prostitution and the need to sustain cultural values • Harvestfield shall assist the activities of the state action committee on STIs/HIV/AIDS as part of				

			her stakeholders' engagement plan. • Harvestfield shall ensure site clinic is provided to take care of minor illnesses for all construction workers				
Coating	Contamination of surface water and soil by paints and coating as a result of spillage	H	• Using of engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard; • Implementing of management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through	L	Site inspection report Compliance monitoring report	Harvestfield/Ogun State Ministry of Environment/FMEnv	During Construction

			engineering measures. • Safe ventilation for storage of volatile materials shall be provided; • Access to areas containing paint substances shall be restricted and controlled; • Paints shall be stored on impervious ground under cover; the area shall be constructed as spill tray to avoid spread of accidental spills				
	Hazardous waste generation from coating operation	H	• Good housekeeping shall be instituted and maintained • hazardous wastes shall be collected, stored and disposed appropriately in	L	Site inspection report Waste Management report	Harvestfield/Ogun State Ministry of Environment/FMEnv	During Construction

	s such as metals		line with FMEnv standard at an approved disposal sites		Waste tracking records		
Installation of the modules and Construction of administrative blocks	Impairment of air quality	M	Harvestfield shall ensure: • there is regular maintenance of the engines; • engines are switched off when not in use • engines to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; • that nose masks and ear muffs are worn by site workers during excavation • Use of the cleanest fuel economically available shall be adopted • Combustion technology and	L	Site inspection report Compliance monitoring report	Harvestfield/Ogun State Ministry of Environment/FMEnv	During Construction

			pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance;				
	Noise and vibration nuisance	M	Harvestfield shall ensure that: • Machine engines are fitted with effective silencers; • regular maintenance of machine/ engines are performed; • engines are switched off when not in use; • soundproof electric power generators are engaged • the use of PPEs is encouraged • vibration containment	L	Site inspection report Compliance monitoring report	Harvestfield/Ogun State Ministry of Environment/FMEnv	During Construction

			shall be made for generators and machines				
	Waste generation from Installation and construction activities	M	Harvestfield shall ensure that: • toilets are created at the site. • site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water and	L	Waste Management Plan Compliance monitoring report	Harvestfield/Ogun State Ministry of Environment/FMEnv	During Construction

			sewage to the environment • Minimum wastes are generated • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials shall not be burned; • safety measures are followed while disposing wastes;				
	Fall from height/	H	Harvestfield shall ensure and require that contractors	L	Site inspection report	Harvestfield/Ogun State	During Construction

	Worksite accidents		implement the following fall prevention and protection measure for all workers exposed to the hazard of falling while working: • Test structures for integrity prior to undertaking work • Implement a fall protection program that includes training in climbing techniques and use of fall protection measures; inspection, maintenance, and replacement of fall protection equipment; and rescue of fall-arrested workers, among others • Provide adequate work-positioning device system for workers. • Contractors working at site		Compliance monitoring report	Ministry of Environment/FMEnv	

			must use appropriate PPE • workers and visitors are properly kitted (use of appropriate PPEs) • use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site.				
	Loss of vegetal cover with possible impact on biodiversity loss	H	Harvestfield shall: ▪ Provide siltation pond in areas of heavy erosion ▪ Place filtration berms and sediment barriers. ▪ Use methods that minimize perturbation to aquatic environment. ▪ Avoid spills prohibiting refueling near waterway	L	Site inspection report Compliance monitoring report	Harvestfield/Ogun State Ministry of Environment/FMEnv	During Construction

			Minimise destruction or modification of the vegetation cover by restoring vegetation at the end of the work				
Site Demobilisation	. Road traffic accidents	H	Harvestfield shall ensure: • enforcement of the use of PPEs • daily pep talk is carried out • job hazard analysis is carried out • compliance with journey management policy	L	Inventory of approved journey management forms	Harvestfield	Construction

Table 7.3: Environmental and Social Management Plan (ESMP) of the Aflasafe Bio-control Plant – Operation/Maintenance

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Operations and Maintenance	Air Pollution (1) Fugitive emissions from plant facilities are associated with leaks in the tubing; valves; connections; flanges; packings; open-ended lines; floating roof storage tank, pump and compressor seals	H	Harvestfield shall ensure: • Regular monitoring of fugitive emissions from valves, seals, tanks, and other infrastructure components with vapor detection equipment, and maintenance or replacement of components as needed in a prioritized manner • Maintain stable tank pressure and vapor space by: o Coordinating filling and withdrawal schedules, and implementing vapor balancing between tanks, (a process whereby vapor		Site inspection report Compliance monitoring report Site inspection report	Harvestfield /Ogun State Ministry of Environment/FMEnv	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			displaced during filling activities is transferred to the vapor space of the tank being emptied or to other containment in preparation for vapor recovery); ○ Using white or other color paints with low heat absorption properties on exteriors of storage tanks for lighter distillate such as gasoline, ethanol, and methanol to reduce heat absorption; • Where vapor emissions contribute or result in ambient air quality levels in excess of health-based				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			standards, installation of secondary emissions controls, such as vapor condensing and recovery units, catalytic oxidizers, vapor combustion units, or gas adsorption media.				
	Air Pollution (2) Exhaust gas emissions produced by the combustion or other hydrocarbon fuels in turbines compressors, pumps and other engines for power generation	H	Harvestfield shall ensure that: • Emissions related to the operation of power sources shall be minimized through the adoption of a combined strategy which includes a reduction in energy demand, use of cleaner fuels, and application of emissions controls where required	L	Site inspection report Compliance monitoring report	Harvestfield	During Operation
	Processing wastewater to	H	Harvestfield shall ensure: • Use of heat recovery methods	L	Effluent	Harvestfield /Ogun State	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	include storm water which may contain anti-fouling agents		(also energy efficiency improvements) or other cooling methods to reduce the temperature of heated water prior to discharge to ensure the discharge water temperature does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone that takes into account ambient water quality, receiving water use, assimilative capacity , etc.; • Minimizing use of antifouling and corrosion-inhibiting chemicals through proper selection of depth		report	Ministry of Environment/FMEnv	

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			for placement of water intake and use of screens; selection of the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential; and dosing according to local regulatory requirements and manufacturer recommendations; and • Where liquids are handled, segregate contaminated and non-contaminated stormwater, implement spill control plans, and route stormwater from process areas into the wastewater treatment unit				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	Noise and vibration nuisance from processing equipment like compressors, pumps, turbines, electric motors.	H	• Selecting equipment with lower sound power levels • Installing silencers for fans • Installing suitable mufflers on engine exhausts and compressor components • Installing acoustic enclosures for equipment casing radiating noise • Improving the acoustic performance of constructed buildings, apply sound insulation • Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m^2 in order to minimize the transmission of sound through the barriers.	L	Site inspection report Compliance monitoring report	Harvestfield	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			• Barriers shall be located as close to the source or to the receptor location to be effective • Installing vibration isolation for mechanical equipment • Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas • Encourage the use PPEs				
	Poor disposal of wastes generated during operation and maintenance	H	Harvestfield shall ensure: • Toilets are created at the site. • Site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from	L	Site inspection report Compliance monitoring	Harvestfield /Ogun State Ministry of Environment/FMEnv	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment • Minimum waste are generated • Reuse waste materials wherever possible and use designated • Non-hazardous wastes are segregated, stored and disposed through an approved state waste collector		report Waste management report		
	Threat from major	H	Harvestfield shall ensure:	L	Site	Harvestfield	During

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	accidents related to the fires and explosions at the facility and potential accidental releases of raw materials or finished products during their transport outside of the processing facility.		• Limiting the inventory that may be released by isolation of the process operations in the facility from large storage inventories; • Avoiding potential sources of ignition (e.g., by configuring the layout of piping to avoid spills over high temperature piping, equipment, and / or rotating machines); • Controlling the potential effect of fires or explosions by segregation of process, storage, utility, and safe areas by designing, constructing, and operating them according to international standards for the prevention and		inspection report Compliance monitoring report		Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			control of fire and explosion hazards, including provisions for distances between tanks in the facility; • Limiting the areas that may be potentially affected by accidental releases by: ○ Defining fire zones and equipping them with a drainage system to collect and convey accidental releases of flammable liquids to a safe containment area including secondary containment of storage tanks; • Installing fire / blast partition walls in areas where appropriate separation				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			distances cannot be achieved.				
	Air emission during maintenance/servicing of production equipment and ancillaries	M	Harvestfield shall ensure • Regular maintenance or servicing of production equipment as at when due • Prompt attention shall be given to any faulty production equipment • Use of original part to replace the faulty ones • Experts and professional must always be used to handle any repairs of production equipment and ancillaries • Harvestfield shall treat and dispose all waste oil and	L	Compliance monitoring report	Harvestfield	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			lubricants in accordance with regulatory requirements • and best practice using approved contractors • Harvestfield shall ensure that none of these wastes are disposed into any water body or on land				
	The threat of Naturally Occuring Radioactive Material (NORM) to the environment (Soil, water and air)	H	Harvestfield shall ensure: • Regular maintenance or servicing of production equipment as at when due; • Regular NORM monitoring programs to detect materials and equipment with NORM; • a surface contamination survey in	L	Compliance monitoring report	Harvestfield	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			a workshop to confirm that NORM contamination controls are working; • sampling and analysis of waste streams to confirm that they remain within regulatory limits; • materials used in NORM control procedures, such as gloves, plastic sheeting, disposable coveralls etc. if an area, materials or equipment is affected by NORM.				
	Road and traffic accidents as a result of transportation activities during facility operation	H	Harvestfield shall ensure: • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance	L	Compliance monitoring report	Harvestfield /Ogun State Ministry of	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			certificate issued. • the use of PPEs at sites; daily pep talk, carry out job hazard analysis • ensure that all traffic rules are obeyed by the drivers			Environment/FMEnv	

