ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF THE PROPOSED PALM OIL MILL EXPANSION PROJECT AT OVIA-SOUTHWEST LOCAL GOVERNMENT AREA, EDO STATE, NIGERIA

BY

OKOMU OIL PALM COMPANY

FINAL REPORT

NOVEMBER 2017

Environmental Impact Assessment (EIA) of the Proposed Palm Oil Mill Expansion Project at Ovia- Southwest Local Government Area, Edo State, Nigeria

By Okomu Oil Palm Company Plc

Submitted to;

Federal Ministry of Environment, Abuja

Final Report

Prepared by

Foremost Development Services Limited

21 Mercy Eneli Street, Surulere, Lagos. Tel: 01-8981250, 08033314800.
Email:foremost.development@gmail.com, Website: www.foremostdevelopmentservices.com

November 2017

TABLE OF CONTENT

LIST OF TABLES

LIST OF MAPS

LIST OF FIGURES

LIST OF PLATES

LIST OF ANNEXURE/APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

AGO -Automotive Gas Oil
ALARP -As low as reasonably practical
ANC -Antenatal Care
APHA -American Public Health Association
BOD -Biochemical Oxygen Demand
BS -Base Saturation
BSR -Basal Stem Rot
CBD -Convention on Biological Diversity
CBR -Crude Birth Rate
CEC -Cation Exchange Capacity
CDR -Crude Death Rate
CH_4 - Methane
CITES -The Convention for the Prevention of International Trade in Endangered Species
Cm -Centimeter
CO_2 -Carbondioxide
COD -Chemical Oxygen Demand
CSR -Corporate Social Responsibility
CPO -Crude Palm Oil
CPKO -Crude Palm Kernel Oil
dB(A) -Decibel
DO -Dissolved Oxygen
DOE -Department of Environment
EC -Electrical Conductivity
ECEC -Effective Cation Exchange Capacity
EEA -Environmental Evaluation Assessment
EFB -Empty Fruit Bunch
EHS -Environmental Health and Safety
EIA -Environmental Impact Assessment
EMP -Environmental Management Plan
EMS -Environmental Management System
ERM -Electrical Resistivity Methodaaa
ERP -Emergency Response Plan
ESAs -Environmentally Sensitive Areas
ESMP -Environmental and Social Management Plans
ETPs - Effluent Treatment Plants
FDS -Foremost Development Services Limited
FEPA -The Federal Environmental Protection Agency
FFA -Free Fatty Acids
FFB -Fresh Fruit Bunch
FMARD - Federal Ministry of Agriculture and Rural Development
FMEnv -Federal Ministry of Environment

FSC -Forest Stewardship Council
GC-FID -Gas Chromatography with flame ionization Detector
GHG -Green House Gas
GPS -Geographic Positioning System
Ha -Hectare
HCVF -High Conservation Value Forest
HIA -Health Impact Assessment
HIV/AIDS - Acquired Immune Deficiency Syndrome
Hr - Hour
HRT -Hydraulic Retention Time
HSE -Health Safety and Environment
IEE -Initial Environmental Examination
IFC -International Finance Corporation
IUCN -International Union for the Conservation of Nature and Natural Resources
KII -Key Informant Interviews
LC -Least Concern
LGA -Local Government Area
MgO -Magnesium Oxide
MOP -Muriate of Potash
MOU -Memoranda of Understanding
NCF -Nigerian Conservation Foundation
NES -Nigerian Environmental Society
NESREA -National Environmental Standards and Regulations Enforcement Agency
NGO -Non Governmental Organization
NIFOR -Nigerian Institute for Oil Palm Research
NIMET -Nigeria Meteorological Agency
NOS -Non Oily Solids
NPK -Nitrogen Phosphorus Potassium fertilizer
NSE -Nigeria Stock Exchange
OKM -Okomu
OOPC - Okomu Oil Palm Company
PAT -Profit After Tax
P&C -Principles & Criteria
PK -Palm Kernel
PKC -Palm Kernel Cake
PKO -Palm Kernel Oil
PKOF -Palm Kernel Oil Factory
POM -Palm Oil Mill
POME -Palm Oil Mill Effluent
POPs -Persistent Organic Pollutants
PPE -Personal Protective Equipment
PS -Performance Standards
RAMSAR -Convention on the Protection of Wetlands of International Importance

RBDPO -Refined, Bleached and Deodorized Palm Oil
RSPO -Roundtable on Sustainable Palm Oil
SFB -Sterilized Fruit Bunches
SHOC -Safe Handling of Chemicals
SIA -Social Impact Assessment
SMP -Social Management Plan
SPC -Standard Plate Count
SPO -Special Palm Oil
SPM - Suspended Particulate Matter
SSP -Single Super Phosphate
STD -Sexually transmitted diseases
TCPC - Technical committee on Privatization and Commercialization
TDS -Total Dissolved Solid
THC -Total Hydrocarbon Content
TN - Total Nitrogen
TOC -Total organic Carbon
TOR -Terms of Reference
UNCCD -United Nation Convention on Combating Desertification
UNDP -United Nation Development Programme
UNFCCC -UN Framework Convention on Climate Change
US -United State
VES -Vertical Electrical Sounding
VOC -Volatile Organic Compound
WHO -World Health Organization
Yr -Year

WEIGHTS AND MEASURES

kVA (kilovolt-ampere)	– 1,000 volt-amperes
kW (kilowatt)	– 1,000 watts
kWh (kilowatt-hour)	– 1,000 watts-hour
MW (megawatt)	– 1,000,000 watts
MT	- Metric Tonne
W (watt)	– unit of active power
T (Ton)	– 1,000 kilogram

EIA STUDY TEAM AND REPORT PREPARERS

The EIA study and report were carried out and prepared by Foremost Development Services' multi-disciplinary team of consultants including:

Names of Consultant	Qualification	Role Played
Mr. F.A. Afolabi	M.Sc. Development Planning	Overall job execution and delivery
Professor Kokunre Eghafona	PhD. Socio-Cultural Anthropology Rural sociology	Team Leader, Social Impact Assessment (SIA).
Professor Chris Oke	PhD. Forestry Management	Biodiversity studies, Flora and Fauna.
Mr. A. A. Olanigan	M.Phil. Environmental Management & Protection	Environmental Monitoring; Determination of Sampling Control Point, Air Quality, Water Quality, Noise Measurement, Field work coordinator.
Mr. Abiodun Makinde	B.Sc. Soil Science	Community Liaison Officer and Field Assistant, Team member; Soil Survey,
Mr. M. O. Ajala	B.Sc. Geology/Water Resources)	Environmental Geology and Soil Analysis
Henry Okeke	M.Sc. Remote Sensing and Geographic Information System (GIS)	GIS Expert
Dr. Femi Oyediran	PhD. Environmental Management	Public Analyst
Phemolab Environmental Service (No. 15A, Niyi Ayeye street off channels TV Avenue, OPIC Estate (Via Berger), Isheri, Ogun-state)	Federal Ministry of Environment Accredited Laboratory	Technical and Laboratory Services

ACKNOWLEDGEMENTS

The Management of the Okomu Oil Palm Company Plc is grateful to:

1. Our experienced consultant, Foremost Development Services Limited for the execution, compiling and writing this report. We also thank the following Okomu Oil Palm Company Plc staff who worked dedicatedly with the consultant on this study:

Dr. Graham Hefer;	*Managing Director*
Mr. Leonit Shaji ;	*Industrial Coordinator*
Mr. Samuel Oseghale	*Mill Manager*
Mr. Allain Mary;	*Financial Director*
Mr. Mikle George;	*HSE Manager*
Paulyn Ojukwu;	*Managing Director's Secretary*

2. Federal Ministry of Environment:
   a. Abuja Staff:
      Mr. J. Alonge; Director, Environmental Assessment
      Mr. A. Mohammed
   b. Zonal Office, Benin City, Edo State:
      Mr. P.A. Bagudu; Controller, EdoState
      Mr. Chris Aiwuyo
      Mr. Charles Enoyoze
3. Edo State Ministry of Environment and Sustainability
   Mrs. Eunice Ekhator
4. Ovia Southwest Local Government Area, Edo State
5. The adjoining communities and migrant camps.

EXECUTIVE SUMMARY (ES)

ES 1.0 Purpose and Need for the Project

The Okomu Oil Palm Company Plc (OOPC) has been planting oil palm (*Elaeis*) since 1979. The company in addition acquired an existing plantation of about 6000 hectares with both mature and immature trees in 2000. The bulk of the new plantings have attained the harvesting age and the acquired plantation has increasingly been producing FFB in the last five years.

As the bulk of the plantations attain full maturity, the future prospects of the company is threatened by the following problems and hindrances if the existing capacity is maintained: (i) There is no palm oil mill in the neighborhood to absorb the excess FFB produced on the plantations; (ii) The risk is high of large quantities of FFB not being harvested and rotting on the trees; (iii) Loss of value added advantage; (3) High prospects of loss of revenue.

In order to address these problems, the Okomu Oil Palm Company Plc (OOPC) proposes to expand the capacity of the mill from the existing 30MT FFB/hour to 60MT FFB/hour to process the excess FFB to be harvested from its plantations. The operation of the expanded palm oil mill would enhance the revenue base of the company and help it to further meet its financial obligations to its employees and shareholders and improve on its corporate social responsibilities.

ES 2.0 The Proponent

The Okomu Oil Palm Company Plc (OOPC Plc) is an agricultural and food-processing company located at Okomu-Udo, Ovia Southwest Local Government Area, Edo State, Nigeria. The company specializes in plantation development and production of special palm oil, palm kernel oil and palm kernel cake and crump rubber. It started operation in 1976 as a Federal Government project and was privatized in 1990. The then Bendel State government granted the company a total concession of about 15,000 hectares within the Okomu forest reserve in 1978. The entire 15,000 hectares of the total concession at the main estate has been developed into oil palm and rubber plantations.

The company operates the Main Estate (a concession of 15,000 hectares) and the Extension One Estate (a concession of 6,000 hectares), both located in Edo State. It supplies special palm oil, palm kernel oil, palm kernel cake and crump rubber.

The Okomu Oil Palm Company Plc has over 14,000 individual and institutional shareholders, both Nigerian (40%) and foreign (60%). The company employs about 692 permanent workers including expatriates and Nigerians.

ES 3.0 Proposed Project Locations and Description

The mill expansion project is located beside the existing mill at OOPC main estate where the company headquarters is situated. The company is located at Okomu-Udo, within the Okomu Forest Reserve in Ovia Southwest Local Government Area of Edo State, Nigeria. The company is accessible through a network of roads from Lagos and Benin City. It lies between latitude $5^0$07.120' and $5^0$25.220'E and longitude $6^0$18.870' and $6^0$26.110'N.

The proposed project is mill expansion from its present 30MT FFB/Hr to 60MT FFB/Hr with total land area of about 972m^2. The proposed mill expansion project is a modern palm oil mill with a tilting sterilization system, which will consist of five (5) major components namely: Mill Processing Line with all its components; Reception Station; Sterilization Station; Boiler Station and Palm Oil Mill Effluent (POME) Treatment Ponds.

ES 4.0 EIA Study Procedure

The EIA study was carried out after due consultation with the Federal Ministry of Environment (FMEnv), and in accordance with the Ministry's Procedural Guidelines, and Terms of Reference (TOR) and scope of work, approved by the Ministry.

ES 5.0 Verification by the FMEnv

The FMEnv visited the proposed mill expansion project site in order to verify the proposals and statements in the OOPC Plc's application for an environmental impact assessment permit.

ES 6.0 Period of EIA Study

Field data gathering for scientific studies of the existing environment was carried out in June 2014 and September 2015 for wet season and February to March 2015 for dry season. Stakeholders were consulted from September 2014 to January 2015.

ES 7.0 Consultations with and Participation by Stakeholders

The Stakeholders identified were: (i) Federal Ministry of Environment (FMEnv), (ii) Ministry of Environment and Public Utilities, Edo State; (iii) Ovia southwest Local Government Area; (iv) Project's neighbouring community, Udo), which is about 25 km away from project site and outside the project's area of influence.

The objective of the consultation was to inform and educate stakeholders on details of the project, its justification, discuss the scope of study and the project's potential and associated environmental impacts, and obtain their views and

comments. The summary of the community's assessment of the likely environmental impacts of the proposed project was that the proposed project would largely have insignificant adverse impacts.

ES 8.0 Project Justification

The proposed project will complement considerably both the Agricultural Transformation Agenda (ATA) and the economic transformation strategy and plans of the country. Justification is therefore found for the mill expansion project in its potential to: i) Add value to the existing production of the company, ii) Provide and sustain direct employment, iii) Continuous creation of additional jobs, iv) Contribute to the socio-economic development of Udo community, and iv) Increased economic benefits to the nation.

ES 9.0 Envisaged Sustainability

In order to achieve the desirable sustainability of the proposed mill expansion project, OOPC Plc will develop and operate the project based on industry best practices, applying especially the IFC Performance Standards and the Principles and Criteria of the Roundtable on Sustainable Palm Oil (RSPO).

Technically, best hands and agricultural practices shall be employed to carry out the project to ensure its technical sustainability while environmental sustainability will be attained through the OOPC Plc Environmental Management System (EMS) that is already in place. The life span of an oil mill is about 30 years or more after which the oil mill can again be upgraded.

The project will be financed from the company's yearly turnover and profits. The financial performance of the company has improved considerably. OOPC Plc is listed on the Nigerian Stock Exchange. The financial performance of the company over the years would enable it to execute and sustain the project operations. The estimated cost of the project is about N600 billion, Nigerian Naira.

ES 10.0 Relevant Environmental Laws, Decrees, Regulations and Edicts

The following laws and regulations apply to the proposed project: (i) National Policy on Environment (FEPA, 1989); (ii) EIA Act Cap E12 LFN, 2004; (iii) National Guidelines and Standards for Environmental Pollution Control in Nigeria, (FEPA,1991); (iv) National Effluent Limitations Regulations S.I.8 (FEPA,1991); (v) National Pollution Abatement in Industries and Facilities Generating Wastes Regulations S.I.9 (FEPA,1991); (vi) S. I. 15 National Environmental Protection (Management of Solid and Hazardous Wastes) Regulations 1991. (vii) National Environmental Standards and Regulations Enforcement Agency (NESREA), 2007. (viii) Environmental Edicts of Edo States' Ministry of Environment and Public Utilities; (ix) Edo State Environmental Waste

Management Board Edicts/Mandate; (x) Local Government Area Mandate on environmental sanitation and solid waste management; (xi) Factory Act 1990; (xii) Land Use Act Cap L5 LFN, 2004; (xiii) The Nigerian Urban and Regional Planning Laws.

ES 11.0 Existing Baseline Environment

The biophysical socio-economic and health environments that might be impacted by the proposed project were ascertained from field data gathering within the spatial boundaries of the study area which is about 5 km from project boundaries, previous natural resources and environmental studies and in-house environmental records of the company in the periods indicated in ES 4.0 in dry and wet seasons 2014/2015/2016. A total of 18 sampling stations, geo-referenced with a GPS, were established.