Table 7.5: Environmental and Social Management Plan (ESMP) of the Aflasafe Bio-control Plant – Decommissioning

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Demolition and Evacuation	Interference with road transportation	M	• Harvestfield shall monitor the no of trucks per day to know if there is need to create other accessible roads • Harvestfield shall develop a transport management plan specifying routes, speeds, times of travel and key roads/waterway in terms of local services; • Consideration shall be given to avoid reliance on public transport and contractors shall be required to use private vehicles	L	Inventory of approved journey management forms	Harvestfield/Ogun State Ministry of Environment/FMEnv	During Decommissioning
	Noise and vibration	M	Harvestfield shall ensure that: • electric power generators are	L		Harvestfield /Ogun State	During Decommissio

	nuisance		fitted with effective silencers; • there shall be regular maintenance of vehicles and generators; • generators and vehicles are switched off when not in use; • soundproof electric power generators are engaged • PPEs are used		Compliance monitoring report	Ministry of Environment/FMEnv	ning
	Impairment of air quality	H	Harvestfield shall ensure: • Engine to comply with international standards for exhaust gases; Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • that water shall be sprayed on construction sites to reduce dust levels especially during dry season.	L	Compliance monitoring report	Harvestfield /Ogun State Ministry of Environment/FMEnv	During Decommissioning
	Contaminati	M	Harvestfield shall ensure:	L		Harvestfield	During

	on of surface and Groundwater & soil		• Soil disturbance shall be kept to minimum required for operation and safety • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface/ groundwater • Follow FMEnv guidelines on waste management • Cleanup in compliance with relevant national and International guidelines, involving the removal of the waste, etc. • Restore the to a condition in no way inferior to the condition prior to the commencement of work.		Compliance monitoring report	/Ogun State Ministry of Environment/FMEnv	Decommissioning
	Solid waste generation and impact on disposal facility	H	• Harvestfield shall treat and dispose all wastes in accordance with regulatory requirements and best practice using approved contractors	L	Site inspection report Waste Management	Harvestfield /Ogun State Ministry of Environment/FMEnv	During Decommissioning

			• Harvestfield shall ensure that none of these wastes are disposed into any water body or on land • follow safety measures while disposing wastes • Harvestfield shall keep all waste consignment, treatment and disposal records for regulatory verification • Proper disposal of solid waste from labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water to the environment • All other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner. • There is minimum generation		Policy/ tracking sheet		

			of waste • Unsuitable excavated materials shall be systematically carried away from areas prone to erosion; • Reuse waste materials wherever possible • Wastes shall be segregated, stored and disposed by an accredited state waste collector				
	Loss of job	H	Harvestfield shall • Counsel worker who losses job. • Give enough notice • Assist staff that are likely to loss job in skill acquisition • Assist in setting small scale business	L	Contract documents/ list of community members employed	Harvestfield /Ogun State Ministry of Environment/FMEnv	During Decommissioning
	Injury / fatalities in workforce /communities	H	Harvestfield shall • Ensure Safety awareness training for workforce • Emergency response procedures shall be put in place and enforced	L	Progress/site inspection report	Harvestfield	During Decommissioning

			• ensure use of PPE • provide first aid and clinic on site			/Ogun State Ministry of Environment/FMEnv	
	Kidnapping of workers and visitors on site	H	• Harvestfield shall ensure that both contractor and Harvestfield personnel develops a high level of security consciousness both within and outside the work area • Daily security reports shall be reviewed by the Harvestfield Project Manager • Special security force shall be established and deployed for the project. This shall include deploying some of Harvestfield police to strengthen security in the area • Harvestfield shall ensure that a liaison to foster partnership with the community so as to guarantee security for the project is established and sustained	M	Daily/weekly security report	Harvestfield/Nigerian Police Force	During Decommissioning Phase

			In order to beef up security for the project, Harvestfield shall support government authorities by providing assistance with equipment e.g. patrol vehicles, to ensure improved security				
	Third Party Agitation due to employment Issues and Loss of Benefits as Host Communities.	M	• Assist staff that are likely to lose job in skill acquisition • Assist in setting small scale business	L	Contract documents/ list of community members employed	Harvestfield /Ogun State Ministry of Environment/FMEnv	During Decommissioning

7.7 Performance Indicator Monitoring

7.7.1 Environment

7.7.1.2 Environmental Monitoring Program

Environmental monitoring programs for the plant will be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during both normal operations and upset conditions (emergencies and consequent flaring). Environmental monitoring activities will be based on direct or indirect indicators of emissions, wastewater, and resource use applicable to the project, and for point sources of emissions which will include both concentration and mass flow rate of pollutants.

Monitoring frequency will be sufficient to provide representative data for the parameter being monitored. Monitoring will be conducted by trained individuals following suitable and appropriate monitoring and record-keeping procedures and using regularly calibrated and suitably maintained equipment. Monitoring data shall be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. The proposed operation phase monitoring programme is provided in ***Table 7.8*** below. However, during construction, the surveillance programme will exclude wastewater and emissions monitoring.

Table 7.8: Environmental Monitoring Programme for Harvestfield Refineries

Component	**Type**	**Monitoring Parameter**	**Source point / Sampling point**	**Monitoring Frequency**	**Responsibility**
Environment					
Emissions	Fugitive emission	H; CH4; VOCs, PAHs; NH3, CO, CO_2, SO_2 and SO_3, NOx, MTBE, ETBE, TAME, HF, and H2S.	Storage tanks, Flanges and/or Valves and machinery seals; Blending tanks, Pumps, Oily sewage and Wastewater Treatment Systems, Bitumen storage tanks, Vapor recovery unit vents	Weekly and 2-year Audit	Consultant/ HSE
Nuisance	Ambient	Noise level, odour, vibration, radiation	Within site and 2km radius	Weekly and 2-year Audit	Consultant/ HSE
Surface water	Rivers, streams, ponds, etc. (2km radius)	pH, Hydrocarbons (BTEX, TPH, PAH, THC), Temperature, Conductivity, Chloride, Turbidity, TDS, BOD_5, COD, THC, DO, Total hardness, Heavy metals, *E. coli* and *Enterococci*	Upstream, midstream and downstream	Quarterly (Compliance monitoring) and 2 year Audit	Consultant/ HSE
Ground water	Shallow wells and	Temperature, hydrocarbons (BTEX, TPH, PAH, THC), pH,	Boreholes and shallow wells	Quarterly (Compliance	Consultant, HSE

Component	Type	Monitoring Parameter	Source point / Sampling point	Monitoring Frequency	Responsibility
	boreholes (2km radius)	Electrical Conductivity, Total Solids, Dissolved Oxygen, Total Hydrocarbon Content, BOD_5, COD Sulphate, Nitrate, Phosphate, phenol, Heavy metals, Total coliform and Faecal Coliform bacteria		monitoring)	
Rainwater and storm water	Rainwater and storm water	Precipitation rate, pH, TDS, acidity, alkalinity, colour, hardness, etc.	Storm water (Point of discharge from the facility / Oil water separator)	Quarterly (Compliance monitoring), 2-year Audit	Consultant, HSE
Sanitary sewage	-	Residual chlorine, pH, TSS, DO, BOD5, Total Coliform and Faecal coliform	Sanitary sewage treatment plant (SSTP)	Post treatment	Consultant/ HSE
Air quality	Ambient air	Particulate matter, C_XH_Y, SOx, CO, VOC, NOx, Noise, H_2S, NH_3.	Established sampling points and 2km radius of the plant	Weekly and 2-year Audit	Consultant/ HSE
Traffic	Vehicular traffic	Vehicular volume count, origin and destination survey	Established observation points and 20km radius of the plant	2-year audit	Consultant, HSE/ Logistics
Safety and health					

Component	Type	Monitoring Parameter	Source point / Sampling point	Monitoring Frequency	Responsibility
	Occupational safety and health	Lost time injury (LTI), Lost time injury frequency (LTIF), Medical cases, Fatality, etc.	Within site	Daily	HSE
	Community health	Oil spill, fire, explosion, benzene concentration, vehicular accident, accidental chemical release or other major hazards	Stakeholder communities	Daily	HSE

7.7.2 Occupational Health and Safety

7.7.2.1 Occupational Health and Safety Guidelines

Currently, there is no standard for occupational safety and health established by Nigeria. However, the project's occupational health and safety performance will be evaluated against internationally published exposure guidelines, of which examples include the

a) Threshold Limit Value (TLV®) occupational exposure guidelines
b) Biological Exposure Indices (BEIs®) published by the American Conference of Governmental Industrial Hygienists (ACGIH),
c) Pocket Guide to Chemical Hazards published by the United States National Institute for Occupational Health and Safety (NIOSH),
d) Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA),
e) Indicative Occupational Exposure Limit Values published by European Union member states, or other similar sources.

7.7.2.2 Accident and Fatality Rates

The projects will put in place safety and health management system (MS) in place to help reduce the number of incidents and near misses among the project workers (whether directly employed or subcontracted) to a rate of zero, especially incidents that could result in lost work time, different levels of disability, or even fatalities. Facility rates may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g., U.S. Bureau of Labor Statistics and U.K. Health and Safety Executive).

7.7.2.3 Occupational Health and Safety Monitoring

The working environment will be monitored for occupational hazards relevant to the project. Monitoring will be designed and implemented by accredited consultant/professional as part of the project's occupational health and safety monitoring program. Facilities shall also maintain a record of occupational accidents and diseases and dangerous occurrences and accidents.

7.7.3 Auditing Programme

In addition to the routine inspection, environmental monitoring and audits shall be carried out internally and externally by Harvestfield to ensure compliance with regulatory requirements as well as its own HSE standards and policies. The audit will include a review of compliance with the requirements of the ESIA and of this ESMP and include, at minimum, the following:

- Completeness of HSE documentation, including planning documents and inspection records;
- Conformance with monitoring requirements;
- Efficacy of activities to address any non-conformance with monitoring requirements; and
- Training activities and record keeping. There will be a cycle of audits into specific areas of the project such as waste management, and effectiveness of local content plans and discharge controls. The frequency of audits will be risk based and will vary with the stage of the project (more frequent during operation and in the early stages of the project and later part of the well life) and will depend on the results of previous audits.

7.7.4 Corrective Action

Impacts will be proactively identified and associated risks as part of the corrective action implementation process. Investigating a 'near miss' or actual incident after it occurs can be used to obtain valuable lessons and information that can be used to prevent similar or more serious occurrences in the future. Harvestfield will implement a formal non-compliance and corrective action tracking procedure for investigating cause and identifying corrective actions in response to accidents or environmental or social non-compliances. This will ensure coordinated action between Harvestfield and its subcontractors. The HSE coordinator will be responsible for keeping records of corrective actions and for overseeing the modification of environmental or social protection procedures and/or training programs to avoid repetition of non-conformances and non-compliances.

7.7.5 Reporting

Harvestfield shall keep regulatory authorities informed of the project performance with respect to HSE matters by way of written status reports and face-to-face meetings throughout the project.

Harvestfield shall prepare a monthly report on environmental and social performance and submit same to relevant regulators. In addition to regular reporting, official notification shall be made to the government for any of the following:

- Significant modifications to this ESMP or the ESIA;
- Significant design, routing or implementation changes;
- Results of environmental monitoring;
- Community incidents; and
- Safety incidents or accidents.

Harvestfield will make accessible to government authorities, or provide upon request appropriate documentation of HSE related activities, including internal inspection records, training records, and reports. Subcontractors are also required to provide HSE performance reporting to Harvestfield on a regular basis through weekly and monthly reports.

7.7.6 Regulatory Oversight

Communications between the Harvestfield management and government regulatory agencies will be instituted through a variety of mechanisms, including written reports and memos, as well as informal and formal meetings. Meetings will include regularly scheduled sessions as well as additional meetings called on an as-needed arise. At the field level, formal meetings with government regulatory agency representatives will be held as needed to discuss scheduling/planning issues, current areas of concern, and emerging HSE and socioeconomic issues.

At the management level, formal meetings are expected to be held, but on a less frequent basis. Informal meetings and communications will also hold as necessary. With respect to formal meetings, the HSE Manager will meet with government regulatory agency representatives to review HSE and socioeconomic performance based on the analysis of internal HS-EMS and field reports. These meetings can be expected to include discussion of upcoming work plans and coordination issues and resolution of problems that could not be adequately addressed at the field level. At the field level, government regulatory agency field representatives will inform

appropriate Harvestfield representatives if compliance concerns arise. At the management level, regularly scheduled meetings will hold between HSE Mangers and the appropriate government regulatory agency representative to review HSE performance, areas of concern, and emerging issues.

7.8 Fiscal Plan for the ESMP

To effectively implement the environmental and social management measures suggested as part of the ESMP, estimated budget has been made by Harvestfield for the project components. Please see budget section in **Tables 7.10** below.

Table 7.10: Budget for the ESMP

Component	Type	Monitoring Parameter
Emissions	Flue gases, gas flaring	Carbon dioxide (CO_2), nitrogen oxides (NOx), sulphur oxides (SOx), carbon monoxide (CO), and particulate matter (PM), Hydrogen sulphide (H_2S)
	Fugitive emission	H; CH_4; VOCs, PAHs; NH_3, CO, CO_2, SO_2 and SO_3, NOx, MTBE, ETBE, TAME, HF, and H_2S.
Budget	***₦4,500,000.00***	
Wastewater (Influent and effluent)	Process wastewater	Quantity, pH, Temperature, Heavy metals, TDS, Hydrocarbons (BTEX, TPH, PAH, THC), H_2S, NH_3, organic sulphur compounds (R-S-H mercaptans), organic acids, and phenol.
	Hydrostatic test fluid	Inhibitor, Ferrous, TDS, pH
	Sanitary sewage	Residual chlorine, pH, TSS, DO, BOD_5, Total Coliform and Faecal coliform
Budget	***₦3,500,000.00***	
Air quality and Nuisance	Nuisances	Noise level, odour, vibration, radiation
	Ambient air quality	Particulate matter, C_XH_Y, SOx, CO, VOC, NOx, Noise, H_2S, NH_3, etc.
Budget	***₦1,500,000.00***	
Surface water	Rivers, streams, seasonal ponds, etc	pH, Hydrocarbons (BTEX, TPH, PAH, THC), Temperature, Conductivity, Chloride, Turbidity, TDS, BOD_5, COD, THC, DO, Total hardness, Heavy metals, *E. coli* and *Enterococci*
Ground water	Boreholes	Temperature, hydrocarbons (BTEX, TPH, PAH, THC), pH, Electrical

Component	**Type**	**Monitoring Parameter**
		Conductivity, Total Solids, Dissolved Oxygen, Total Hydrocarbon Content, BOD_5, COD Sulphate, Nitrate, Phosphate, phenol, Heavy metals, Total coliform and Faecal Coliform bacteria
Rainwater and storm water	Rainwater and storm water	Precipitation rate, pH, TDS, acidity, alkalinity, colour, hardness, etc.
Budget	***₦3,500,000.00***	
Traffic	Vehicular traffic	Vehicular volume count, origin and destination survey
Budget	***₦2,500,000.00***	
Safety and health		
	Occupational safety and health	Lost time injury (LTI), Lost time injury frequency (LTIF), Medical cases, Fatality, etc.
	Community health	Fire, explosion, benzene concentration, vehicular accident, accidental chemical release or other major hazards
Budget	***₦7,000,000.00***	

CHAPTER 8
DECOMMISSIONING AND RESTORATION PLANS

8.1 Introduction

All projects activities have a life span hinged on certain considerations, which include:

- The basis of the design and construction materials;
- Availability of raw materials and feedstock;
- Market and regulatory acceptance of the end-product; and
- Facility maintenance and technological development.

The Aflasafe Bio-control Plant facility design has a lifespan of at least 30 years, which implies that the facility will be fully operational for that period, before a consideration for redesign or plant replacement.

The project impact consideration on the environment will require a recovery or restorative plan to remediate the facility site to its original state after project decommissioning. This will require a good understanding of all applicable environmental components within the project ecosystem during its lifespan.

This section of the report provides an overview of the various decommissioning activities that will accompany this project and therefore need to be planned for at the conceptual stage.

8.2 Decommissioning Activities

8.2.1 Rehabilitation of Construction Activities

Construction Camps

Permanent camps

Rehabilitation will be necessary in the following areas:

- Concrete and compacted earth civil works;
- Excavation of septic tank;
- Access roads running into and through the camps.

Concrete works will be de-constructed and the rubble disposed of at an approved waste disposal site or used for the rehabilitation of pits. The exposed surface must be tested for contaminants at an FMEnv accredited laboratory, and remediation of contaminated surfaces carried out, and waste disposed at an approved site, before re-vegetation of the land is carried out.