11.1 Climate and Meteorology

Rainfall, temperature and sunshine hours (1995-2014),wind speed and direction, relative humidity and atmospheric pressure were obtained from meteorological record of the Okomu Oil Palm Company Plc.

11.2 Air Quality and Noise Level

Automatic reading equipment was employed to determine air quality, north and south of the project site. The concentrations of SO_2, H_2S, CO, CO_2, NO_X, were all below the limits set by FMEnv. The concentrations of particulates were also below the set limit, showing clean, unpolluted ambient air in the locations. Except for the existing palm oil mill (POM) powerhouse [91.6dB(A) and 99.2 dB(A)], the noise levels were well below the FMEnv exposure level of 90dBA.

11.3 Geology and Geomorphology

The geology of the area at the proposed factory location comprises two main sedimentary formations namely (a) coastal sedimentary lowlands (about 80%) and (b) coastal alluvium mangrove and freshwater swamp (about 20%). The area contains arenecious sands, which are generally consolidated and porous. It is very prolific with extensive aquiferous zone. It may yield sub-artesian to artesian water if conditions are favourable. The overlying soils are acidic (pH 4.34 to 6.90).

11.4 Soil Physico-Chemical Characteristics and Microbiology

The soils are very deep, well drained sandy loam and loamy sand. Wetland soils occur at localized wet spots and swamps. Soils were rich in micro-organism species diversity but the percentage of hydrocarbon utilizing micro-organisms was very low below the detection limit showing that there were no chronic pollution from oil and grease/hydrocarbons in the proposed mill expansion area.

Table 4-11 shows the dominant species of soil micro-organisms at swamps around the proposed mill expansion at Okomu Oil Palm Company Plc. As there were no significant differences observed in topsoil and subsoil samples, so therefore only topsoil data are presented. The predominant heterotrophic and hydrocarbon utilizing bacterial species present in the soils were: *Bacillus sp., Corynebacterium sp., Micrococcus sp.* These microbial groups have been associated with organic transformation and re-cycling in soils. Some *Fusarium* species cause oil palm diseases such as vascular wilt.

Population levels of hydrocarbon utilizers in soil, sediment and water reflects the historical exposure of these habitats to hydrocarbons. Sizeable increase in the population of hydrocarbon utilizing micro-organisms occurs when a particular environment is exposed to hydrocarbons such as petroleum and vegetable oils. The population levels within the microbial community are used as indication of or index of sensitivity to environmental exposure to hydrocarbons. In unpolluted ecosystem, hydrocarbon utilizers constitute less than 0.1% of the total microbial community. While in oil polluted ecosystem, they constitute more than 1.0% and up to 100.0%. But in the case of the proposed study area, the hydrocarbon utilizers constitute less than 0.1% of the total microbial community.

11.5 Vegetation and Forestry

The vegetation at the proposed factory area is predominantly trees (palm and rubber trees) of economic importance to the company except at the eastern part of the proposed factory, which had a vegetation of dense freshwater swamp of riparian forests dominated by raffia palms. There were no IUCN Red-listed categories of threatened, endangered, rare and endemic plants, medicinal and economic crops.

11.6 Terrestrial Fauna and Wildlife

The most diverse in species richness found at the proposed mill expansion area were butterflies, and beetles. No IUCN Red listed endangered, rare and endemic species were present and neither the wildlife listed in the Federal Government Decree No. 11, 1985 which prohibits international trade and traffic on them were present in the freshwater swamp forest along the surface rivers of the study area. The decree is in response to the convention on International Trade on Endangered wild species of fauna and flora (CITES).

Most of the Okomu Oil Palm Company Plc land concessions have been planted with oil palms and rubber trees of different ages leaving mainly ecological sensitive areas (wetland, watersheds etc). The entire banks of the

flowing rivers inside the company are populated by riparian forests stretching across the six rivers within the estate.

11.7 Surface and Groundwater Assessment

The quality of all the streams (6 Nos.) and the Okomu River were good (both source and outlet). The waters were clean and unpolluted, except for the pH that was generally acidic with value ranging between 5.54 and 6.93 in dry season and 5.80 and 6.98 in wet season. The rivers are perennial. The physico-chemical, microbiological and heavy metals concentrations in both wet and dry seasons were all within the permissible limits recommended by FMEnv.

The groundwater quality is good and free from pollution except for pH that is generally low. The water samples from nearby sources have all the physico-chemical and microbiological parameters within the permissible limits recommended by WHO and FMEnv for wholesome water

11.8 Land Uses

There were no built up areas/settlements, private oil palm estate and rubber plantations, farmlands in the study area.

11.9 Socio-Economic Environment

There were no settlements within 25 km radius of the proposed project site. However, for Udo, which is over 25km away, the traditional administrative structure, associations and organizations, culture, religion, archaeology, demographic characteristics and occupation are not affected but instead the income of the Udo community is positively affected.

ES 12.0 Present Impacts and Significant Potential and Associated Environmental and Health Impacts

The summary of current environmental and social impacts of the existing oil mill and proposed mill expansion were determined. Similarly, major/significant anticipated impacts arising from the mill expansion project were examined and considered at four phases but with more emphasis on three phases including: (i) Construction; (ii) Operation; (iii) Decommissioning and Abandonment.

The significant impacts of the proposed palm oil mill expansion project include: 1.) Heavy machinery use; 2.) Installation of equipment; 3.) Generator use; 4.) Civil, electrical and mechanical works; 5.) Solid waste disposal; 6.) Transportation of FFB; 7.) Noise and Gaseous emissions; 8.) Palm Oil Mill Effluent (POME) disposal; 9.) Laying off staff and 10.) Palm Oil Mill abandonment.

ES 13.0 Mitigation Measures

Mitigation measures are defined for the identified significant associated and potential impacts based on the following criteria:

- **Prevention –** design and management measures for ensuring that significant potential impacts and risks do not occur,
- **Reduction –** operational and management measures for ensuring that the effects or consequences of those significant associated and potential impacts that cannot be prevented are reduced to a level as low as reasonably practical (ALARP)
- **Control -** Operational and management measures for ensuring that residual associated impacts are reduced to a level as low as reasonably practical (ALARP).

However, most of the significant environmental impacts that can likely arise from the construction and operation of the proposed palm oil mill expansion project can be mitigated once appropriate precautions are in place as defined in Tables 6-1 to 6-3.

ES 14.0 Proposed Environmental and Social Management Plans, (EMP and SMP)

All mitigation measures will be adhered to by the Environment, Health and Safety (HSE) department of the company; (i) Emissions testing, Laboratory analysis of groundwater and POME will be done and reporting will be done in accordance with the regulatory requirements and record submitted to FMEnv; (ii) Fire prevention precautions will be in place as required by the State Fire Service; (iii) All firefighting equipment will be inspected and maintained regularly; iv) Regular inspections will be conducted to verify the integrity of the fuel tanks. v) Written procedures governing the operation of the fuel tanks and precautions to be taken will be developed; (vi) The occupational health, safety and environmental policies shall be implemented; vii) Capacity building programme for mill staff including awareness, in-plant training, seminars, workshops and short courses shall be undertaken regularly to enhance the implementation of the EMP.

The environmental monitoring programme would cover a number of parameters including meteorology, ambient air quality, surface water quality, groundwater quality, palm oil mill effluent quality and noise levels. All these would be regularly monitored by OOPC.

The schedule of EMP detailing impact, mitigation measures, actions to be taken and the persons responsible for mitigation actions has also been drawn. It will equally be monitored for compliance.

ES 15.0 Decommissioning

The approaches to the decommissioning of the palm oil mill would involve the combination of assets recovery, dismantling, demolition, decontamination and remediation.

ES 16.0 Conclusion

The EIA process demonstrates that the mill expansion project at OOPC main estate will fully comply with legislative requirements in Nigeria and other relevant international regulations applicable to the planned activities and operations.

The proposed project is an attestation to the sustainable growth of oil palm industry, which will result in substantial economic benefits for Nigeria through employment opportunities generation in particular during the construction and operation phases.

This EIA also indicates that discharges including wastewater and/or effluent, gaseous emissions and noise are expected from the operation of the palm oil mill. However, any such discharges, which can be considered as potential sources of adverse environmental effects, can be fully managed through preventive actions and mitigating measures. This means that no significant negative impact on the natural, health and social environmental sensitivities of the project area is expected to result from discharges, let alone the occurrence of a residual impact.

The Project is environmentally and socially sound, and will promote balanced and environmentally sustainable operation of Okomu Oil Palm Company Plc (OOPC).

CHAPTER ONE

1.0 INTRODUCTION

1.1 History and Business of Okomu Oil Palm Company Plc

The proponent of the proposed Palm Oil Mill Expansion project; The Okomu Oil Palm Company Plc (OOPC Plc) is an agricultural and food-processing company located at Okomu-Udo, Ovia Southwest Local Government Area, Edo State, Nigeria. The company specializes in plantation development and production of special palm oil, palm kernel oil and palm kernel cake.

The Okomu Oil Palm Company Plc was established in 1976 as a Federal Government pilot project aimed at rehabilitating oil palm production in Nigeria. At inception, the pilot project covered a surveyed area of 15,580 hectares out of which 12,500 hectares could be planted with oil palm. It was incorporated on December 3, 1979 as a limited liability company.

In 1990 the Technical Committee on Privatization and Commercialization (TCPC) privatized the company on behalf of the Federal Government of Nigeria. At the turn of the millennium, the company acquired a 6,000 hectares property known as Extension One to further boost its available hectarage.

The Okomu Oil Palm Company Plc has since grown to become one of Nigeria's leading agricultural companies. Presently Okomu has almost 10,000 ha of oil palm of which 8713 ha is mature and 7500 of rubber of which around 5000 ha is mature. It has also expanded its milling capacity from a meagre 1.5 tonnes FFB/hr in 1985 to 30 tonnes FFB/hr in 1992.

The steady rise in the size of the plantation has resulted in increase in the FFB production, which in turn has necessitated a further increase in the milling capacity to 60 tonnes FFB/hr, thus making the company to operate the largest mill in Nigeria.

The privatization of The Okomu Oil Palm Company has been a great success and a huge encouragement for the Nigerian agricultural sector, with profound positive consequences of stable socio-economic growth for the region where it is located. The company has consistently posted profits in the last 15 years; a period during which most other similar establishment in the country have either folded up or performing sub-optimally.

What is most inspiring is not just the growth and profitability of the company, but the fact that it is the only agri-business in the NSE's top 18 companies with the largest turnovers.

Today, what is now known as The Okomu Oil Palm Company Plc has transformed into an economic success, earning presidential recommendation and recording over 300 percent rise in profit-after-tax (PAT). The excellent quality of the palm oil and crumb rubber produced by the company, guarantees premium selling prices on the local and international markets.

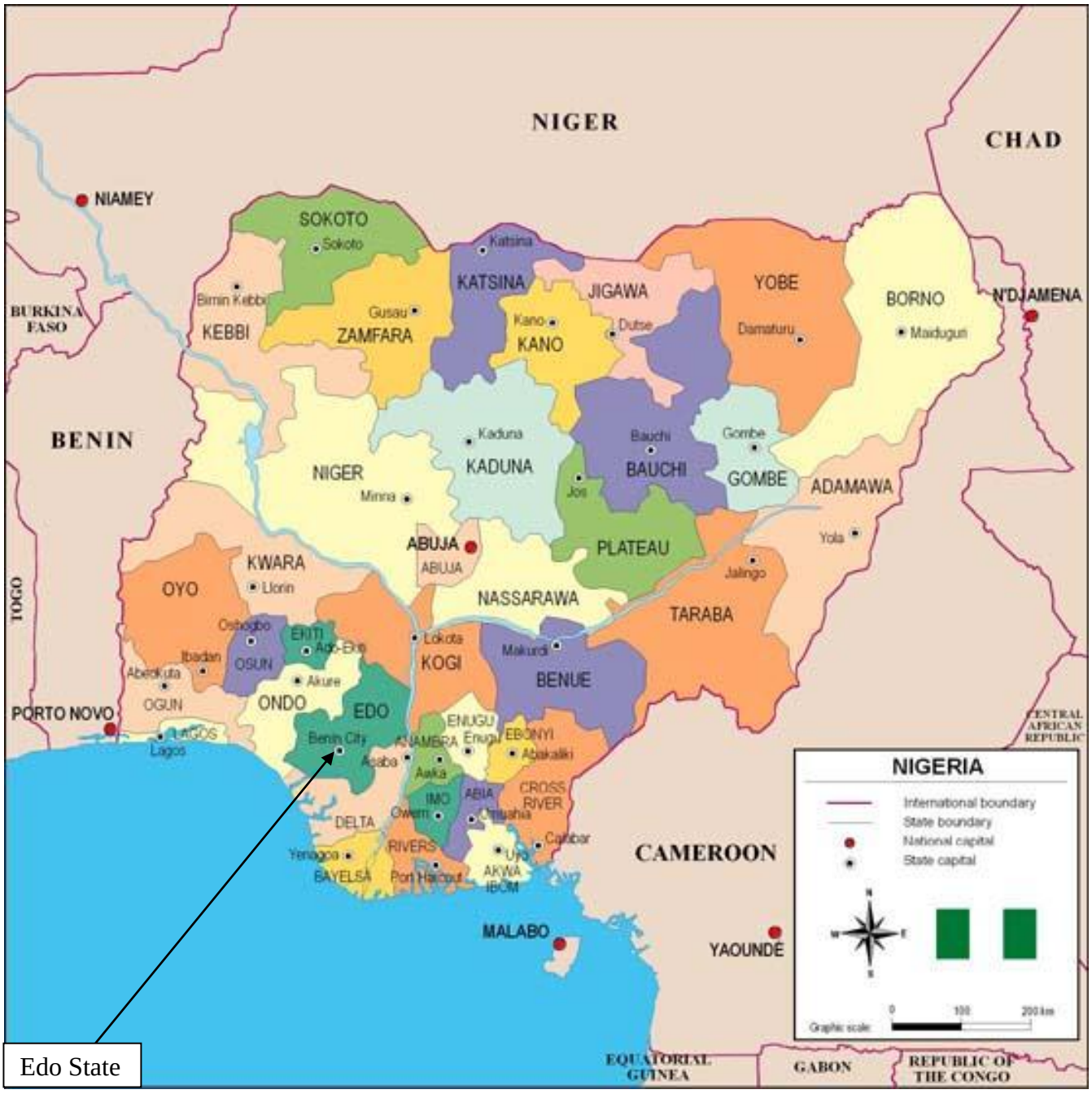
Just as the company is expanding in size, its corporate environment is also expanding. The Company has over 12,000 individual and institutional shareholders, both Nigerian (40%) and foreign (60%). Currently, the company employs over 2000 permanent staff and several independent sub-contractors. All these have added up to place Okomu Oil Palm Company Plc on top in the burgeoning oil palm business and to position it as an emerging leader in rubber production.

Okomu Oil Palm Company Plc benefits from the quality management provided by its main shareholders and technical partner, Socfinco SA, with a 62% shares in Okomu Oil Palm Plc. Socfinco SA is the biggest single shareholder that brings into Okomu a little under a century of sound acclaimed technical expertise in the world stage on tropical agriculture.

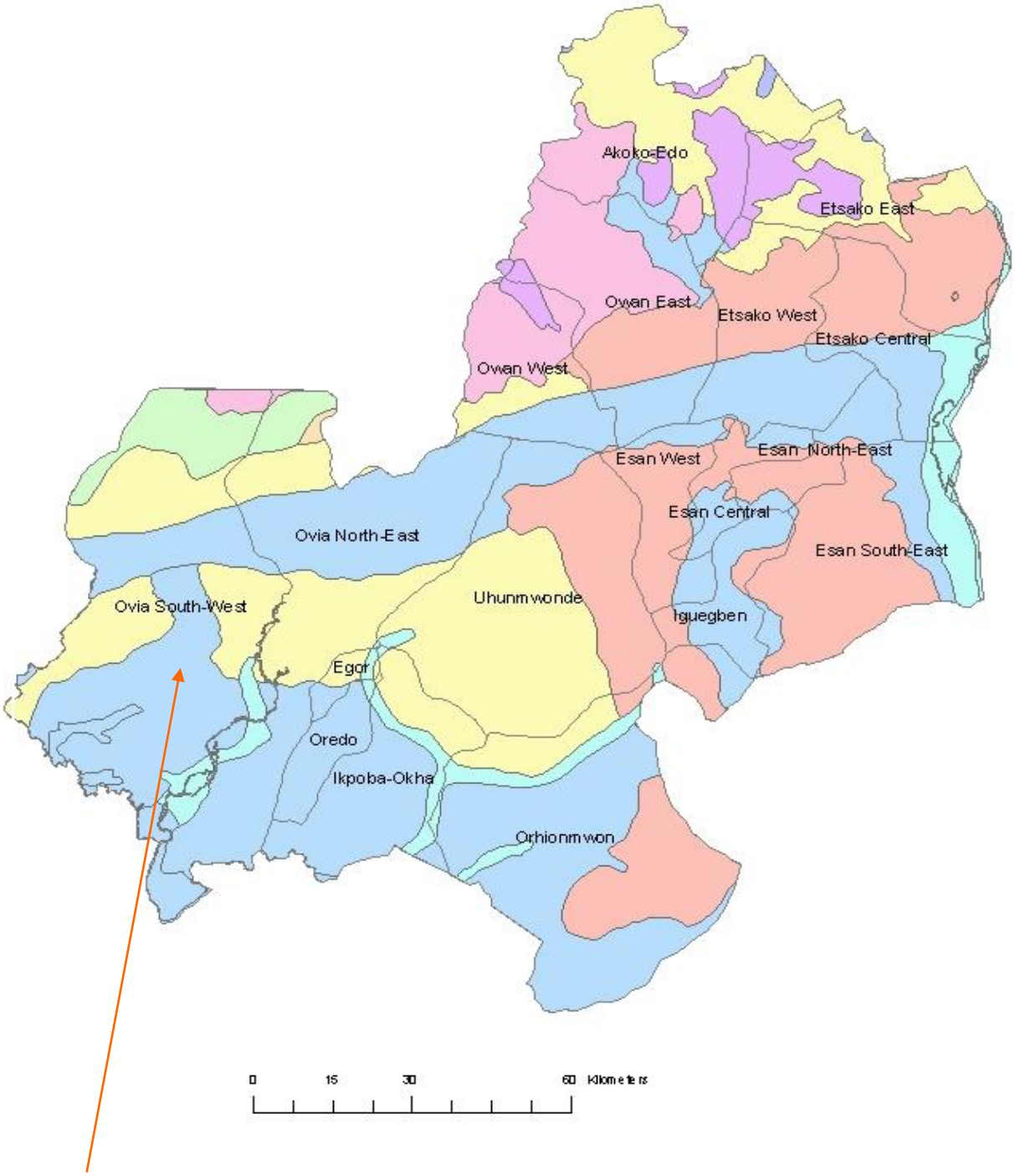
Socfinco SA is a global player in the cultivation of oil palm, rubber, coffee and tropical flower. Socfinco SA founded in 1912 was the first industrial company to plant oil palm in Africa and Indonesia. It has ongoing plantations in Cote D'ivoire, Liberia, Guinea, Cameroun, Indonesia, Kenya Sierra Leone and Congo.

1.2 Location and Access

The company is located at Okomu-Udo, within the Okomu Forest Reserve in Ovia Southwest Local Government Area of Edo State, Nigeria. The company is accessible through a network of roads from Lagos and Benin City. It lies between latitude $5^0$07.120' and $5^0$25.220'E and longitude $6^0$18.870' and $6^0$26.110'N. (see Map 1-3: Location Map)



Map 1-1: Map of Nigeria indicating Edo State



Ovia Southwest LGA

Map 1-2: Map of Edo State indicating Ovia Southwest LGA

Map 1-3: Palm Oil Mill Location within OOPC Plantation Map

1.3 Activities

The company undertakes plantation agriculture involving the growing of oil palm (*Elaeis guineensis*) and the processing of Fresh Fruit Bunches (FFB) into special palm oil. The company is also involved in the planting and tapping of rubber trees (*Hevea brasilenses*), and also the processing of cup lumps into crumb rubber. The major activities of the company include the oil palm plantation, palm oil mill, rubber plantation and rubber factory operations.

1.4 Mission Statement of The Okomu Oil Palm Company Plc

"To be Nigeria's leading agribusiness, through the efficient and effective management of our various plantations by a highly motivated workforce, working in harmony with other stakeholders, and continuously returning favourable results to our shareholders".

1.5 Literature Review on the Palm Oil

Fruit of oil palm tree

Palm oil is rich in carotenoids, (pigments found in plants and animals) from which it derives its deep red colour, and the major component of its glycerides is the saturated fatty acid palmitic; hence it is a viscous semi-solid, even at tropical ambient, and a solid fat in temperate climates.

Because of its economic importance as an high-yielding source of edible and technical oils, the oil palm is now grown as a plantation crop in most countries with high rainfall (minimum 1 600 mm/yr) in tropical climates within 10° of the equator. The palm bears its fruit in bunches varying in weight from 10 to 40 kg. The individual fruit, ranging from 6 to 20 gm, are made up of an outer skin (the exocarp), a pulp (mesocarp) containing the palm oil in a fibrous matrix; a central nut consisting of a shell (endocarp); and the kernel, which itself contains an oil, quite different to palm oil, resembling coconut oil.

Figure 1-1: Fresh Fruit Bunch (FFB)

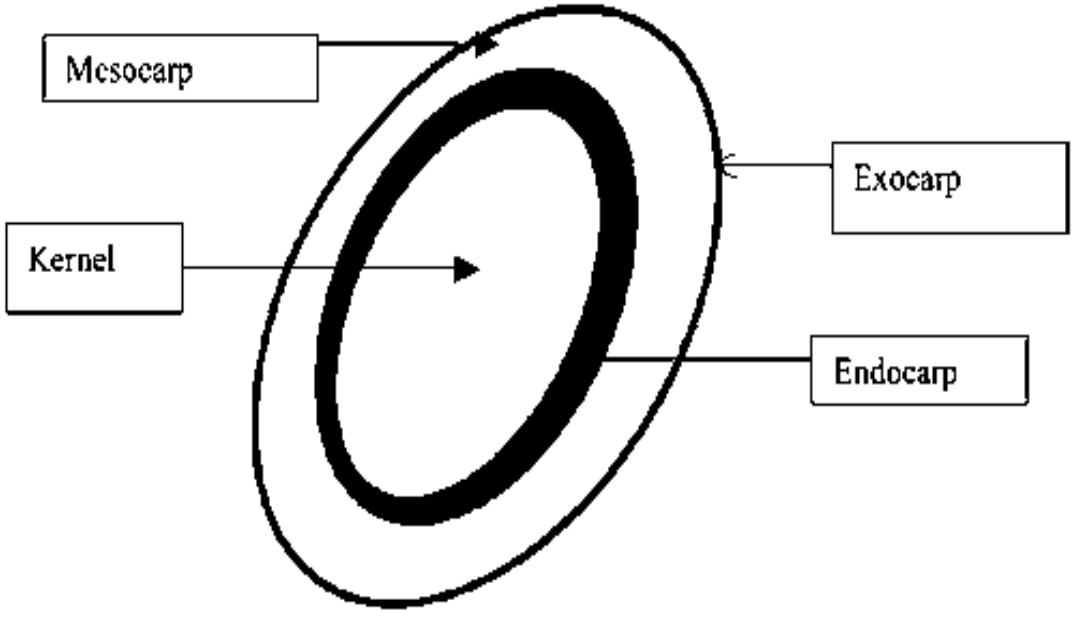


Figure 1-2: Structure of the palm fruit

The wild oil palm groves of Central and West Africa consists mainly of a thick-shelled variety with a thin mesocarp, called Dura. Breeding work, particularly crosses between Dura and a shell-less variety (Pisifera), have led to the development of a hybrid with a much thicker mesocarp and a thinner shell, termed Tenera. All breeding and planting

programs now use this latter type, the fruits of which have a much higher content of palm oil than the native Dura.

Modern high-yielding varieties developed by breeding programs, under ideal climatic conditions and good management, are capable of producing in excess of 20 tonnes of bunches/ha/yr, with palm oil in bunch content of 25 percent. This is equivalent to a yield of 5 tonnes oil/ha/yr (excluding the palm kernel oil), which far outstrips any other source of edible oil.

Palm Oil

Palm oil (also known as dendê oil, from Portuguese) is an edible vegetable oil derived from the mesocarp (reddish pulp) of the fruit of the oil palms, primarily the African oil palm *Elaeis guineensis*, and to a lesser extent from the American oil palm *Elaeis oleifera* and the maripa palm *Attalea maripa*.

Palm oil is naturally reddish in color because of a high beta-carotene content. It is not to be confused with palm kernel oil derived from the kernel of the same fruit, or coconut oil derived from the kernel of the coconut palm (*Cocos nucifera*). The differences are in color (raw palm kernel oil lacks carotenoids and is not red), and in saturated fat content: Palm mesocarp oil is 41% saturated, while palm kernel oil and coconut oil are 81% and 86% saturated respectively.

Along with coconut oil, palm oil is one of the few highly saturated vegetable fats and is semi-solid at room temperature. Like most plant-based products, palm oil contains very little cholesterol.

Palm oil is a common cooking ingredient in the tropical belt of Africa, Southeast Asia and parts of Brazil. Its use in the commercial food industry in other parts of the world is widespread because of its lower cost and the high oxidative stability (saturation) of the refined product when used for frying.

1.6 Legal and Administrative Policy Framework

Nigeria has enacted a comprehensive policy and legal framework for environmental assessment and management. The country has policies, legislation, and strategies in place to manage the protected facilities, to satisfy its international obligations, and to protect the quality of the environment for the health and well-being of its citizens. The hierarchy of policies and legislative provisions for environmental management in Nigeria is comprised of different enactments ranging from the Constitution to international treaties, and to environment and resource protection laws.

The Permit and Licence obtained from FMEnv will have reporting requirements and other obligations, which will need to be fulfilled. Other regulators such as the Edo State Ministry of Environment and Public Utilities, Edo State Waste Management Board and

Federal Ministry of Labour and Employment will also have requirements. Persons who have to ensure that the obligations are fulfilled will need to be trained in the regulatory requirements.

A fundamental principle of the Nigerian environmental policy is that economic development must be in harmony with the extraction and utilization of natural resources and that air, water, and soil pollution will be controlled.

The applicable Domestic environmental laws and regulations are as follows:

1.6.1 National Legislation

The National legislation applicable to this project includes:

- Environmental Impact Assessment (EIA) Act, Cap E12 LFN 2004
- The National Policy On Environment, 1989
- National Guidelines and Standards for Environmental Pollution Control in Nigeria, 1991
- Harmful waste (criminal provision) Act 42 of 1988
- National Effluent Limitations Regulations S.I.8, 1991
- National Pollution Abatement in Industries and Facilities Generating Wastes Regulations S.I.9, 1991
- National Guidelines for Environmental Audit in Nigeria, 1999
- National Guidelines on Environmental Management System in Nigeria 1999.
- National Environmental Standards and Regulations Enforcement Agency (NESREA), 2007.
- Hazardous and solid waste management Regulations S.1.9., 1991
- Waste Management and Hazardous Waste Regulations S.I.15, 1991
- Factory Act 1990
- Nigerian Land Use Act, 1978
- Forestry Law Cap 51, 1994
- The Nigerian Urban and Regional Planning Law
- National Policy on Renewable Energy Development

Environmental Impact Assessment Act 86 of 1992

EIA act was promulgated in 1992. It makes environmental impact assessment (EIA) mandatory for all new major projects. Therefore, an EIA permit is required for the proposed project.

National Guidelines and Standards for Environmental Pollution Control in Nigeria 1991

This schedule deals with the control of industrial effluent discharge, gaseous emissions and hazardous wastes, so also noise pollution control. This schedule established environmental guidelines and standards for the abatement and control of all forms of pollution.

The proposed project would therefore have to ensure that any discharges into the land, water and atmosphere are of acceptable quality to ensure that there are no legal repercussions under this schedule.

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

These Regulations give the parameters in industrial gaseous emissions and wastewater (effluents) and their limitations, concentration and standards for discharge into land, atmosphere and receiving surface waters.

The proposed project would therefore have to ensure that any discharges into the land, water and atmosphere are of acceptable quality to ensure that there are no legal repercussions under this schedule.

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

This regulation requires every industry to install anti-pollution/pollution abatement equipment to treat effluent discharges and gaseous emissions to the standards and limits prescribed in Regulation S.I.8, 1991.

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

This regulation requires that all steps that are necessary must be taken for the effective management of solid and hazardous wastes in order to safeguard public health, ensure that waste is collected, stored, transported, recycled, reused or disposed in an environmentally sound manner and promote safety standards in relation to such waste.

National Environmental (Sanitation and Waste Control) Regulations, 2009 (S.I.28)

The purpose of these regulations is the adoption of sustainable and environment friendly practices in environmental sanitation and waste management to minimize pollution. The provisions of the regulations state that a person in care, management or control of any industrial facility shall:

(a) Provide educational and pictorial signs to direct persons where they can drop waste.
(b) Provide receptacles for recyclable materials in appropriate and easily accessible locations.
(c) Keep the premises, drains and all public or private lands, street, lanes, walkways; beaches or docks within 5 meters of the boundary of the property free from litter at all times.
(d) Ensure that discarded materials are regularly collected and disposed of sanitarily.
(e) Ensure that recyclable materials are properly packed and neatly stacked.
(f) Ensure sorting and segregation of solid waste at source.