All access roads and thoroughfares (whether pedestrian or vehicular), which have been denuded of vegetation and have been compacted, shall be checked for substantial spillage of contaminants such as chemicals, oils (lubricants) and fuels, and remediated accordingly.

Stockpiles and Storage Facilities

Storage facilities shall be inspected for traces of chemical contaminates and appropriate remedial actions shall be conducted to ensure that there is no transfer to soils around the project site and subsequently to plants. Where stockpiles have been removed, the ground surface is to be inspected for compaction and appropriate remedial actions taken. Where required, the surface is to be stripped off and re-vegetation carried out.

Production Plants and Formulation Equipment

All production plant infrastructures will be completely removed and the area will be restored to a level that is fit for other future uses. Above ground steelwork and concrete will be entirely removed from the site and disposed of to an approved waste disposal facility, recycled or sold off to other end users as required.

Re-vegetation Process

The basic re-vegetation steps, which shall be adopted for the project-specific environmental remediation programme, are listed below:

1. Preparation of top soils for the areas to be re-vegetated. This process may require soil ripping or scarifying. The scarification should take place to a depth of 150 mm. If ridges are made, they should be about 100 mm high and about 400 mm wide.

2. Replace stored topsoil on the slope to be re-vegetated to a depth of between 75 mm and 150 mm. The topsoil should be spread when it is dry by means of hand raking or mechanical balding and trimmed to a uniform thickness of not less than 100 mm.

3. Apply seeds or grass sods according to the supplier's specifications. The seed must be fresh, good quality seed as specified in the seed mix, certified by the supplier and free from contamination by seeds of other species.

If indigenous grass sods are used, they should be placed close together and level with each other. Gaps between the sods should be filled in with topsoil. A light cover of topdressing may be required to encourage growth and establishment.

4. Mulch should be applied to protect the seeded area from erosion. The mulch should be composed of straw or other material of cellulose origin and free of undesirable seeds. The mulch must not be excessively fresh and green or in an advanced state of decomposition as it could smother growth. It must be applied to a depth and density that will prevent erosion by wind and water, but not completely block out the access of sunlight to the soil or prevent penetration by young plants.

5. Protect the re-vegetated area from excessive trampling and any other factors that might cause erosion or compaction. No construction equipment, trucks or other heavy equipment should be allowed onto re-vegetated areas.

6. Ensure that suitable temporary and permanent drainage protection is installed ahead of or in parallel with the re-vegetation process.

7. Water the seeded/planted area on a regular basis (according to need, but on average twice per week).

8. Institute an appropriate maintenance and monitoring program for a minimum of 1 year. This program should include, monitoring of the success of seed germination,

growth of the plants, removal of invasive; weeds, replanting of areas where re-vegetation has not been successful once the cause of the inhibiting factor has been identified and remedied, and repair of any funnels or erosion channels. The contractor must not allow erosion to develop on a large scale before implementing repairs.

Seed Mixes

Alternative seed mixes are provided for use under the various topographical conditions in Nigeria. Vetiver grass *(Vetiveria zizaniodes)* for stabilisation of steep slopes and erosion prone areas, are readily available, should a suitable indigenous mix not be available. The seeds can be applied by utilizing a combination of hand seeding with local labour (for minor works) and hydro seeding (for major grassing works). Vetiver grass *(Vetiveria zizanioides) is* not indigenous, but is sterile and will not be invasive.

8.2.2 Rehabilitation of Decommissioning Activities

The procedures highlighted above for rehabilitation of construction area will also apply for rehabilitation of decommissioning works. All of these decommissioned surfaces must be properly re-vegetated, following the procedures highlighted above.

In addition, the process of rehabilitation must be done under strict supervision by concerned regulatory agencies such as the FMEnv, OgMEnv and OGSEPA. Upon the completion of decommissioning activities, a clean bill of health (CBH) must be issued by the concerned regulatory agencies listed above.

8.2.3 Post Closure Monitoring

Post-closure monitoring, will be conducted before transferring the land to the next landowner, to demonstrate the fitness of the land for future use.

CHAPTER NINE

CONCLUSION AND RECOMMENDATION

9.1 Conclusions

In conclusion the ESIA study shall have a number of significant positive impacts during the project construction and operation phases. These impacts include the following:

- creation of employment;
- improved quality of the environment through reduction in the use of persistent organic pesticides;
- Reduction in negative impact on human health from application of agrochemical
- reduction of Nigeria's dependency on imported pre-packaged agrochemical products;
- development of the Ogun economic growth zones;
- Minimized use of foreign exchange earnings; and
- Development and improvement of the food production infrastructure in Nigeria

Ultimately, the objective of developing an Aflasafe Bio-control Plant will increase productivity across several sectors of the Nigerian economy. This will however be accompanied by significant negative effects expected from the proposed project, such as:

- The displacement of the indigenous people and land take.
- Resultant loss of livelihood from land takes
- Potential environmental impacts on environmental media, such as impact on localised air quality

Based on the project design and equipment type, no significant effect is expected on the natural environment. The potential impacts of the project during construction and operation have been mitigated to an acceptable level by a number of measures including:

- Selecting a project site within an area already designated for industrial development, and also linked to the national electrical grid for steady supply of

electricity. The availability of this infrastructure will greatly reduce impacts to the surrounding area.

Other measures to be taken shall include the following:

- Ensuring that the height of the power generator (if required) stack is adequate to ensure proper dispersion
- Noise mitigation measures such as use of silencers and building of an enclosure for the generator.
- Restriction of site construction activities and vehicular movements to end before dark.
- Implementation of a comprehensive environmental and social management consistent with the ESMP;
- The height of the stacks is adequate to ensure proper dispersion in the atmosphere resulting in ambient air quality impacts that are well within Nigerian and World Bank criteria.
- Noise mitigation measures such as filters on the exit stacks and enclosures around the turbines will ensure that noise impacts will be well within Nigerian and World Bank requirements.
- There will be no cooling water discharge from the proposed facility into surface water bodies so impacts on aquatic resources will be insignificant.
- Establishment of a safety zone around the project facility;
- Implementation of a comprehensive environmental management and social plans including to ensure compliance with regulations and international standards;
- All hazardous materials and wastes will be handled, stored and disposed of in accordance with Nigerian and international criteria; and
- Use of a highly skilled and properly trained and equipped workforce will ensure that plant operations are performed in an environmentally responsible manner.

9.2 Recommendations

In addition to the identified mitigation measures Harvestfield shall be committed to:

- Undertake a Best Practicable Environmental Option for the project.

- Ensure the monitoring of the effects of the operation of the facility on the host environment.
- Define and undertake monitoring for atmospheric emissions.
- Regular audit the environmental performance of the project operational elements.
- Carry out further studies to determine the best decommissioning strategy toward the end of the project lifecycle.

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GPS Location of Sampling Points for Soil, Noise, Air Quality and Groundwater Samples around the proposed project area (2014/2015)

Sample Code	Geographical Location		Elevation (m)
SS1, AQ1	N06.77609	E003.42452	23
SS2, AQ2	N06.77620	E003.42456	26
SS3, AQ3	N06.77630	E003.42454	26
SS4, AQ4	N06.77609	E003.42463	23
SS5, AQ5	N06.77603	E003.42521	24
SS6, AQ6	N06.77616	E003.42526	24
SS7, AQ7	N06.77596	E003.42569	25
SS8, AQ8	N06.77573	E003.42600	26
SS9, AQ9	N06.77617	E003.42489	25
SS10, AQ10	N06.77595	E003.42502	27
SSCTR 1, AQCTR 1	N06.77666	E003.42332	30
WS1	N06.77638	E003.42607	32
WS2	N06.77666	E003.42444	35
WSCTR 1	N06.77729	E003.42533	30

Key: SS: Soil Sampling, AQ: Air Quality Sampling **Source**: Field Sampling, 2014/2015

GPS Location of Sampling Points for Soil, Noise Quality, Vegetation and Air Quality sampling within the proposed site

S/N	Sample Code	Coordinate	Elevation(m)
1	AQ1, SS1, N1, V	N6.849003, E3.517855	24
2	AQ2, SS2, N2, V	N6.841468 E3.511587	33
3	AQ3, SS3, N3, V	N6.844779, E3.514292	31
4	AQ4, SS4, N4, V	N6.844751. E3.514750	29
5	AQ5, SS5, N5, V	N6.844630, E3.515179	30
6	AQ6, SS6, N6, V	N6.844915, E3.514838	29
7	AQ7, SS7, N7, V	N6.845192, E3.514682	32
8	AQ8, SS8, N8, V	N6.845403, E3.514773	31
9	AQ9, SS9, N9, V	N6.845484, E3.514758	28
10	AQ10, SS10, N10, V	N6.845532, E3.514770	31
11	AQ11,N11, V	N6.844904, E3.513964	30
12	AQ12(Control 1) SS11, N12, V	N6.844844, E3.513871	31
13	AQ13 (Control 2) SS12, N13, V	N6.844564, E3.517361	31