National Environmental (Noise Standards and Control) Regulations, 2009 (S.I.35)

The purpose of these regulations is to ensure maintenance of a healthy environment for all people in Nigeria, the tranquility of their surroundings and their psychological well-being by regulating noise levels and generally, to elevate the standard of living of the people. The regulations among others state the permissible noise levels to which a person may be exposed; control and mitigation of noise; permits for noise emissions in excess of permissible levels; and enforcement.

Factories Act 1990

The regulations for Health, Safety and Welfare are under this act. This act also requires that: Before any person occupies or uses as a factory any premises which were not so occupied at the commencement of this Decree, he shall apply for the registration of such premises by sending to the Director of Factory an application containing the particulars set out in Schedule 1 to this Decree.

Any person who has not been issued a certificate of registration as aforesaid occupies or uses as a factory any premises that have not been registered as a factory shall be guilty of an offence.

Land Use Act, Cap L5, 2004

The Nigerian Land Use Act 1978 was promulgated in March 1978. It vests all land in each state of the federation (except land already vested in the Federal Government or its agencies) in the Governor of the state. It makes the state Government the authority for allocating land in all urban areas for residential, agricultural commercial and other purposes while it confers similar powers regarding non-urban areas on the Local Government in such area. The Governor of a state can revoke a Right of occupancy (statutory customary) for overriding public interest.

Forestry Law Cap 51, 1994

The Forestry Law Cap 51 is the only substantive legislation applicable to all parts of the federation. The law prohibits any act that may lead to the destruction of or cause injury to any forest produce, forest growth or forestry property. The law prescribes the

administrative framework for the management, utilization and protection of forestry resources in Nigeria.

The Nigerian Urban and Regional Planning Law

Decree 88 of 1992 established a Development Control Department (DCD) charged with the responsibility for matters relating to development, control and implementation of physical development plans at Federal, State, and Local Government levels within their respective jurisdictions.

National Policy on Renewable Energy Development

The primary objective of the National Policy on Renewable Energy Development is to encourage the diversification of sources of energy supply through renewable energy, and as such improve the energy security of the country.

1.7 International Finance Corporation (IFC) Performance Standards (PS)

Other related international guidelines include IFC Performance Standards such as:

- PS 1− Assessment and Management of Environmental and social Risks and Impacts.
- PS 2- Labor and Working Conditions
- PS 3− Resource Efficiency and Pollution Prevention
- PS 4− Community Health, Safety and Security
- PS 5− Land Acquisition and Involuntary Resettlement
- PS 6 − Biodiversity Conservation and Sustainable Management of Living Natural Resource
- PS 7 – Indigenous People
- PS 8− Cultural Heritage

IFC Environmental, Health and Safety Guidelines for Plantation Crop Production.

1.8 Roundtable on Sustainable Palm Oil – Principles and Criteria

RSPO is a not-for-pro-t association that unites stakeholders from seven sectors of the palm oil industry - oil palm producers, palm oil processors or traders, consumer goods manufacturers, retailers, banks and investors, environmental or nature conservation NGOs and social or developmental NGOs - to develop and implement global standards for sustainable palm oil. This is achieved via eight principles as follows:

Principle 1: Commitment to transparency
Principle 2: Compliance with applicable laws and regulations
Principle 3: Commitment to long-term economic and financial viability
Principle 4: Use of appropriate best practices by growers and millers
Principle 5: Environmental responsibility and conservation of natural resources and biodiversity
Principle 6: Responsible consideration of employees, and of individuals and communities affected by growers and mills
Principle 7: Responsible development of new plantings
Principle 8: Commitment to continual improvement in key areas of activity

1.9 International Agreements and Protocols

Nigeria has acceded to a number of international environmental conventions and the key ones are presented in Table 1-1. The applicable international environmental agreements and protocols include:

- The Montreal Protocol
- The Basel Convention
- The Framework Convention on Climate Change
- The Convention for The Prevention of International Trade in Endangered Species (CITES)
- Convention on Biological Diversity (CBD)

The Montreal Protocol

This protocol discourages the use of substances that deplete the ozone layer and promotes the synthesis of new and environment-friendly products.

The Basel Convention

This convention deals with the control of Trans–boundary movement of Hazardous Waste and Substances among member countries.

The Framework Convention on Climate Change

This convention requires member countries to stabilize atmospheric concentrations of greenhouse gases at levels that will prevent human activities from interfering dangerously with the global climate change.

The Convention for the Prevention of International Trade in Endangered Species (CITES)

The trade involving certain wild animals and plants whose numbers are considered to be endangered is been regulated by this convention

Convention on Biological Diversity (CBD)

This convention deals with the conservation of biodiversity, the sustainable use of its component and the fair and equitable sharing of the resulting benefits.

Table 1-1: International Environmental Conventions Signed by Nigeria

Convention	Year of Accession
African Convention on the Conservation of Nature and Natural Resources	1968
Convention on Biological Diversity CBD)	1993
UN Framework Convention on Climate Change (UNFCCC)	1994
Kyoto Protocol	1999
UN Convention on Combating Desertification (UNCCD)	1996
Convention on the Protection of Wetlands of International Importance (RAMSAR)	1998
Vienna Convention for the Protection of the Ozone Layer	1996
Montreal Protocol (regulating substances that deplete the ozone layer)	1996
Convention on International Trade in Endangered Species of Fauna and Flora (CITES)	1996
Convention on Trans-boundary Movement of Hazardous Waste (BASEL)	1997
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	2000
Stockholm Convention on Persistent Organic Pollutants (POPs)	2004
World Heritage Convention	1990
Convention on the Conservation of Migratory Species of Wild Animals (BONN Convention)	1979
International Union for the Conservation of Nature and Natural Resources (IUCN)	1956
The Equator Principles III	2013

1.10 Institutions and Regulatory Agencies

- Federal Ministry of Environment
- National Environmental Standards and Regulations Enforcement Agency
- Edo State Ministry of Environment and Public Utilities
- Edo State Environmental and Waste Management Board
- Ministry of Agriculture and Natural Resources, Edo State
- Ministry of Lands and Surveys, Edo State
- Edo State Fire Service
- Ministry of Health, Edo State
- Departments of Environment, Ovia Southwest Local Government Area of Edo State, Nigeria.
- Federal Ministry of Agriculture and Rural Development
- Agricultural Research council of Nigeria
- Nigerian Institute for Oil Palm Research

Federal Ministry of Environment
The Federal Ministry of Environment is the apex body with the broad mandate to regulate and protect the environment in Nigeria. In addition, Nigeria is party to some international agreements; protocols and conventions on Environment and is bound by their provisions and requirements.

National Environmental Standards and Regulations Enforcement Agency (NESREA)
NESREA is charged with the responsibility of enforcing all environmental laws, guidelines, policies, standards and regulations in Nigeria. It also has the responsibility to enforce compliance with provisions of international agreements, protocols, conventions and treaties on the environment.

Edo State Ministry of Environment and Public Utilities
The Edo State Ministry of Environment and Public Utilities is the arm of government responsible for regulating the environment in Edo State of Nigeria. Depending on certain peculiarities of the state, the Ministry has made and established its own laws and environmental standards, which are not inconsistent with Federal laws.

Edo State Environmental and Waste Management Board
This Board is under the Governor's Office with a mandate for waste management and environmental sanitation.

Department of Forestry and Natural Resources, Edo State
The Forestry Department of the Edo State Ministry of Environment and Public Utilities has responsibility for forest resources management, forest reserves and wildlife conservation in the state.

Ministry of Lands and Surveys, Edo State
The Ministry of Lands and Surveys deals with land issues, plans and controls development, establishes residential, commercial and industrial layouts and execute in the state the Nigerian Urban and Regional Planning law.

Ovia Southwest Local Government Area
The Departments of Environment, Ovia Southwest Local Government Area of Edo State, Nigeria is the tier of government that is responsible for regulating and monitoring the environment at the local level especially the aspects of health and sanitation inspection of business premises to ensure that they conform to set standards.

Federal Ministry of Agriculture and Rural Development
The Ministry has the mandate to Grow Nigeria's agricultural sector and develop strategic partnerships to stimulate investments to drive a market-led agricultural transformation.

Agricultural Research council of Nigeria
To achieve significant improvements in agricultural productivity, marketing and competitiveness by generating appropriate technologies and policy options, promoting innovation, establishing a knowledge management capacity and strengthening the agricultural research system.

Nigerian Institute for Oil Palm Research
The formal mandate of the institute is to conduct research into the production and products of oil palm and other palms of economic importance and transfer its research findings to farmers.

1.11 Non-Governmental Organizations (NGOs)

- Nigerian Conservation Foundation (NCF)
- Nigerian Environmental Society (NES)
- Human Right and Rural Development Organisation of Nigeria
- Grasssroot Development Initiative
- Vision 1 Health
- Women Empowerment and Development Network (WEDEN)
- Gender Development Action (GDA)

Nigerian Conservation Foundation (NCF)
The Nigerian Conservation Foundation (NCF) is Nigeria's foremost non-governmental organisation dedicated to the promotion of nature conservation. Formed in 1980 and registered in 1982 as a Charitable Trust (No. 1917), its ultimate goal is to stop and eventually reverse the accelerating degradation of Nigeria's natural environment and to help build a future in which humans live in harmony with nature.

Nigerian Environmental Society (NES)
The Nigerian Environmental Society (NES), with headquarters in Lagos, is incorporated in Nigeria as a professional, non-profit making, non-governmental Organisation which is committed to the protection, development and sustenance of the environment and to the promotion of the profession of Environmental Science and Engineering, both in theory and in practice. The NES has been in forefront of the vanguard of environmental protection and resource conservation.

1.12 Environmental Impact Assessment Procedural Guidelines
In response to the promulgation of the EIA Act No. 86 of 1992, an Environmental Impact Assessment Procedure for Nigeria was produced by the former Federal Environmental Protection Agency (FEPA, 1995). The procedure provides the steps to be followed from

project conception to commissioning in order to ensure that the project is implemented with maximum consideration for the environment.

The procedure for EIA involves the project proposal stage where the project proponent notifies the Ministry of Environment of the proposed project in writing. The project proposal is to contain all relevant information on the project and a land-use map.

This stage is followed by the screening phase, when the Ministry will carry out an Initial Environmental Examination and assign the project into categories based on the following criteria: magnitude; extent or scope; duration and frequency; risk; significance; mitigation measures available for associated and potential environmental impacts. The location of the project in Environmentally Sensitive Areas is also an important criterion in the project categorization. The area categorized as Environmentally Sensitive Areas (ESA_S) include: coral reefs, mangrove swamps, small islands, tropical rain forests, areas with erosion prone soils, natural conservation areas, watersheds, wetlands etc.

There are three categories (I, II and III) in Ministry of Environment's guidelines.

Category I projects are subjected to full scale EIA, and it consists among others: Petroleum projects such as Oil and Gas fields development; construction of offshore pipeline in excess of 50 kilometres in length; construction of Oil and Gas separation, processing, handling and storage facilities, and large scale construction of depots for storage of petroleum products.

Projects listed in category II may not require a full-scale EIA except when the project is located in an Environmentally Sensitive Area (ESA) and in this case the project will be assigned top category I. The requirement for category II projects is a partial EIA. Also, mitigation measures or changes in project design (depending on the nature and magnitude of the environmental impacts) as well as further actions, may be required from the proponent. Category II projects include reforestation/afforestation projects, land and soil management, small scale irrigation and drainage, mini hydro-power development, small-scale development of petroleum or related activities, etc.

Category III projects are expected to have essential beneficial impacts on the environment. For projects in this category, the Ministry of Environment will issue an Environmental Impact Statement (EIS). Projects in this category include; family program, institutional development, environmental awareness projects, etc.

Another stage of erstwhile FEPA's EIA procedure is the scoping stage, the main feature of which is that the proponent will be required to submit a Terms of Reference (ToR) for the proposed EIA study. In some cases, the Ministry may demand a Preliminary Assessment Report, and any additional information from the proponent to assist in

vetting the scope and the ToR of the proposed EIA study. This stage is followed by actual implementation of the EIA study; Preparation of Draft Final and Final Reports; Review process and Approval/Certification.

The proposed project is an upgrade in capacity of the existing palm oil mill from 30 tons to 60 tons FFB per hour at the main estate of Okomu Oil Palm Company Plc, Okomu-Udo in Edo state. Upon site verification and screening by the Federal Ministry of Environment, it has been placed in Category Two; requiring mandatory EIA Studies and a Technical Review. The fieldwork for data gathering was approved for two seasons.

1.13 Okomu Oil Palm Company Plc IMS Policy

The **OKOMU OIL PALM COMPANY PLC** is committed to:

- Providing customers with high Quality products and services which meet requirements and are fit for their purpose.
- Compliance with all applicable laws, regulations, standards and other requirements related to our activities, products and services and their environmental aspects.
- Enhancing the skills of management and staff through review and actively pursuing an on-going training policy, the objective of which is to prepare staff to perform their work more effectively.
- Promoting the culture of continual improvement of the Quality and Environmental processes and the philosophy of getting things "right first time".
- Advocating the adoption of prudent Quality and Environmental principles to our vendors, suppliers and customers. Reduce and eliminate the generation of waste and emissions at the source and make all efforts to recycle when practical.
- Pledging ourselves to the prudent and sustainable use of the earth's resources and the protection of the natural environment while we strive to fulfil our corporate mission of contributing to enhance prosperity for all.
- Promoting the Integrated Management System and continually improving its effectiveness through the use of the Quality and Environmental Policy, Quality/Environmental objectives, audit results,

analysis of data, corrective and preventive actions and management review.

- Communicating this policy to all persons working for or on behalf of the organization.

The Managing Director confirms the commitment and support, along with that of all employees and those working on behalf of the company, to the above policy statement and the effective application and continual improvement of the Integrated Management System.

1.14 Objectives of Environmental Impact Assessment

The main objective of the EIA is to principally identify the environmental consequences of the operations and activities of the proposed Oil Mill Expansion project and also to establish baseline data of the proposed project site to aid decision making process and serve as future reference. The EIA covers the whole environment from the biotic to abiotic (physical), socio-economic and health aspects of the resident company workers. In this circumstance therefore, and for the purposes of compliance with Federal Environmental Laws, it is required that OOPC Plc as a responsible corporate organization should conduct an Environmental Impact Assessment on its proposed projects. This would serve to adequately analyse the sites, identify any environmental impacts and define framework for contingency plans and mitigation and abatement measures for impacts.

In Nigeria, the legal instruments relevant for the protection of the environment are contained in FEPA (now Federal Ministry of Environment) regulations. Some State governments also made few enactments that are not inconsistent with the Federal laws. In consonance with these laws, OOPC Plc should:

- Develop, Implement and maintain an environmental policy that would enhance the environmental performance of its corporate activities.
- Aim and pursue compliance with existing environmental legislation, identify any non-compliance and endeavour to remedy such non-compliance.
- Develop and maintain environmental awareness of its employees, contractors and any such external parties involved in their corporate activities.
- Improve its corporate image through environmental responsibilities.
- Work in partnership with regulatory agencies for better environment.

- Pay special attention to sustainable development through incorporation of environmental concerns into any development projects.
- Minimize litigation that may arise from environmental non-performance of its projects' activities.

1.15 Terms of Reference (ToR)

The detailed Terms of Reference as approved by the Federal Ministry of Environment are provided in Annexure I.

1.16 Structure of the Report

This report is presented in eight chapters. Chapter One; the introduction provides relevant information about the proponent, background information on the project and statutory regulatory requirements. Chapter Two presents the justification for the project and the project alternatives, while the detailed description of the proposed project is presented in Chapter Three. The baseline environmental and socio-economic statuses of the proposed project area as well as the stakeholders' consultation process are presented in Chapter Four, while the assessment of potential environmental, social and health impacts and the mitigation measures are articulated in Chapters Five and Six respectively. The environmental management plan and decommissioning is presented in Chapter Seven, and lastly, the conclusion is presented in Chapter Eight.

1.17 Declaration

Okomu Oil Palm Company Plc as a corporate organization and the proponent of the proposed project on behalf of herself, the project contractors and other partners hereby declares her intention to undertake this oil palm development project, and in line with her corporate policy and compliance with all applicable national, state and local government laws, regulations and or bye-laws, Okomu Oil Palm Company Plc takes full responsibility for the protection of the environment within the project area.

This EIA report has been prepared by **Foremost Development Services Limited** on behalf of **The Okomu Oil Palm Company Plc** in line with statutory requirements, guidelines, and standards for plantation crop development and the approved Terms of Reference, and the Federal Ministry of Environment is recognised as the sole regulatory authority on Environmental Impact Assessment in Nigeria.

CHAPTER TWO

2.0 PROJECT JUSTIFICATION

2.1 The Proposal

The Okomu Oil Palm Company Plc stated planting oil palm (*Elaeis*) at the main estate since 1979. The company later expanded it plantation holdings with additional oil palm plantation at another site, east of the main estate, called Extension One. It is envisaged that the capacity of the palm oil mill at the main estate will not be able to absorb additional fresh fruit bunches coming from Extension One as more of the new plantings at both extension one and the main estate become mature.

In order to address this problem of capacity limitation, the company proposes to expand its existing palm oil mill from 30MT/Hr FFB to 60MT/Hr FFB. As a requirement of the environmental laws and regulations, a permit application and project description were submitted to the Federal Ministry of Environment. And based on the initial assessment by the Ministry, the proposed palm oil mill expansion project was classified as Category Two requiring a full EIA and a Technical Review process.

2.2 Purpose and Need for the Project

The Okomu Oil Palm Company Plc (OOPC) has been planting oil palm (*Elaeis*) since 1979. The company in addition acquired an existing plantation of about 6000 hectares with both mature and immature trees in 2000. The bulk of the new plantings have attained the harvesting age and the acquired plantation has increasingly been producing FFB in the last five years. Given the existing mill capacity, company is faced with the following challenges as the bulk of the holdings attain full maturity:

- There is no neighbouring palm oil mill to absorb the excess FFB produced on the plantations.
- The risk of large quantities of FFB not being harvested and rotting on the trees.
- Loss of value added advantage.
- High prospects of loss of revenue.

In order to overcome these challenges, the Okomu Oil Palm Company Plc (OOPC) proposes to expand the capacity of the existing mill from 30MT FFB/hour to 60MT FFB/hour to process the excess FFB being harvested from its plantations. The operation of the expanded palm oil mill would enhance the revenue base of the company and help it to further meet its financial obligations to its shareholders and social responsibilities to host communities.

However, because the palm oil business is a going concern, the proposed palm oil mill expansion project will be a combination of development covering the modification and adaptation of existing facilities and addition of new ones. This EIA is being conducted in accordance with the Terms of Reference approved by the FMEnv (See Annexure I). It covers the range of activities and undertakings at the different developmental stages of the project from construction to commissioning and decommissioning.

2.3 Objectives

As part of the Federal Government of Nigeria's effort to revamp the agriculture sector, ensure food security, diversify the economy and enhance foreign exchange earnings, the FMARD embarked on a Transformation Agenda with a focus on the development of agricultural value chains, including the provision and availability of improved inputs (seeds and fertilizer), increased productivity and production, as well as the establishment of staple crop processing zones. It also addresses reduction in post-harvest losses, improving linkages with industry with respect to backward integration, as well as access to financial services and markets. The Transformation Agenda targets rural communities particularly women, youth and farmers' associations as well as improving rural institution and infrastructure. The transformation agenda sets out to create over 3.5 million jobs from rice, cassava, sorghum and cotton value chains, with many more jobs to come from other value chains under the implementation.

The programme aims to provide over 300 Billion Naira (US$ 2 billion) of additional income in the hands of Nigerian farmers. Over 60 Billion Naira (US$ 380 million) is to be injected into the economy from the substitution of 20% of bread wheat flour with cassava flour. Nigeria would therefore be enabled to be food secure by increasing production of key staples.

An important component of the transformation agenda is the Oil Palm Transformation Agenda, which has the specific objectives of (i) Increase vegetable oil production through the increase of oil palm production and processing in order to cancel the supply deficit, which is annually met through import. (ii) Increase the yield and productivity of both the unorganized and organized plantings. (iii) Arouse greater interest and concern for engagement in competitive market activities within the oil palm value chain. (iv) Create employment for youth and reduce poverty in affected states.

The ongoing investments by the company, including the proposed palm oil mill expansion project could be seen as the company's contribution and support aimed at achieving the objectives of the Oil Palm Transformation Agenda in particular and the Economic Transformation Agenda of the Nigerian government in general.

2.4 Cost of the Project

The cost of the proposed palm oil mill expansion project is estimated at about N651 million. The cost covers both capital and recurrent expenditures on building, mechanical and electrical installations as follows:

S/No.	Description	Cost ('000 Naira)
1.	Fruit Reception Station	165,480
2.	Sterilization station	105,340
	NEW OIL MILL LINE	
3.	Threshing Station	77,460
4.	Pressing Station	50,140
5.	Depricarping Station	26,160
6.	Kernel Recovery Station	61,840
7.	Clarification Station	41,120
8.	Shell Bunker	21,800
10.	Raw Water Treatment Plant	34,260
12.	Piping and Valve work for Processing	60,000
13.	Fire Fighting System	7,400
Total		**651,000**

A large proportion of this fund will be injected into the local economy through various contracts and subcontracts. In addition, employment opportunities at various phases of the project, for skilled, semi-skilled and unskilled labour would be available. The project will also bring about additional revenue generation to the government in terms of the various taxes and levies that will be paid into government coffers.

2.5 Justification/Project Benefits

The proposed project will complement considerably the economic transformation strategy and plans of the country. Justification is therefore found for the proposed palm oil mill expansion in its potential to:

- Add value to the existing production of the company
- Provide direct employment
- Create additional jobs
- Contribute to the socio-economic development of neighbouring communities
- Increased economic benefits to the nation.

2.6 Envisaged Sustainability

In order to achieve the desirable sustainability of the proposed palm oil mill expansion project, OOPC Plc will develop and operate the project based on industry best practices, applying especially the IFC Performance Standards and the Principles and Criteria of the Roundtable on Sustainable Palm Oil (RSPO). In effect, OOPC Plc will strive continually to implement its Health, Safety and Environment Policy. In so doing, the following aspects of the project sustainability are therefore predicted:

2.6.1 Financial Sustainability

The planning and management of operations and production activities will aim at long-term financial and economic viability of the project. This will be achieved through sound operational and management practices to attain high productivity and premium quality of products.

In addition, the project will be financed from the company's annual turnover and profits, which has been impressive and promising in the last five years. The company recorded a revenue of N6,087,836,000.00 with profit after tax of N5,290,046,000.00 in year 2010. The financial performance of the company has since improved considerably. For the year ended December 2014, the revenue was N8,655,718,000.00, while the profit after tax was N1,570,137,000.00. OOPC Plc is listed on the Nigerian Stock Exchange. The financial performance of the company over the years would enable it to execute and sustain the proposed palm oil mill expansion project operations.

2.6.2 Technical Sustainability

The company will leverage on both its foreign and local expertise and experience in palm oil mill construction and operation in Edo State, other parts of Africa and Asia to ensure that the proposed palm oil mill expansion enjoys sound technical complements from design to implementation and operation. Such practices will include adequate practices to safe handling of machines, equipment, minimizing emissions and in general operating in an environment friendly manner. They will also effectively protect the environment and its ecological system through a proper management of the POME generated. In addition, the construction material will be of the highest quality available. Essentially, best hands and best management practices will be employed to execute the project. Importantly, all staff and workers will be competent and adequately trained to ensure the technical sustainability of the proposed palm oil mill expansion project.

2.6.3 Environmental Sustainability

The on and off-site impacts of the oil mill activities and/operations will continually be assessed and managed. Continuous monitoring of environmental aspects around the proposed palm oil mill expansion area will be ensured and maintained through

the implementation of the existing policy to monitor its operational area. In addition, POME will not be discharged into Surface River and other strategies to reduce air and water pollution will be implemented. Essentially, the bulk of the solid waste to be generated will be disposed by recycling in the plantation.

2.6.4 Social Sustainability

An assessment of the social impacts of the proposed oil mill expansion project was carried out and the results and social action plan will be implemented to ensure that the desirable support and harmony is established between the project and the communities although, the closest community to the project area is about 25km. But notwithstanding, necessary mechanisms will be put in place to facilitate communication with the communities, including proper documentation and resolution of conflicts and grievances.

2.7 Project Alternatives

The expansion of the existing palm oil mill essentially involves the construction and installation of equipment and facilities to achieve additional 30MT FFB/HR capacity, which will add up to 60MT FFB/HR capacity. In this section, alternatives to the proposed project are discussed including the "do nothing" alternative.

2.7.1 The "Do Nothing Alternative"

The "do nothing" alternative would mean that OOPC Plc should continue to operate without the option of increasing its CPO production capacity. This option is unacceptable when one considers the substantial net financial, economic and social benefits that will accrue to OOPC Plc, the neighbouring communities and the national economy by operating the expanded mill.

2.7.2 Alternative Location

The option of alternative location means the undertaking of new palm oil mill at a different location. This option is undesirable because the prospect of acquiring new land in the neighbourhood is low. Moreover, establishing a new palm oil mill at a different location could mean that it would require travelling longer distances to transport FFB from its estates to this new location and this can be expensive. The advantage of synergy with the existing palm oil mill will be lost.

2.7.3 Alternative Palm Oil Mill Expansion Methods

For large scale palm oil production, the alternative FFB processing methods that could be adopted are:

2.7.3.1 *Alternative Mill (Conventional Palm Oil Mill System)*

The choice of alternative mill is the conventional system with horizontal sterilizer. This option is not favoured because of high power consumption and wastewater discharge. The power requirement of a 30 MT FFB/Hr. conventional palm oil mill system is relatively higher. It also means that this option will require electricity generators of higher ratings and consequently higher fuel consumption.

2.7.3.2 *Third Party Services*

At this time it is not feasible for OOPC Plc to depend on a third party for processing services as there is no oil mill within reasonable distance to the plantations of OOPC that can accommodate the FFB to be harvested.

2.7.3.3 *Modern POM with Tilting Sterilizer*

This is the processing method to be adopted by the project proponent as against the other methods earlier mentioned above because of the following reasons:

- Lower construction cost with less machinery
- High throughput
- Low down time
- Minimum oil loss
- Lower power consumption and wastewater discharge
- Easy and safe to operate
- Lower operation and maintenance costs
- Minimum damage to FFB
- Much smaller sterilization station thereby leading to lower cost.

2.7.3.4 *Preferred Option*

Of all the alternatives considered, the expansion of the existing palm oil mill using tilting sterilizer system (section 2.7.3.3) as proposed is the preferred option.

CHAPTER THREE

3.0 PROJECT/PROCESS DESCRIPTION

3.1 Brief Project/Process Description

The existing palm oil mill is situated within the main estate of Okomu Oil Palm Company Plc. The mill, which was constructed and installed by SAIPEM in 1992 has one production line of 30MT FFB/HOUR. Presently, the 30MT FFB/HOUR cannot accommodate all the FFB coming from the plantations of the company.

Consequently, the company proposed to expand the existing palm oil mill from its present capacity of 30MT FFB/HOUR to 60MT FFB/HOUR. This is to reposition the oil mill to be able to process more FFB coming from its plantations.

The proposed palm oil mill expansion will involve five major civil and mechanical components as follows:

i) **Reception Station:** The function of this station is to receive the FFB brought from the plantations in lorries to the mill for onward delivery for processing.

ii) **Sterilization Station:** This is where sterilization of the FFB takes place. Sterilization inactivates the enzymes that promote the formation of Free Fatty Acid (FFA) and makes easy the fruits loosening from the bunch. It will also break oil cells in the mesocarp so that oil recovery will be easier.

iii) **Oil Mill Processing Line:** This will include the following

- ***Stripping/Threshing Station:*** This station is for separation of the fruits from the bunch using a rotary drum.
- ***Pressing Station:*** This is for extraction of oil. It comprises Digester unit, Screw press and conveying equipment.
- ***Clarification Station:*** This is for separation of crude palm oil and sludge to make pure oil.
- ***Kernel Recovery Station:*** This station is for nut processing to recover kernels. It is divided into three processes -

  - ✓ Depericarper - For separating fibre and Nut
  - ✓ Nut Cracking - For separation of kernel and shell
  - ✓ Kernel Drying – For drying wet kernels from about 20% to 1% moisture content to avoid deterioration while in storage.

- ***PKOF (Palm Kernel Oil Factory):*** This is for extraction of kernel oil and cake. This station consists of Hammer mill, Kernel press, Screened oil and Pressure leaf filter.

iv) ***Boiler Station:*** A new Atmindo boiler of 40 T/Hour will be installed. The boiler will run entirely on the solid waste of oil palm including empty fruit bunches (EFB), fibres, shells and palm kernel cake.

v) ***Palm Oil Mill Effluent (POME) Treatment Lagoon:*** There is an existing effluent treatment lagoon with a size area of 10.93 hectares which will be expanded to 15.95 hectares of total size area. The lagoon is for biological treatment of raw POME received from the oil mill before it is discharged into the plantation field as irrigation water.