Key: SS: Soil Sampling, AQ: Air Quality Sampling, N: Noise, V: Vegetation ***Source: Field Sampling, 2019***

GPS Location of Sampling Points for Groundwater, Surface water and Sediment Samples within the proposed site

S/N	Sample Code	Coordinate	Elevation (m)
1	GW 1	N6.849003, E3.517855	28
2	GW 2 (Control)	N6.841468 E3.511587	30
3	SW 1	N6.844577, E3.517370	31
4	SW 2	N6.844583, E3.517365	29
5	SW 3	N6.844590, E3.517376	30
6	SW 4 (Control)	N6.844564, E3.517361	29

Key: SW: Surface water GW: Groundwater ***Source: Field Sampling, 2019***

GPS Location of Sampling Points for Soil, Noise, Air Quality and Groundwater Samples around the proposed project area (2014/2015)

Sample Code	Geographical Location		Elevation (m)
SS1, AQ1	N06.77609	E003.42452	23
SS2, AQ2	N06.77620	E003.42456	26
SS3, AQ3	N06.77630	E003.42454	26
SS4, AQ4	N06.77609	E003.42463	23
SS5, AQ5	N06.77603	E003.42521	24
SS6, AQ6	N06.77616	E003.42526	24
SS7, AQ7	N06.77596	E003.42569	25
SS8, AQ8	N06.77573	E003.42600	26
SS9, AQ9	N06.77617	E003.42489	25
SS10, AQ10	N06.77595	E003.42502	27
SSCTR 1, AQCTR 1	N06.77666	E003.42332	30
WS1	N06.77638	E003.42607	32
WS2	N06.77666	E003.42444	35
WSCTR 1	N06.77729	E003.42533	30

Key: SS: Soil Sampling, AQ: Air Quality Sampling **Source**: Field Sampling, 2014/2015

GPS Location of Sampling Points for Soil, Noise Quality, Vegetation and Air Quality sampling within the proposed site

S/N	Sample Code	Coordinate	Elevation(m)
1	AQ1, SS1, N1, V	N6.849003, E3.517855	24
2	AQ2, SS2, N2, V	N6.841468 E3.511587	33
3	AQ3, SS3, N3, V	N6.844779, E3.514292	31
4	AQ4, SS4, N4, V	N6.844751. E3.514750	29
5	AQ5, SS5, N5, V	N6.844630, E3.515179	30
6	AQ6, SS6, N6, V	N6.844915, E3.514838	29
7	AQ7, SS7, N7, V	N6.845192, E3.514682	32
8	AQ8, SS8, N8, V	N6.845403, E3.514773	31
9	AQ9, SS9, N9, V	N6.845484, E3.514758	28
10	AQ10, SS10, N10, V	N6.845532, E3.514770	31
11	AQ11,N11, V	N6.844904, E3.513964	30
12	AQ12(Control 1) SS11, N12, V	N6.844844, E3.513871	31
13	AQ13 (Control 2) SS12, N13, V	N6.844564, E3.517361	31

Key: SS: Soil Sampling, AQ: Air Quality Sampling, N: Noise, V: Vegetation ***Source: Field Sampling, 2019***

GPS Location of Sampling Points for Groundwater, Surface water and Sediment Samples within the proposed site

S/N	Sample Code	Coordinate	Elevation (m)
1	GW 1	N6.849003, E3.517855	28
2	GW 2 (Control)	N6.841468 E3.511587	30
3	SW 1	N6.844577, E3.517370	31
4	SW 2	N6.844583, E3.517365	29
5	SW 3	N6.844590, E3.517376	30
6	SW 4 (Control)	N6.844564, E3.517361	29

Key: SW: Surface water GW: Groundwater ***Source: Field Sampling, 2019***

APPENDIX 4.1: PHYSICOCHEMICAL AND MICROBIOLOGY RESULTS OF SOIL

TOP SOIL (DRY SEASON 2019)

S/N	PARAMETERS	SS 1 TOP	SS 2 TOP	SS 3 TOP	SS 4 TOP	SS 5 TOP	SS 6 TOP
A	**Physico-chemical Test**						
1	pH	4.7	5.5	4.9	4.8	5.1	4.6
2	Conductivity (µS/cm)	273.1	285.9	295.6	279.9	427	265
3	Sulphate (mg/kg)	470	220	290	240	210	360
4	Nitrate (mg/kg)	4.14	3.69	3.28	3.53	3.43	3.60
5	Phosphate (mg/kg)	19.2	14.3	19.7	9.0	15.5	16.4
6	Total Nitrogen (mg/kg)	0.78	1.04	1.14	1.11	1.16	0.93
7	CEC (meq/100g)	48.78	60.95	65.67	61.85	74.47	58.42
8	Ammonium (mg/kg)	3.5	3.0	1.8	3.5	1.8	2.4
9	TOC (%)	1.29	1.00	1.02	1.45	0.43	0.86
10	Nitrite (mg/kg)	2.13	1.14	1.47	2.04	1.13	0.46
11	THC (mg/kg)	0.580	1.313	0.675	0.648	1.073	1.437
12	TPH (mg/kg)	0.1	0.1	0.1	0.1	0.1	0.1
13	PAH (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
14	BTEX (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
15	Phenols (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
16	Moisture content (%)	26.6	22.5	23.5	27.1	24.4	22.1
	CATION/HEAVY METALS						
17	Potassium (mg/kg)	6.89	6.08	10.05	9.78	9.00	6.78
18	Calcium (mg/kg)	20.05	21.90	25.56	32.98	37.67	26.37
19	Sodium (mg/kg)	13.96	23.90	23.28	14.09	20.75	18.72
20	Magnesium (mg/kg)	7.88	9.07	6.78	5.00	7.05	6.55
21	Iron (mg/kg)	41.5	43	28	31	35	34
22	Chromium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
23	Nickel (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

24	Vanadium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
25	Barium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
26	Copper(mg/kg)	28.47	19.76	24.47	17.35	16.47	23.18
27	Zinc (mg/kg)	1.26	1.02	1.56	0.68	1.44	1.55
28	Manganese (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
29	Cadmium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
30	Lead (mg/kg)	0.02	0.02	0.02	0.02	0.01	0.02
31	Mercury (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	MICROBIOLOGY						
32	THB (x 10^4 cfu/g)	365	488	378	235	428	280
33	HUB (x 10^4 cfu/g)	112	121	157	208	143	191
34	THF (x 10^4 cfu/g)	258	214	234	161	261	214
35	HUF (x 10^4 cfu/g)	60	46	44	51	31	59
36	Total Coliforms (x 10^4 cfu/g)	56	50	86	31	75	77
37	HUB/THB Ratio	0.3077	0.2473	0.4152	0.8832	0.3351	0.6830
38	HUF/THF Ratio	0.2323	0.2157	0.1896	0.3141	0.1197	0.2744

S/N	PARAMETERS	SS 7 TOP	SS 8 TOP	SS 9 TOP	SS 10 TOP	SS 11 TOP (Control 1)	SS 12 TOP (Control 2)
A	**Physico-chemical Test**						
1	pH	4.5	5.0	5.4	5.1	5.3	4.8
2	Conductivity (µS/cm)	391.7	367.8	317.9	293.4	406.7	295.2
3	Sulphate (mg/kg)	400	260	190	130	210	140
4	Nitrate (mg/kg)	3.99	3.58	3.70	3.6	3.75	4.05
5	Phosphate (mg/kg)	12.9	8.0	10.8	10	10.7	9.9
6	Total Nitrogen (mg/kg)	0.95	1.15	1.14	0.64	0.97	1.15
7	Ammonium (mg/kg)	3.1	2.4	2.0	2.65	2.1	2.2
8	CEC (meq/100g)	71.56	70.2	75.48	60.85	73.91	65.36
9	TOC (%)	0.98	1.00	0.71	1.79	0.35	0.48
10	Nitrite (mg/kg)	2.01	0.90	0.65	0.32	0.91	1.92
11	THC (mg/kg)	1.178	1.461	1.018	0.525	1.038	1.342
12	TPH (mg/kg)	0.1	0.1	0.1	0.1	0.1	0.1
13	PAH (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
14	BTEX (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
15	Phenols (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
16	Moisture content (%)	25.1	22.6	19.3	16.3	16.1	25.5
	CATION/HEAVY METALS						
17	Potassium (mg/kg)	8.65	6.55	7.97	10.91	8.92	6.38
18	Calcium (mg/kg)	31.13	36.53	34.54	30.06	28.20	23.24
19	Sodium (mg/kg)	24.29	20.23	24.07	12.33	29.81	29.08
20	Magnesium (mg/kg)	7.49	6.89	8.90	7.55	6.98	6.66
21	Iron (mg/kg)	43	23	25	45	32	36
22	Chromium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
23	Nickel (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
24	Vanadium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
25	Barium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
26	Copper(mg/kg)	33.45	20.24	32.94	29.94	21.06	28.00