3.2 General Processes of Palm Oil Production

The palm oil mill processes FFB into Special Palm Oil (SPO) and Palm kernel (PK). The FFB after weighing in the weighbridge are carried in boogies, which feed them into Sterilizers. The fruits are washed, threshed and are then digested in the Digester. From the Digester, crude oil is extracted at the Press, leaving the cake. The cake line further processes the nuts and fibres. The nuts are cracked and separated into shells and kernels. The kernels are recovered and sent to the PKO plant, while the shells and fibres are fed into the boiler as fuel.

The crude oil is further decanted to produce purified Crude Palm Oil (CPO), which is stored in the storage tank, while the sludge is deposited in the effluent fat pit where oil is further recovered before the effluent is discharged into the effluent lagoon or effluent treatment ponds.

3.2.1 Palm Kernel Oil Processing

The palm kernel crushing plant processes palm kernel (PK) into palm kernel oil (PKO). The kernels undergo size reduction and are passed through the drying silo before going through the primary expeller to obtain the first palm kernel cake. The first palm kernel cake is taken through the second expeller to obtain the final Palm Kernel Cake (PKC) and Palm Kernel Oil (PKO). The PKC is dried and bagged, while the PKO passes through three separate vibrating screens to produce the purified Crude Palm Kernel Oil (CPKO). The CPKO is further filtered and stored in the CPKO storage tank.

3.3 Oil Mill Processing Line (Process Flow chart)

There are several stages of processing the extraction of palm oil from fresh fruit bunches. These include sterilization, bunch stripping, digestion, oil extraction and finally clarification and purifications; each process with its own unit operations.

The typical operations that take place during the processing of the EFB at the mill are described below

Sterilization

This is the first stage that involves subjecting freshly harvested fruit bunches brought to the mill to a high pressure steam (120 to 140˚cat 40 psi) with a minimal delay so as to inactivate the lipolitic enzymes that cause oil hydrolysis and fruit deterioration. There are various types of sterilizers; vertical, horizontal, spherical and more recently tilting sterilizers. The sterilizer capacity depends on the length; a large horizontal sterilizer would take six or more cages and a large mill would have several sterilizers. In this case, tilting sterilizers will be employed. Once the sterilizer has been loaded and closed, steam is introduced and pressure is built to a temperature just above 130˚C and held for 1 hour. The sterilizer serves two main purposes: It prevents FFA build-up in the oil, and it loosens the fruit on the bunch to facilitate stripping and also softens the pericarp for easier digestion and allows preconditioning of nuts to reduce breakage in the press.

Stripping

This offers a means of separating the fruits from the bunch stalks and spikelets by mechanical stripping. The stripper consists of a horizontal drum (standard in modern mills) made of bars spaced so that fruits can fall through, but the bunches remain inside the drum. Cages of sterilized fruit are lifted and tipped into a bunch feeder; bunches are fed from this into one end of the stripper drum either manually or automatically sometimes with a feedback control from the digester. The drum rotates at about 22 rpm.

Digestion

This is achieved by reheating the fruits using steam to a temperature of 80-90˚C. Fruit from the stripper is carried by a conveyor belt to the digester. The design of digesters has had minimal changes over the years. There is a vertical cylinder, with rotating beater arms which pulverizes the fruit, loosening the pulp from the nut. This prepares the fruits for oil extraction by rupturing the oil bearing cells in the mesocarp. The mass of nuts and pulp is heated, before passing into the press, either by a heating jacket or by live steam injection.

Pressing

The crude oil is extracted from the digested fruit mash by the use of the screw press without kernel breakage. The mill operation and press capacity normally determine the through put of the mill. Centrifuges were used in many early mills, but hydraulic presses were introduced in the 1920s and gave greater extraction efficiencies. Screw presses were first used in the 1950s and although there was much debate to the merits of screw and hydraulic presses, it is now universally used.

The advantages of the screw press over the hydraulic press are detailed below:

- Continuous operation – hence, less labour required; the screw press was a 'batch' process;
- Higher throughput – hence, less investment in buildings and machinery;
- Less power required for a given throughput;
- Nut/fiber separation is easier because of the lower oil content after pressing;
- Screw presses can handle a wide range of throughput rates.

A variety of different screw press designs is in use with single screw or double screws throughputs of up to 20MT of fresh fruit bunches (FFB)/hr. The digested mixture of fiber, oil, and nuts is forced through a perforated press cylinder by the rotation of the screw, or counter-rotating screws in the double screw press. Adjustable cones restrict the mass so that pressure builds up in the press cylinder. In some designs, the pitch of the screw is gradually diminished thus increasing the pressure.

The extracted liquid and nuts are discharged from the screw press. However, the extracted oil contains varying amounts of water, solids, and dissolved impurities that must be removed.

Clarification

The crude oil from the press consists of a mixture of oil, water, and other 'non-oily solids' (NOS: mainly dirt and fiber). The exact composition depends on how much water was added prior to pressing. The fiber particles from the pressed crude oil are first removed by passing oil over a vibrating screen; sand and dirt are allowed to settle. Where the water and non-oily solids are low, simple physical settling is quite effective. The water is removed by settling or centrifuging and finally by vacuum drying. It is worthy to note that the moisture content of the clarified crude oil is still about 0.1–0.25% of moisture. This helps in maintaining oxidative stability, also prevents the deposition of small amounts of soluble solids known as gums. The oil and waste fractions are then centrifuged. More recently, decanters have been introduced which can handle oil straight from the press without the need for a settling tank. The final product is consumed locally as crude palm oil or can further be refined.

Drying and Storages

Finally, the oil must be dried by the use of vapour extract non units or vacuum dryers to prevent FFA formation by autocatalytic hydrolysis. Storage is generally in welded steel tanks which contain heating coils to prevent crystallization and subsequent settling out of the solid phase. They may be filled with carbon dioxide or other inert gas above the oil to prevent oxidation. The sensitivity of palm oil higher temperature is well established and the temperature during storage and in transit is controlled between 32˚C and 40˚C with loading and unloading temperatures between 50˚C and 55˚C. Temperature should be kept as low as possible to minimize deterioration in quality during storage.

Fiber Separation and Kernel Handling

This may be pneumatic, mechanical or hydraulic, but pneumatic fiber separators have become the standard in modern mills. In the most commonly used type the fiber-nut mixture, partially dried, passes from a 'cake breaker' conveyor into a vertical airstream sufficient to carry the fiber upwards while the nuts fall into a smaller, lower rotating drum, where they are polished by friction.

Some air also passes through this drum, carrying any light particles upwards to join the main flow. The cake coming from the presses of nuts and moist fiber with some residual oil. To extract the kernels it is necessary to separate the nuts from the fiber, crack the nuts, and separate the Kernels from the cracked shells.

Nut Screening and Cracking

The clean nuts may be dried in a nut silo or if the drying during fiber separation has been sufficient, they may be conveyed straight to screens for grading by size before cracking. In nut-cracking machines of the centrifugal type, the nuts are fed through a central spindle, rotating at 1600 – 2000 rpm, and flung out against the wall of the cracker.

A new development has been the self-sorting nutcracker, which incorporates grading slots, and pitching blades, which grade the nuts and give them the correct speed for cracking; this makes prior nut screening unnecessary. The ripple mill cracker has the advantage that prior nut conditioning is not required and it is now been widely used.

Kernel and Shell Separation

Modern mills use hydro cyclones for separation. The mixture is fed into a rotating vortex of water and the heavier shell particles settle while the kernels are carried off upwards. The shell is sent to the boiler house for fuel. The kernels should contain no more than 2.75% shell and other foreign matter.

Kernel Drying

Fresh kernels have a moisture content of about 20% and cannot be stored without deterioration. Drying is usually done in a silo. The fresh kernels are fed in at the top, warm air is blown upwards from below and dry kernels (7% moisture) are removed at the base. The kernels can also be steam-sterilized for 5-6 minutes before drying and the FFA of the kernel oil will then remain below 1% after storage for 6 months or more.

Kernel Oil Extraction

In most mills, palm kernels are the final product and the crushing is done elsewhere, but sometimes kernel oil is extracted in the mill by pressing. This has the advantage of using the same power supply derived from shell and fiber as the rest of the mill.

The Process Flow Chart is presented in Figures 3-1a to 3-1b.

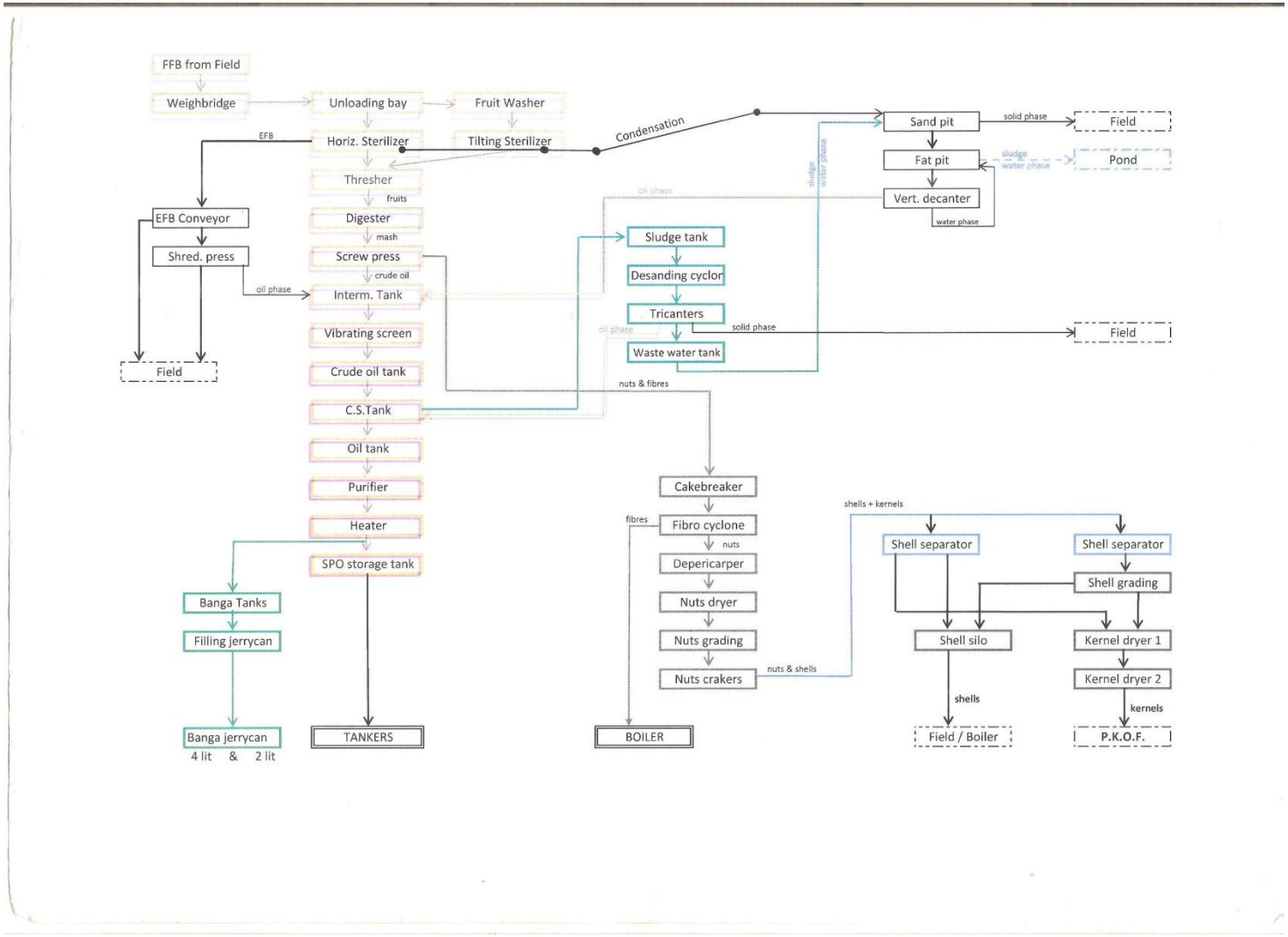


Figure 3-1a: Flowchart for Extraction of Crude Palm Oil

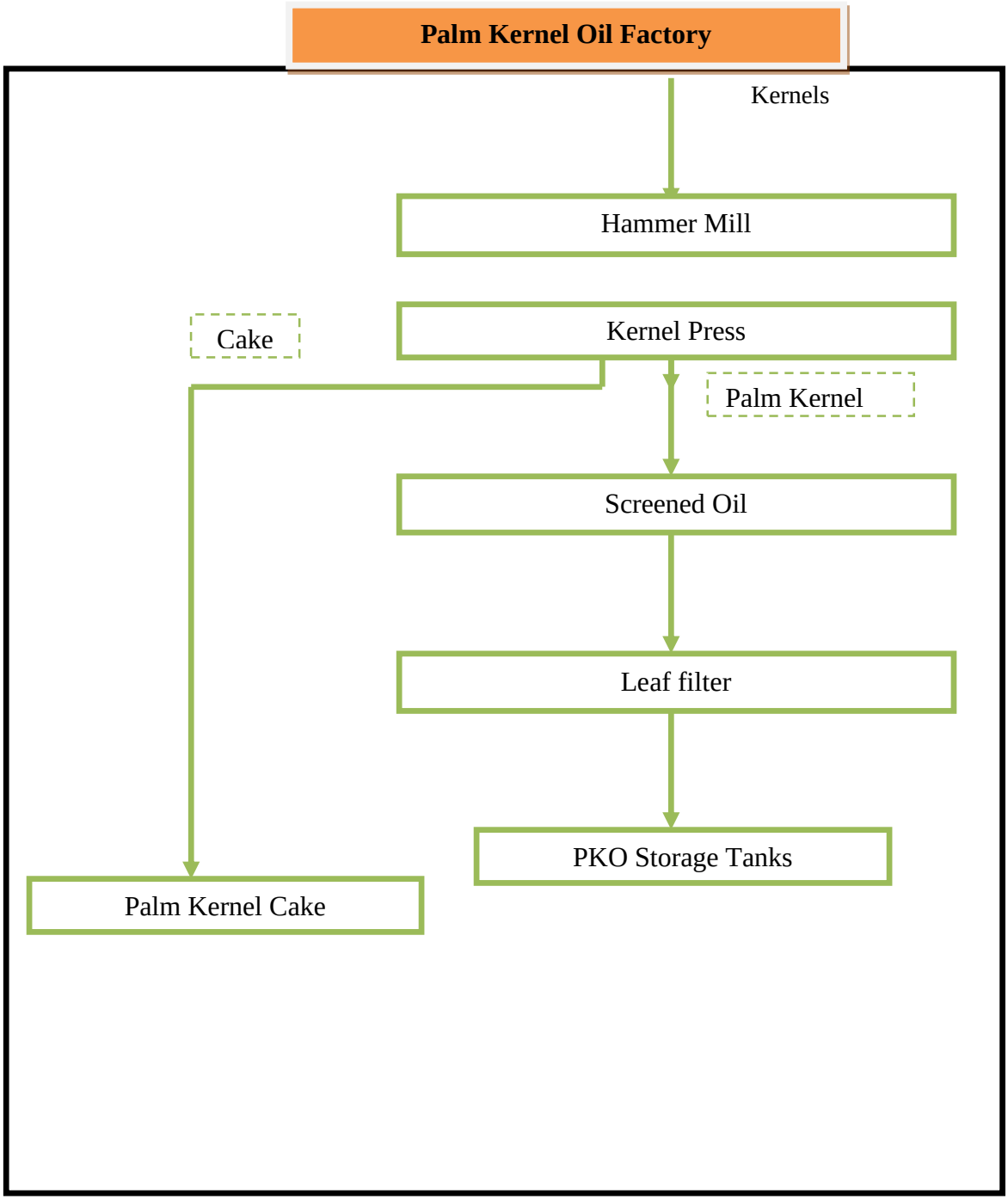


Figure 3-1b: Flowchart for Palm Kernel Oil Factory

3.4 General Palm Oil Processing Description

The following description was adapted from
http://www.fao.org/docrep/005/y4355e/y4355e05.htm

Research and development work in many disciplines - biochemistry, chemical and mechanical engineering - and the establishment of plantations, which provided the opportunity for large-scale fully mechanized processing, resulted in the evolution of a sequence of processing steps designed to extract, from a harvested oil palm bunch, a high yield of a product of acceptable quality for the international edible oil trade. The oil winning process, in summary, involves the reception of fresh fruit bunches from the plantations, sterilizing and threshing of the bunches to free the palm fruit, mashing the fruit and pressing out the crude palm oil. The crude oil is further treated to purify and dry it for storage and export.

Large-scale plants, featuring all stages required to produce palm oil to international standards, are generally handling from 3 to 60 tonnes of FFB/hr. The large installations have mechanical handling systems (bucket and screw conveyers, pumps and pipelines) and operate continuously, depending on the availability of FFB. Boilers, fuelled by fibre and shell, produce superheated steam, used to generate electricity through turbine generators. The lower pressure steam from the turbine is used for heating purposes throughout the factory. Most processing operations are automatically controlled and routine sampling and analysis by process control laboratories ensure smooth, efficient operation. Although such large installations are capital intensive, extraction rates of 23 - 24 percent palm oil per bunch can be achieved from good quality Tenera.

Conversion of crude palm oil to refined oil involves removal of the products of hydrolysis and oxidation, colour and flavour. After refining, the oil may be separated (fractionated) into liquid and solid phases by thermo-mechanical means (controlled cooling, crystallization, and filtering), and the liquid fraction (olein) is used extensively as a liquid cooking oil in tropical climates, competing successfully with the more expensive groundnut, corn, and sunflower oils.

Extraction of oil from the palm kernels is generally separate from palm oil extraction. The stages in this process comprise grinding the kernels into small particles, heating (cooking), and extracting the oil using an oilseed expeller or petroleum-derived solvent. The oil then requires clarification in a filter press or by sedimentation. Extraction is a well-established industry, with large numbers of international manufacturers able to offer equipment that can process from 10 kg to several tonnes per hour.

Alongside the development of these large-scale fully mechanized oil palm mills and their installation in plantations supplying the international edible oil refining industry, small-scale village and artisanal processing has continued in Africa. Ventures range in

throughput from a few hundred kilograms up to 8 tonnes FFB per day and supply crude oil to the domestic market.

Palm oil processors of all sizes go through these unit operational stages. They differ in the level of mechanization of each unit operation and the interconnecting materials transfer mechanisms that make the system batch or continuous. The scale of operations differs at the level of process and product quality control that may be achieved by the method of mechanization adopted.

The general flow diagram is presented in Figure 3-2:

Palm Oil Processing Unit Operations

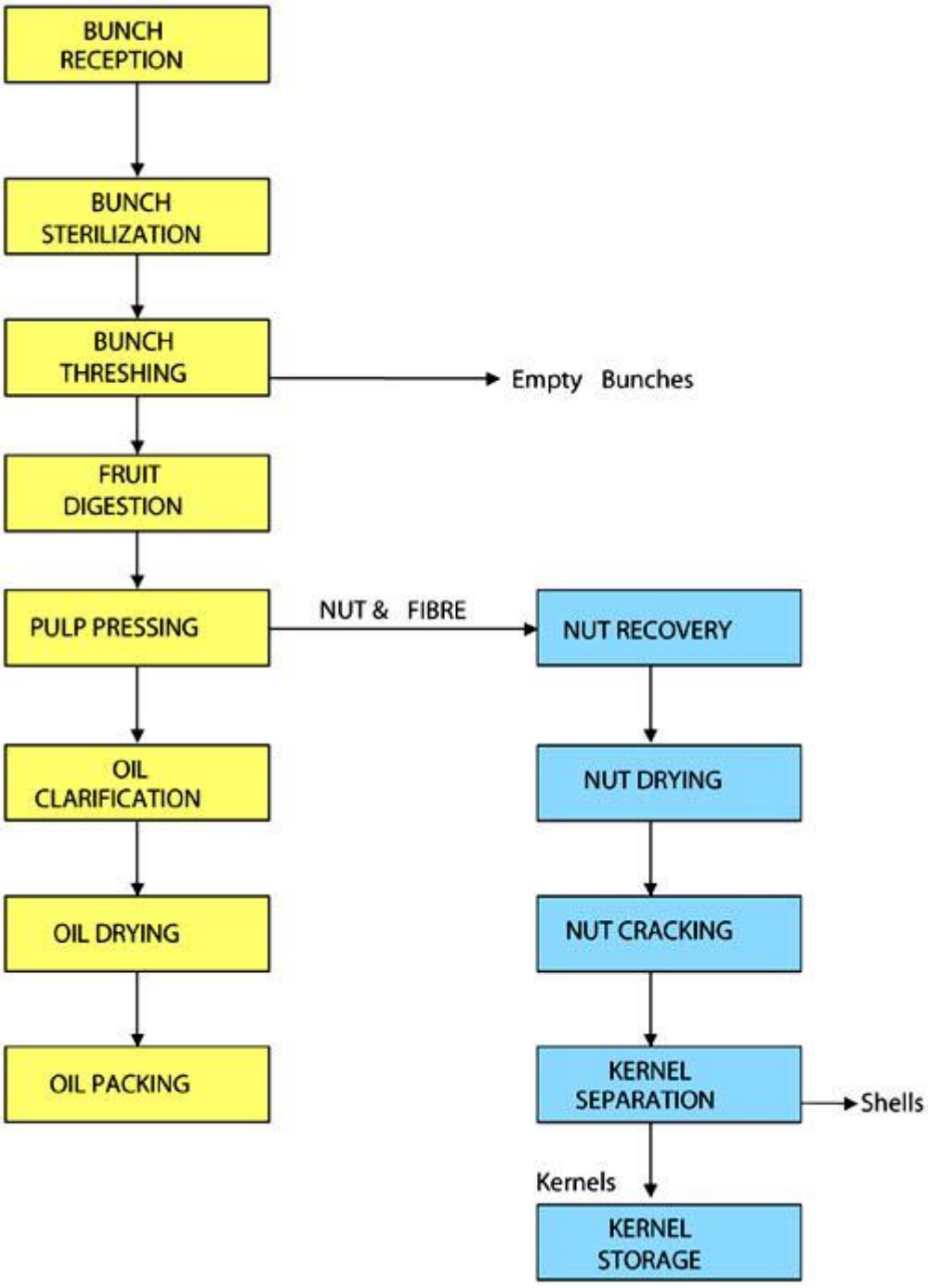


Figure 3-2: General Palm Oil Flow Diagram

3.4.1 Bunch reception

Fresh fruit arrives from the field as bunches or loose fruit. The fresh fruit is normally emptied into wooden boxes suitable for weighing on a scale so that quantities of fruit arriving at the processing site may be checked. Large installations use weighbridges to weigh materials in trucks.

The quality standard achieved is initially dependent on the quality of bunches arriving at the mill. The mill cannot improve upon this quality but can prevent or minimize further deterioration.

The field factors that affect the composition and final quality of palm oil are genetic, age of the tree, agronomic, environmental, harvesting technique, handling and transport. Many of these factors are beyond the control of a small-scale processor. Perhaps some control may be exercised over harvesting technique as well as post-harvest transport and handling.

3.4.2 Threshing (removal of fruit from the bunches)

The fresh fruit bunch consists of fruit embedded in spikelet's growing on a main stem. Manual threshing is achieved by cutting the fruit-laden spikelet's from the bunch stem with an axe or machete and then separating the fruit from the spikelet by hand. Children and the elderly in the village earn income as casual laborers performing this activity at the factory site.

In a mechanized system a rotating drum or fixed drum equipped with rotary beater bars detach the fruit from the bunch, leaving the spikelets on the stem.

Most small-scale processors do not have the capacity to generate steam for sterilization. Therefore, the threshed fruits are cooked in water. Whole bunches which include spikelet's absorb a lot of water in the cooking process. High-pressure steam is more effective in heating bunches without losing much water. Therefore, most small-scale operations thresh bunches before the fruits are cooked, while high-pressure sterilization systems thresh bunches after heating to loosen the fruits.

Small-scale operators use the bunch waste (empty bunches) as cooking fuel. In larger mills the bunch waste is incinerated and the ash, a rich source of potassium, is returned to the plantation as fertilizer.

3.4.3 Sterilization of Bunches

Sterilization or cooking means the use of high-temperature wet-heat treatment of loose fruit. Cooking normally uses hot water; sterilization uses pressurized steam. The cooking action serves several purposes.

- Heat treatment destroys oil-splitting enzymes and arrests hydrolysis and autoxidation.

- For large-scale installations, where bunches are cooked whole, the wet heat weakens the fruit stem and makes it easy to remove the fruit from bunches on shaking or tumbling in the threshing machine.

- Heat helps to solidify proteins in which the oil-bearing cells are microscopically dispersed. The protein solidification (coagulation) allows the oil-bearing cells to come together and flow more easily on application of pressure.

- Fruit cooking weakens the pulp structure, softening it and making it easier to detach the fibrous material and its contents during the digestion process. The high heat is enough to partially disrupt the oil-containing cells in the mesocarp and permits oil to be released more readily.

- The moisture introduced by the steam acts chemically to break down gums and resins. The gums and resins cause the oil to foam during frying. Some of the gums and resins are soluble in water. Others can be made soluble in water, when broken down by wet steam (hydrolysis), so that they can be removed during oil clarification. Starches present in the fruit are hydrolyzed and removed in this way.

- When high-pressure steam is used for sterilization, the heat causes the moisture in the nuts to expand. When the pressure is reduced the contraction of the nut leads to the detachment of the kernel from the shell wall, thus loosening the kernels within their shells. The detachment of the kernel from the shell wall greatly facilitates later nut cracking operations. From the foregoing, it is obvious that sterilization (cooking) is one of the most important operations in oil processing, ensuring the success of several other phases.

- However, during sterilization it is important to ensure evacuation of air from the sterilizer. Air not only acts as a barrier to heat transfer, but oil oxidation increases considerably at high temperatures; hence oxidation risks are high during sterilization. Over-sterilization can also lead to poor bleach ability of the resultant oil. Sterilization is also the chief factor responsible for the discoloration of palm

kernels, leading to poor bleach ability of the extracted oil and reduction of the protein value of the press cake.

3.4.4 Digestion of the Fruit

Digestion is the process of releasing the palm oil in the fruit through the rupture or breaking down of the oil-bearing cells. The digester commonly used consists of a steam-heated cylindrical vessel fitted with a central rotating shaft carrying a number of beater (stirring) arms. Through the action of the rotating beater arms the fruit is pounded. Pounding, or digesting the fruit at high temperature, helps to reduce the viscosity of the oil, destroys the fruits' outer covering (exocarp), and completes the disruption of the oil cells already begun in the sterilization phase. Unfortunately, for reasons related to cost and maintenance, most small-scale digesters do not have the heat insulation and steam injections that help to maintain their contents at elevated temperatures during this operation.

Contamination from iron is greatest during digestion when the highest rate of metal wear is encountered in the milling process. Iron contamination increases the risk of oil oxidation and the onset of oil rancidity.

3.4.5 Pressing (Extracting the palm oil)

There are two distinct methods of extracting oil from the digested material. One system uses mechanical presses and is called the 'dry' method. The other called the 'wet' method uses hot water to leach out the oil.

In the 'dry' method the objective of the extraction stage is to squeeze the oil out of a mixture of oil, moisture, fibre and nuts by applying mechanical pressure on the digested mash. There are a large number of different types of presses but the principle of operation is similar for each. The presses may be designed for batch (small amounts of material operated upon for a time period) or continuous operations.

3.4.6 Batch Presses

In batch operations, material is placed in a heavy metal 'cage' and a metal plunger is used to press the material. The main differences in batch press designs are as follows: a) the method used to move the plunger and apply the pressure; b) the amount of pressure in the press; and c) the size of the cage.

The plunger can be moved manually or by a motor. The motorized method is faster but more expensive.

Different designs use either a screw thread (spindle press) or a hydraulic system (hydraulic press) to move the plunger. Higher pressures may be attained using the hydraulic system but care should be taken to ensure that poisonous hydraulic fluid does

not contact the oil or raw material. Hydraulic fluid can absorb moisture from the air and lose its effectiveness and the plungers wear out and need frequent replacement. Spindle press screw threads are made from hard steel and held by softer steel nuts so that the nuts wear out faster than the screw. These are easier and cheaper to replace than the screw.

The size of the cage varies from 5 kg to 30 kg with an average size of 15 kg. The pressure should be increased gradually to allow time for the oil to escape. If the depth of material is too great, oil will be trapped in the center. To prevent this, heavy plates' can be inserted into the raw material. The production rate of batch presses depends on the size of the cage and the time needed to fill, press and empty each batch.

Hydraulic presses are faster than spindle screw types and powered presses are faster than manual types. Some types of manual press require considerable effort to operate and do not alleviate drudgery.

3.4.7 Continuous Systems

The early centrifuges and hydraulic presses have now given way to specially designed screw-presses similar to those used for other oilseeds. These consist of a cylindrical perforated cage through which runs a closely fitting screw. Digested fruit is continuously conveyed through the cage towards an outlet restricted by a cone, which creates the pressure to expel the oil through the cage perforations (drilled holes). Oil-bearing cells that are not ruptured in the digester will remain unopened if a hydraulic or centrifugal extraction system is employed. Screw presses, due to the turbulence and kneading action exerted on the fruit mass in the press cage, can effectively break open the unopened oil cells and release more oil. These presses act as an additional digester and are efficient in oil extraction.

Moderate metal wear occurs during the pressing operation, creating a source of iron contamination. The rate of wear depends on the type of press, method of pressing, nut-to-fibre ratio, etc. High pressing pressures are reported to have an adverse effect on the bleach ability and oxidative conservation of the extracted oil.