27	Zinc (mg/kg)	1.33	2.99	3.01	2.32	1.90	2.22
28	Manganese (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
29	Cadmium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
30	Lead (mg/kg)	0.01	0.02	0.02	0.01	0.01	0.02
31	Mercury (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	MICROBIOLOGY						
32	THB (x 10^4 cfu/g)	425	463	345	213	410	439
33	HUB (x 10^4 cfu/g)	186	182	102	124	167	204
34	THF (x 10^4 cfu/g)	165	231	229	185	204	231
35	HUF (x 10^4 cfu/g)	56	18	17	17	34	41
36	Total Coliforms (x 10^4 cfu/g)	82	31	102	104	54	89
37	HUB/THB Ratio	0.4383	0.3942	0.2956	0.5823	0.4082	0.4654
38	HUF/THF Ratio	0.3428	0.0798	0.0727	0.0899	0.1654	0.1751

APPENDIX 4.1 : PHYSICOCHEMICAL AND MICROBIOLOGY RESULTS OF SOIL

BOTTOM SOIL (DRY SEASON 2019)

S/N	PARAMETERS	SS 1 BOTTOM	SS 2 BOTTOM	SS 3 BOTTOM	SS 4 BOTTOM	SS 5 BOTTOM	SS 6 BOTTOM
A	**Physico-chemical Test**						
1	pH	5.4	5.4	5.1	5	4.3	4.7
2	Conductivity (µS/cm)	258.7	271.3	286	291.4	292.6	260.6
3	Sulphate (mg/kg)	250	230	380	390	140	230
4	Nitrate (mg/kg)	3.87	2.83	3.57	3.02	2.89	3.76
5	Phosphate (mg/kg)	8.5	9.4	10.1	11.9	13.6	10.7
6	Total Nitrogen (mg/kg)	0.69	0.67	0.61	0.72	0.59	0.53
7	Ammonium (mg/kg)	1.9	2.1	1.7	2.3	1.8	1.9
8	CEC (meq/100g)	62.6	71.96	64.01	66.67	64.26	70.63
9	TOC (%)	1.35	1.99	2.61	2.10	1.01	0.92
10	Nitrite (mg/kg)	0.53	0.51	0.38	0.54	0.53	0.19
11	THC (mg/kg)	1.532	1.595	0.886	0.929	0.414	1.749
12	TPH (mg/kg)	0.1	0.1	0.1	0.1	0.1	0.1
13	PAH (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
14	BTEX (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
15	Phenols (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
16	Moisture content (%)	30.3	32.6	30.8	27.2	27.8	33.3
	CATION/HEAVY METALS						
17	Potassium (mg/kg)	13.21	13.85	11.11	13.39	11.41	12.02
18	Calcium (mg/kg)	20.82	35.51	23.32	25.08	20	31.82
19	Sodium (mg/kg)	21.95	15.15	23.02	19.27	25.08	19.10
20	Magnesium (mg/kg)	6.62	7.45	6.56	8.93	7.77	7.69
21	Iron (mg/kg)	215	84	214	171	360	212
22	Chromium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
23	Nickel (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

24	Vanadium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
25	Barium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
26	Copper(mg/kg)	10.56	11.23	9.23	11.23	13.44	16.78
27	Zinc (mg/kg)	3.89	3.22	2.99	2.57	1.99	2.30
28	Manganese (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
29	Cadmium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
30	Lead (mg/kg)	0.01	0.02	0.02	0.01	0.01	0.02
31	Mercury (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	MICROBIOLOGY						
32	THB (x 10^4 cfu/g)	232	272	169	231	241	274
33	HUB (x 10^4 cfu/g)	149	117	102	95	170	136
34	THF (x 10^4 cfu/g)	112	187	159	191	204	229
35	HUF (x 10^4 cfu/g)	25	54	31	40	61	31
36	Total Coliforms (x 10^4 cfu/g)	34	68	20	32	28	53
37	HUB/THB Ratio	0.6445	0.4294	0.6043	0.4102	0.7072	0.4954
38	HUF/THF Ratio	0.2220	0.2892	0.1933	0.2103	0.3006	0.1367

S/N	PARAMETERS	SS 7 BOTTOM	SS 8 BOTTOM	SS 9 BOTTOM	SS 10 BOTTOM	SS11 Control 1 Bottom	SS12 Control 2 Bottom
A	**Physico-chemical Test**						
1	pH	5.0	5.4	5.3	4.6	4.5	4.4
2	Conductivity (µS/cm)	275.1	251.7	262.0	271.8	277.9	259.7
3	Sulphate (mg/kg)	350	310	230	150	260	290
4	Nitrate (mg/kg)	2.96	3.06	3.05	3.19	2.90	3.98
5	Phosphate (mg/kg)	11.6	13.3	11.2	12.5	9.7	10.0
6	Total Nitrogen (mg/kg)	0.62	0.53	0.69	0.59	0.67	0.67
7	Ammonium (mg/kg)	2.4	2.4	2.5	1.7	2.4	2.5
8	CEC (meq/100g)	68.41	58.48	58.17	69.85	68.29	73.13
9	TOC (%)	1.76	0.73	1.71	2.23	2.96	3.11
10	Nitrite (mg/kg)	0.27	0.57	0.41	0.17	0.33	0.57
11	THC (mg/kg)	1.558	0.560	1.788	1.547	0.262	0.919
12	TPH (mg/kg)	0.1	0.1	0.1	0.1	0.1	0.1
13	PAH (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
14	BTEX (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
15	Phenols (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
16	Moisture content (%)	33.9	34.1	34.1	33.1	33.5	27.6
	CATION/HEAVY METALS						
17	Potassium (mg/kg)	14.37	11.17	11.08	12.15	13.71	10.94
18	Calcium (mg/kg)	22.86	24.06	23.16	30.75	24.20	32.58
19	Sodium (mg/kg)	24.41	17.46	16.03	18.07	21.06	22.82
20	Magnesium (mg/kg)	6.77	5.79	7.90	8.88	9.32	6.79
21	Iron (mg/kg)	121	111	187	104	189	246
22	Chromium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
23	Nickel (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
24	Vanadium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
25	Barium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
26	Copper(mg/kg)	18.90	20.22	15.65	13.22	18.90	20.11

27	Zinc (mg/kg)	1.99	2.22	2.01	2.17	2.33	1.98
28	Manganese (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
29	Cadmium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
30	Lead (mg/kg)	0.01	0.02	0.02	0.01	0.01	0.02
31	Mercury (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	MICROBIOLOGY						
32	THB (x 10^4 cfu/g)	211	277	266	228	229	262
33	HUB (x 10^4 cfu/g)	91	96	159	167	70	85
34	THF (x 10^4 cfu/g)	190	247	185	184	239	211
35	HUF (x 10^4 cfu/g)	28	28	28	42	48	41
36	Total Coliforms (x 10^4 cfu/g)	72	73	44	32	23	45
37	HUB/THB Ratio	0.4306	0.3480	0.6001	0.7320	0.3055	0.3224
38	HUF/THF Ratio	0.1491	0.1146	0.1510	0.2266	0.1996	0.1949

APPENDIX 4.2a: PHYSICO-CHEMICAL AND MICROBIOLOGY RESULTS OF SURFACE WATER

DRY SEASON 2019

S/N	PARAMETERS	HF-SW1	HF-SW 2	HF-SW3	HF-SW4 (CONTROL
A	**Physico-chemical Test**				
1	COD (mg/L)	33	22	24	41
2	pH	5.7	6.2	5.9	6.1
3	TDS (ppm)	119	220	153	81
4	EC (us/cm)	245	410	315	158
5	Temp (^{o}C)	30.5	37.3	30.3	35.5
6	TSS (mg/L)	12	14	10	12
7	BOD (mg/L)	14	12	11	11
8	DO (mg/L)	5.0	4.9	4.3	5.6
9	Turbidity	2	3	3	2
10	Acidity (mg/L)	23	17	25	20
11	Total Hardness (mgCaCO3/L)	115	70	146	132
12	Sulphate (mg/L)	21	18	19	26
13	Nitrate (mg/L)	0.05	0.02	0.02	0.04
14	Phosphate (mg/L)	0.19	0.05	0.07	0.12
15	TOC (%)	0.039	0.048	0.039	0.050
16	THC (mg/L)	1.545	4.289	1.751	4.713
17	Oil & Grease (mg/L)	<0.001	<0.001	<0.001	<0.001
18	PAH (mg/L)	<0.001	<0.001	<0.001	<0.001
19	TPH (mg/L)	<0.001	<0.001	<0.001	<0.001
20	BTEX (mg/L)	<0.001	<0.001	<0.001	<0.001
21	Phenol (mg/L)	<0.001	<0.001	<0.001	<0.001
22	Available Phosphate (mg/L)	0.05	0.06	0.08	0.07
23	Total Nitrogen (mg/L)	0.41	0.65	0.30	0.51
24	Ammonium (mg/L)	0.44	0.49	0.32	0.33
25	Nitrite (mg/L)	0.011	0.017	0.015	0.016
	CATION/HEAVY METALS				
26	Sodium (mg/L)	4.35	3.44	4.36	5.06
27	Potassium (mg/L)	2.97	1.76	3.73	2.19
28	Magnesium (mg/L)	0.720	0.219	0.141	0.201
29	Iron (mg/L)	0.49	0.8	0.67	0.64
30	Chromium (mg/L)	<0.001	<0.001	<0.001	<0.001
31	Nickel (mg/L)	<0.001	<0.001	<0.001	<0.001
32	Calcium (mg/L)	45.29	28.06	44.40	53.08
33	Vanadium (mg/L)	<0.001	<0.001	<0.001	<0.001

34	Barium (mg/L)	<0.001	<0.001	<0.001	<0.001
35	Copper(mg/L)	0.038	0.061	0.048	0.056
36	Zinc (mg/L)	<0.001	<0.001	<0.001	<0.001
37	Manganese (mg/L)	<0.001	<0.001	<0.001	<0.001
38	Cadmium (mg/L)	<0.001	<0.001	<0.001	<0.001
39	Lead (mg/L)	<0.001	<0.001	<0.001	<0.001
40	Mercury (mg/L)	<0.05	<0.05	<0.05	<0.05
	MICROBIOLOGY				
41	THB (x 10^4 cfu/ml)	148	152	149	133
42	HUB (x 10^4 cfu/ml)	12	12	17	9
43	THF (x 10^4 cfu/ml)	101	179	113	200
44	HUF (x 10^4 cfu/ml)	11	11	6	10
45	Total Coliforms (x 10^4 cfu/ml)	47	58	36	29
46	HUB/THB Ratio	0.0789	0.0802	0.1174	0.0663
47	HUF/THF Ratio	0.1127	0.0615	0.0491	0.0518

APPENDIX 4.4: PHYSICO-CHEMICAL AND MICROBIOLOGY RESULTS OF SEDIMENT

DRY SEASON (2019)

S/N	PARAMETERS	HF-SW SED 1	HF-SW SED 2	HF-SW SED 3	HF-SW SED 4 (CONTROL)
	Physico-chemical Test				
1	**pH**	7.5	6.9	7.1	8.5
2	Conductivity	532	345	234	201
3	Sulphate (mg/kg)	1800	780	780	750
4	Nitrate (mg/kg)	1.32	1.39	2.80	1.81
5	Phosphate (mg/kg)	8	6.4	9.2	6.7
6	Total Nitrogen (%)	0.28	0.16	0.24	0.12
7	Ammonium (mg/kg)	17.5	6.46	10.61	7.61
8	Nitrite (mg/kg)	0.91	0.76	1.01	0.67
9	TOC (%)	2.65	2.34	2.53	2.01
10	Phenols (mg/kg)	<0.001	<0.001	<0.001	<0.001
11	THC (mg/kg)	0.1	0.03	0.09	0.03
12	TPH (mg/kg)	<0.001	<0.001	<0.001	<0.001
13	PAH (mg/kg)	<0.001	<0.001	<0.001	<0.001
14	BTEX (mg/kg)	<0.001	<0.001	<0.001	<0.001
15	Moisture Content (%, Oven- dry basis)	206	242	132	259
	HEAVY METALS				
16	Sodium (mg/kg)	4.9	6.22	6.28	5.87
17	Potassium (mg/kg)	3.55	4.18	4.09	3.71
18	Calcium (mg/kg)	32.12	36.01	32.82	38.93
19	Magnesium (mg/kg)	0.950	0.325	0.211	0.256
20	Iron (mg/kg)	170	675	645	605
21	Vanadium (mg/kg)	<0.001	<0.001	<0.001	<0.001
22	Chromium (mg/kg)	<0.001	<0.001	<0.001	<0.001
23	Barium (mg/kg)	<0.001	<0.001	<0.001	<0.001
24	Nickel (mg/kg)	3.846	2.416	2.896	2.689
25	Copper (mg/kg)	0.038	0.061	0.048	0.056
26	Zinc (mg/kg)	<0.001	<0.001	<0.001	<0.001
27	Manganese (mg/kg)	<0.001	<0.001	<0.001	<0.001
28	Cadmium (mg/kg)	<0.001	<0.001	<0.001	<0.001
29	Lead (mg/kg)	<0.001	<0.001	<0.001	<0.001
30	Mercury (mg/kg)	<0.05	<0.05	<0.05	<0.05
	MICROBIOLOGY				
31	THB (x 10^4 cfu/g)	163	286	181	182

32	HUB (x 10^4 cfu/g)	5	7	5	8
33	THF (x 10^4 cfu/g)	129	157	119	107
34	HUF (x 10^4 cfu/g)	18	15	20	10
35	Total Coliforms (x 10^4 cfu/g)	49	38	35	40
36	HUB/THB Ratio	0.0284	0.0237	0.0289	0.0429
37	HUF/THF Ratio	0.1427	0.0947	0.1658	0.0921

QUESTIONNAIRES USED IN THE SOCIAL AND HEALTH ASSESSMENT OF PROPOSED HARVESTFIELD AFLASES PLANT IN MAKUN, OGUN STATE

(1)QUESTIONNAIRE FOR SOCIAL IMPACT ASSESSMENT (SIA)

Name of Community / Village: ----------

Name of Clan: ----------

Ethnicity / Language ----------

Name of Respondent: ----------

Post held in Community ----------

Respondent's code ----------

Date of Interview ----------

Occupation: ……..…….....

Section A: Social and Bio data

01 Age of Respondent ---------- 02 Period of Birth ----------

03 Respondent's Sex [ ] Male [ ] Female

04 Respondent's Religion [ ] none [ ] Church ----------
[ ] African Traditional Religion

05 Marital Status [ ] Single [ ] Married [ ] Divorced
[ ] Re-married [ ] Widowed [ ] others specify

06 If married, How [ ] introduction [ ] Bride price [ ] Church
[ ] Court [ ] Yet to pay the bride price

07 Are you Polygamous? [ ] Yes [ ] No

08 What is the predominant type of marriage in this community? Suggest Proportion

09 How many wives / mate do you have? [ ] 1 [ ] 2-3 [ ] 4-5 [ ] Above 5

10 How old were you when you married? [ ] 12-16 [ ] 17-20 [ ] 21-24
[ ] 25-29 [ ] 30-35 [ ] over 36

11 How many children has God blessed you with? [ ] 1-3 [ ] 4-6 [ ] 7-10
[ ] above 10

12 How old is your oldest / first child [ ] and youngest child [ ]

13 Educational level: [ ] No formal Education [ ] Primary School
[ ] Secondary / TCII/GCE [ ] Diploma /NCE
[ ] Degree/ HND [ ] others, specify---------

14 Vocational Training / Skill Acquired
[ ] Tailoring [ ] Hair dressing [ ] Mat Making
[ ] Pot making [ ] Baking [ ] Mechanic /Technician
[ ] Mason [ ] Builder [ ] Blacksmith [ ] Trade
[ ] Farming [ ] others, please specify

14 Can you [ ] Read [ ] Write

15 How many persons live with you in your house? Please specify relationship.

	Males	**Female**	**Employed**	**Unemployed**	**Total**
Children					
Relatives					
Other Assistants					

16 How many years have you been practicing your occupation? Years of experience
[ ] 1-5 [ ] 6 -10 [ ] 11-15 [ ] 16 – 20 [ ] 21– 25 [ ] 26 - 30 [ ] over 30 years

Section B. Socio-Economic Information

17 What type of house do you live in?
[ ] one room [ ] Room and parlour [ ] Flat
[ ] self contain [ ] others, specify …….
18 The accommodation is, rented [ ] family owned [ ]
19 If it is rented how much do you pay (monthly or yearly, please specify) ……
20 What is the rent in this community now? [ ] last two years [ ]

21 In this community land is owned by [ ] the community [ ] individuals
22 How is land acquired in this community either for building a house or farming?
[ ] By buying from those who have
[ ] Through inheritance
[ ] Others,. specify .....
23 Tick and indicate the importance of crops grown. (Most important = 1)

	Rank	**Main reason for rank given**	**Income**
Yam			
Plantain			
Oil Palm tree			
Rubber			
Pineapple			
Pepper			
Maize			
Melon			
Tomatoes			
Cassava			
Plantain			
Vegetables			

24 List your sources of income / cash/ money/. ……

25 How much do you spend on the following items

	Monthly	Quarterly	Yearly
House rent			
Meat/fish			
Garri			
Rice			
Uniforms			
Books			
School fees			

Political/ Culture of Community

26 Who is the head of this community? …….
27 How are disputes/quarrels settled in the community [Draw the hierarchy]
28 What role do women play in peace keeping in this community?
29 Do you forbid eating any [ ] animal or plant ? List them……

30 What shrines/sacred places do you know of in this community?
31 Name the gods. ----------
32 List the traditional festivals and when they are held.

Awareness and Impact of proposed Project / Activities

Awareness of Proposed Project

33 Are you aware of the LNG/CNG Plant project proposed in this community?
[ ] Yes [ ] No
34 If yes, what was your source of the information (Please specify) ……..
35 Can you tell us your perception about the proposed project …… .
……
36. What is the community perception? ……
37 Which of the following Amenities exist in this community? Please state source, condition and distance from community centre.

Facility / Benefit	No.	Provided By	Year	Condition	Distance
Jetty					
Public Toilet					
Tarred roads					
Primary school					
Secondary school					
Health centre					
Town hall					
Work for some people					
Scholarship					
Skill acquisition centre					
Electricity					
Pipe borne water					
Training					
Market Stall built					
Micro credit					

38. Please list the benefits you think will accrue to this community if this project is executed. …….
39. What do you consider as the negative impact of the proposed project on this community? Specify and give details.
40. Please fill in this impact matrix below

Potential Impact	When expected	Good or Bad	Degree	Remark
Employment				
Social Vices				
Income Generation				
Influx of People				

41 Suggest solutions to the negative impacts.

42. Would you want this project to be executed? [ ] 100% [ ] 60-40 [ ] 50-50 [ ] 0-0

(2) HEALTH IMPACT ASSESSMENT QUESTIONNAIRE

We are interested in studying the Health Impact for the ESIA study of the proposed project in your community. This questionnaire is designed to enable us obtain related information. We need your assistance and cooperation in answering the questions asked below. Your answers will be treated as confidential.

Please fill in or tick as appropriate.

(A) Socio-Demographic Variables

(1) Name of Town / Village……

(2) Age (Last Birthday)……

(3) Sex: (a) Male ☐ (b) Female ☐

(4) What is your marital status?

Single	
Married	
Divorced	
Separated	
Widow/Widower	

(5) Educational Status:

a) No formal education
b) Primary School
c) Secondary school
d) Tertiary (NCE / OND / AL / HND / Degree)
e) Higher degree

(6) Occupation: (a) Farming ☐ (b) Fishing ☐ (c) Trading ☐ (d) Civil servant ☐

(e) Others (specify)……

(7) In Your work place, what health problems are you exposed to:……..

……

(8) Income Per month (Adults only)……

(9) How much does it cost you to take care of your family in a month?…….

(10) Religion……

(11) Ethnic group…….

(12) How long have you lived in this community? ……..

(13) Have you changed your residence in this community within the last five (5) years? Yes/No

(14) If your answer to question 6 is yes, please state why?

(15) What do you think are the most important five health needs of your community?.....
.....

Reproductive Health Data:

How many children were born in your household between Jan. 1, 2019 and Dec. 31, 2019 and what are the ages of their mothers?

Age of mother	Total Number of Children ever born by the same mother		Number of children born between Jan. 1, 2019 & Dec 31, 2019.	
	Male	Female	Male	Female
(i)				
(ii)				
(iii)				
(iv)				
(v)				
(vi)				

(B) Life Style/ Habits

(1) Do you drink alcohol? Yes ☐ No ☐

(2) If yes, How often

- Every day
- At least once a week
- Occasional

(3) Do you smoke? Yes / No

If yes, how many sticks/day …….

(4) Exercise: Yes / No

What type of exercise do you do? …….

Knowledge, Attitudes, Practices and Behaviour on Sexually Transmissible Infections

1. Do you have sexual partners not married to you? Yes ☐ No ☐
2. How many are they? Yes ☐ No ☐
3. Have you heard of sexually Transmissible Infections before? Yes ☐ No
4. Have you ever had any sexually Transmissible Infections? Yes ☐ No
5. What symptoms (complaints) did you have then _____

   _____
6. Were you treated by a doctor, a nurse or by yourself?
   - Treated by a doctor Yes ☐ No ☐
   - By nurse Yes ☐ No ☐
   - By self Yes ☐ No ☐
7. How many times have you had STIs before? _____
8. Have you heard of HIV/AIDS before? Yes ☐ No ☐

9. Do you know how HIV/AIDS can infect somebody? Yes ☐ No ☐

10. Name the method by which somebody can get HIV/AIDS

_____

11. Have you checked your HIV status? Yes ☐ No ☐

12. Do you know anybody who has HIV/AIDS? Yes ☐ No ☐

13. How many do you? _____

14. Has any member of your family, friend or community had or having tuberculosis?

Yes ☐ No ☐

Morbidity and Mortality:

1. Please list persons (if any) who died in your household between Jan. 1, 2019 and Dec 31, 2019.

Name (Optional)	Sex	Age	Cause of death (if known)
(i)			
(ii)			
(iii)			
(iv)			
(v)			
(vi)			
(vii)			
(viii)			

2. Please indicate number of members of your household that suffered from each of the different diseases listed below between Jan. 1, 2019 and Dec 31, 2019. (If any)

Type of Disease	Male	Female	Total
(i) Diarrhoea			
(ii) Dysentery			
(iii) Measles			
(iv) Pneumonia			
(v) Typhoid Fever			
(vi) Malaria			
(vii) Cholera			
(viii) Polio			
(ix) Yellow Fever			
(x) Chicken pox			
(xi) Diphtheria			
(xii) Cancer			
(xiii) Tetanus			
(xiv) Tuberculosis			
(xv) AIDS			
(xvi) Guinea worm			
(xvii) Sleeping Sickness			
(xviii) River blindness			

(xix) Stroke			
(xx) Others (Specify)			

3. Please indicate how many members of your family that are below 5 years who have suffered from the under-listed conditions between Jan. 1, 2019 and Dec 31, 2019.

Clinical Condition	Male	Female	Total
(i) Kwashiokor			
(ii) Anaemia			
(iii) Rickets			
(iv) Goitre			
(v) others (specify)			

4. How many members of your family have died from each of the diseases listed below between Jan.1, 2019 and Dec 31, 2019 (If any)

Type of Disease	Male	Female	Total
(i) Diarrhoea			
(ii) Dysentery			
(iii) Measles			
(iv) Pneumonia			
(v) Typhoid Fever			
(vi) Malaria			
(vii) Cholera			
(viii) Polio			
(ix) Yellow Fever			
(x) Chicken pox			
(xi) Diphtheria			
(xii) Cancer			
(xiii) Tetanus			
(xiv) Tuberculosis			
(xv) AIDS			
(xvi) Guinea worm			
(xvii) Sleeping Sickness			
(xviii) River blindness			
(xix) Stroke			
(xx) Others (Specify)			

Health Seeking Behaviour Data

1. Indicate types/number of health care institutions in your community?

Types	Total Number	Total Number of Midwives / Nurses	Total Number of Doctors	Total Number of Medical Staff
(i) Hospital				
(ii) Maternity				
(iii) Dispensary				
(iv) Health Center				
(v) Private Clinic				
(vi) Patent Medicine Store				

(vii) Pharmacy (Chemist)				
(viii)Traditional Healing Homes				

2. What treatment did/do you employ when sick?

i) Attended hospital/clinic
ii) Buys drugs from nearby chemist
iii) Consult native doctors
iv) Self medication

3. Where did/you go for child delivery(ies)?

(ii) Attend hospital/health centre ….
(iii) Maternity/private clinic …….
(iv) At home alone ……
(v) Native Doctor/traditional midwife
(vi) Any other (specify) ……

Environmental Health Data:

1. What is the major source of water available to your household? (tick the correct option)
   (i) River/Stream
   (ii) Well
   (iii) Pond
   (iv) Rain Water
   (v) Public pipe-borne water
   (vi) Mono pump
   (vii) Borehole (Commercial)
   (viii) Borehole (private)
   (ix) Commercial tanker

2. What type(s) of residential houses do you have in your community? (Tick the correct option)

Types of Houses (by Nature of construction Materials)	Total Number
(i) Wood (Batcher)	
(ii) Mud	
(iii) Corrugated iron sheets (zinc batcher)	
(iv) Cellophane (nylon)	
(v) Thatch	
(vi) Block (cement or brick)	
(vii) Others (Specify)	

3. How many persons live in a house?_____

4. How many rooms are in your house / residence?_____

5. What type of toilet facility do you use? Please tick from below.
   (1) Pit
   (2) Bush
   (3) Prier head

(4) Bucket

(5) Water closet

(6) Others (specify)_____

6. How do you dispose of your household refuse? Please tick from the list below.

i) Private open dump
ii) Public open dump
iii) Organized collection (by Local Government, Community etc)
iv) Organized collection *by Individual – Commercial)
v) Burning
vi) Bush
vii) Burying
viii) River/Stream