3.4.8 Clarification and Drying of Oil

The main point of clarification is to separate the oil from its entrained impurities. The fluid coming out of the press is a mixture of palm oil, water, cell debris, fibrous material and 'non-oily solids'. Because of the non-oily solids the mixture is very thick (viscous). Hot water is therefore added to the press output mixture to thin it. The dilution (addition of water) provides a barrier causing the heavy solids to fall to the bottom of the container while the lighter oil droplets flow through the watery mixture to

the top when heat is applied to break the emulsion (oil suspended in water with the aid of gums and resins). Water is added in a ratio of 3:1.

The diluted mixture is passed through a screen to remove coarse fibre. The screened mixture is boiled from one or two hours and then allowed to settle by gravity in the large tank so that the palm oil, being lighter than water, will separate and rise to the top. The clear oil is decanted into a reception tank. This clarified oil still contains traces of water and dirt. To prevent increasing FFA through autocatalytic hydrolysis of the oil, the moisture content of the oil must be reduced to 0.15 to 0.25 percent. Re-heating the decanted oil in a cooking pot and carefully skimming off the dried oil from any engrained dirt removes any residual moisture. Continuous clarifiers consist of three compartments to treat the crude mixture, dry decanted oil and hold finished oil in an outer shell as a heat exchanger.

The wastewater from the clarifier is drained off into nearby sludge pits dug for the purpose. No further treatment of the sludge is undertaken in small mills. The accumulated sludge is often collected in buckets and used to kill weeds in the processing area.

3.4.9 Oil Storage

In large-scale mills the purified and dried oil is transferred to a tank for storage prior to dispatch from the mill. Since the rate of oxidation of the oil increases with the temperature of storage the oil is normally maintained around 50°C, using hot water or low-pressure steam-heating coils, to prevent solidification and fractionation. Iron contamination from the storage tank may occur if the tank is not lined with a suitable protective coating.

Small-scale mills simply pack the dried oil in used petroleum oil drums or plastic drums and store the drums at ambient temperature.

3.4.10 Kernel Recovery

The residue from the press consists of a mixture of fibre and palm nuts. The nuts are separated from the fibre by hand in the small-scale operations. The sorted fibre is covered and allowed to heat, using its own internal exothermic reactions, for about two or three days. The fibre is then pressed in spindle presses to recover a second grade (technical) oil that is used normally in soap-making. The nuts are usually dried and sold to other operators who process them into palm kernel oil. The sorting operation is usually reserved for the youth and elders in the village in a deliberate effort to help them earn some income.

Large-scale mills use the recovered fibre and nutshells to fire the steam boilers. The super-heated steam is then used to drive turbines to generate electricity for the mill. For

this reason it makes economic sense to recover the fibre and to shell the palm nuts. In the large-scale kernel recovery process, the nuts contained in the press cake are separated from the fibre in a depericarper. They are then dried and cracked in centrifugal crackers to release the kernels. The kernels are normally separated from the shells using a combination of winnowing and hydro cyclones. The kernels are then dried in silos to a moisture content of about 7 percent before packing.

During the nut cracking process some of the kernels are broken. The rate of FFA increase is much faster in broken kernels than in whole kernels. Breakage of kernels should therefore be kept as low as possible, given other processing considerations.

3.4.11 Traditional Method of Palm Oil Processing

The village traditional method of extracting palm oil involves washing pounded fruit mash in warm water and hand squeezing to separate fibre and nuts from the oil/water mixture. A colander, basket or a vessel with fine perforated holes in the bottom is used to filter out fibre and nuts. The wet mixture is then put on the fire and brought to a vigorous boil. After about one or two hours, depending on the volume of material being boiled, the firewood is taken out and the boiled mixture allowed to cool. Herbs may be added to the mixture at this point just before reducing the heat. On cooling to around blood temperature, a calabash or shallow bowl is used to skim off the palm oil. Because of the large quantities of water used in washing the pulp this is called the 'wet' method.

3.4.12 Processing and Use

Refining

After milling, various palm oil products are made using refining processes. First is fractionation, with crystallization and separation processes to obtain solid (stearin), and liquid (olein) fractions. Then melting and degumming removes impurities. Then the oil is filtered and bleached. Physical refining removes smells and coloration to produce "refined, bleached and deodorized palm oil" (RBDPO) and free sheer fatty acids which are used in the manufacture of soaps, washing powder and other products. RBDPO is the basic palm oil product sold on the world's commodity markets. Many companies fractionate it further to produce palm olein for cooking oil, or process it into other products.

Red palm oil

Since the mid-1990s, red palm oil has been cold-pressed and bottled for use as cooking oil, and blended into mayonnaise and salad oil.

Antioxidants

Red palm oil antioxidants like tocotrienols and carotenes are added to foods and cosmetics because of their purported health benefits.

Butter and Trans Fat Substitute

The highly saturated nature of palm oil renders it solid at room temperature in temperate regions, making it a cheap substitute for butter or trans fats in uses where solid fat is desirable, such as the making of pastry dough and baked goods. A recent rise in the use of palm oil in the food industry has partly come from changed labelling requirements that have caused a switch away from using trans fats. Palm oil has been found to be a reasonable replacement for trans fats; however, a small study conducted in 2009 found that palm oil may not be a good substitute for trans fats for individuals with already-elevated LDL levels.

Biomass and Bioenergy

Palm oil is used to produce both methyl ester and hydro deoxygenated biodiesel. Palm oil methyl ester is created through a process called trans esterification. Palm oil biodiesel is often blended with other fuels to create palm oil biodiesel blends. Palm oil biodiesel meets the European EN 14214 standard for biodiesels.

The organic waste matter that is produced when processing palm oil, including oil palm shells and oil palm fruit bunches, can also be used to produce energy. This waste material can be converted into pellets that can be used as a biofuel. Additionally, palm oil that has been used to fry foods can be converted into methyl esters for biodiesel. The used cooking oil is chemically treated to create a biodiesel similar to petroleum diesel.

3.5 The Proposed Palm Oil Mill Expansion

While the design of the proposed palm oil mill expansion is similar to the existing one at the same location, the sterilizers are not the same. Also, the manufacturers and suppliers of plant and other equipment are not the same. As a going concern, the bulk of the mill plant has been supplied and being installed without suspending or stopping the mill operations.

The proposed mill expansion is being undertaken as an addition of a complete module of a modern palm oil mill with tilting sterilizer type, based on extraction, depericarping and clarification system designed for 24hours/day operations and rated at 30MT FFB per hour capacity. This modern mill with tilting sterilizer ensures the following;

- ✓ High throughput with shortest steaming time of 45-50 minutes
- ✓ Minimum downtime due to lesser moving parts
- ✓ Lower capital cost in overall palm oil mill construction
- ✓ Low operation and maintenance costs
- ✓ High efficiency in oil extraction and cost effective
- ✓ Quality in oil extraction
- ✓ Easy and safe to operate and needs minimal training for the engineers and operators.

The plant is designed for a useful life of over 20 years once it is operated and maintained according to the manufacturers' instructions.

The proposed mill expansion project comprises five major components. The technical drawings of the new fruit reception station and the mill facility layout are presented in Figures 3-3a and 3-3b respectively, while the technical drawing of the new processing line is presented in Figure 3-4.

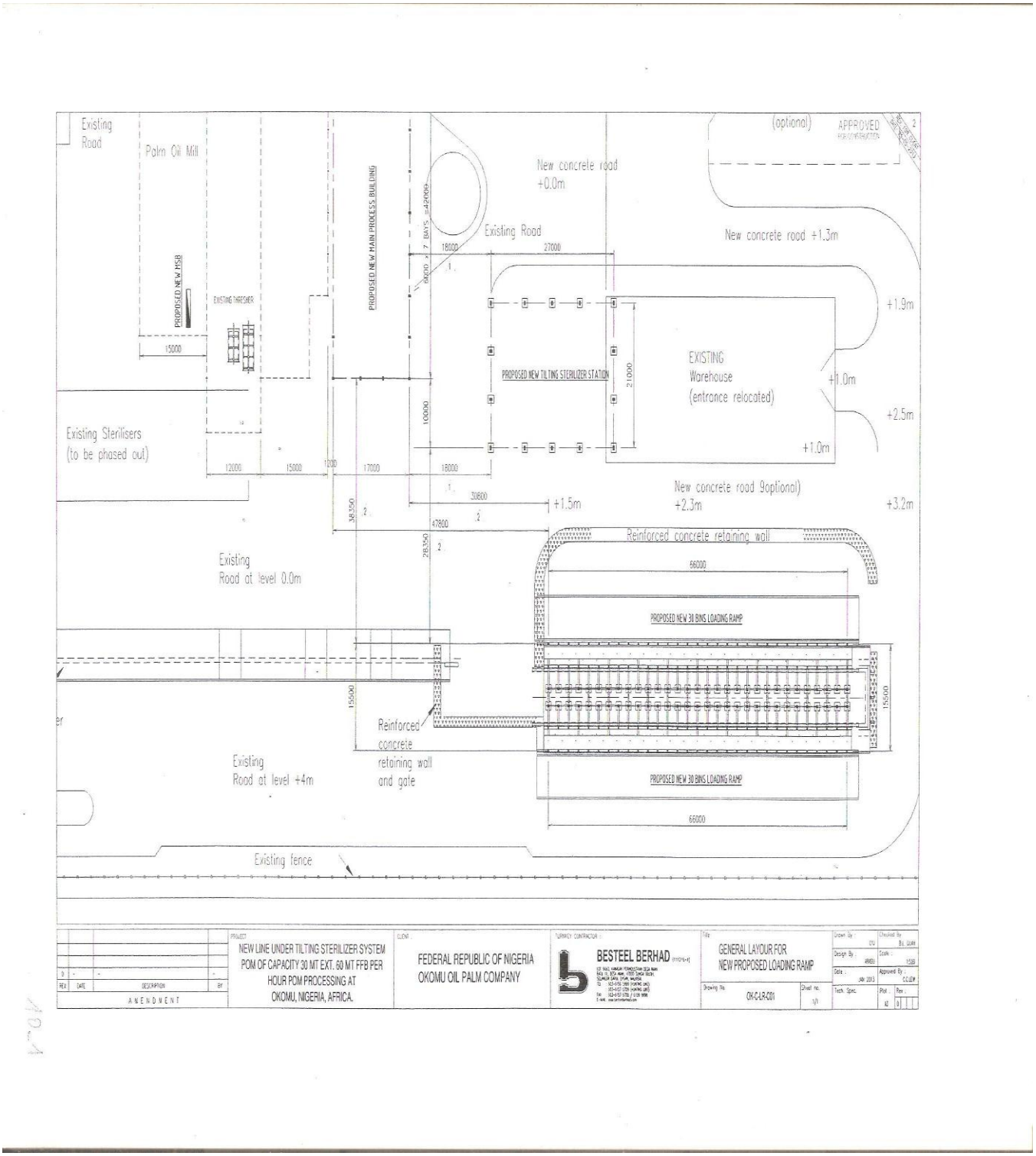


Figure 3-3a: Technical Drawing of proposed mill's fruit reception station

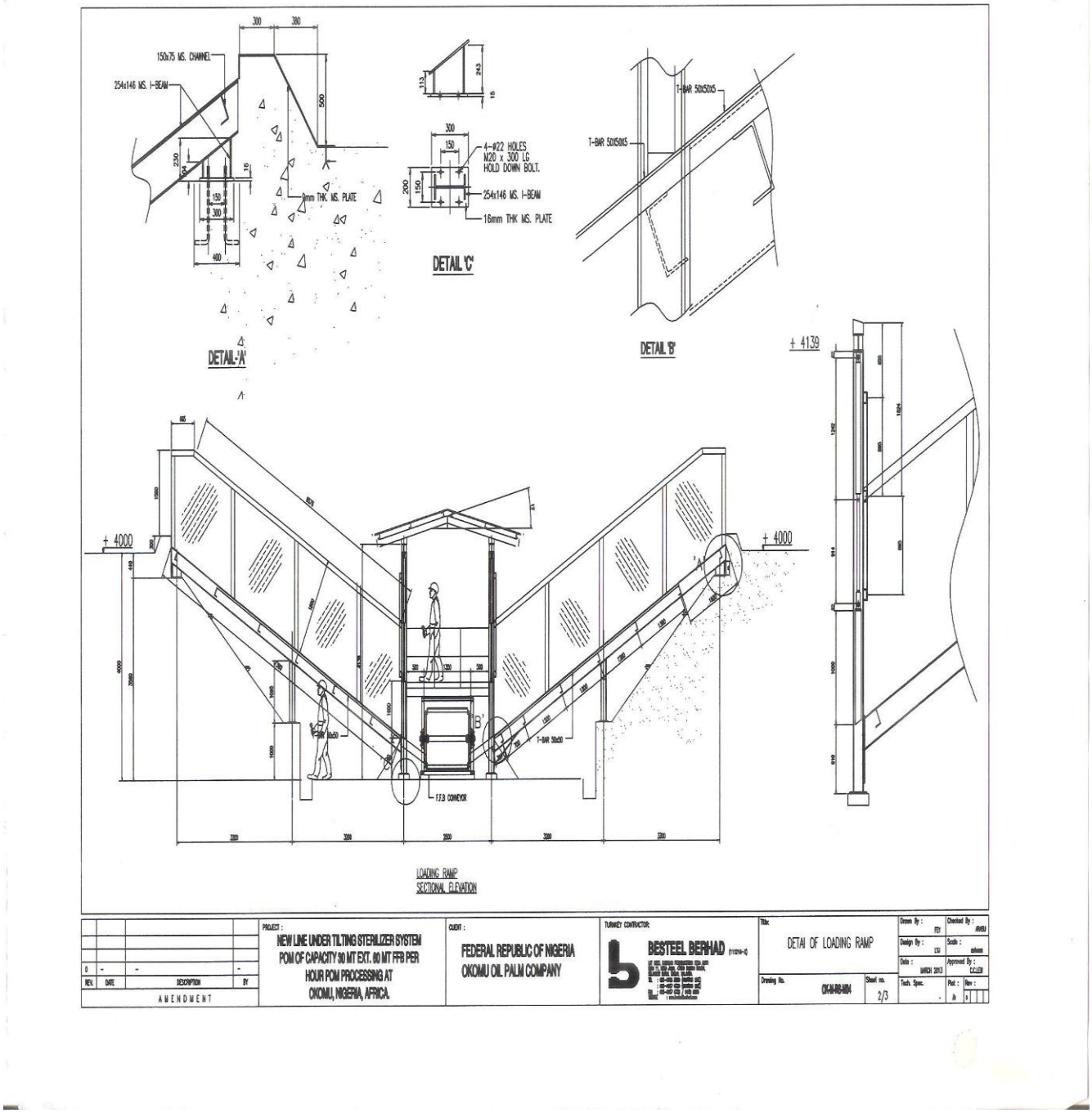


Figure 3-3b: Detail Technical Drawing of proposed mill's fruit reception station

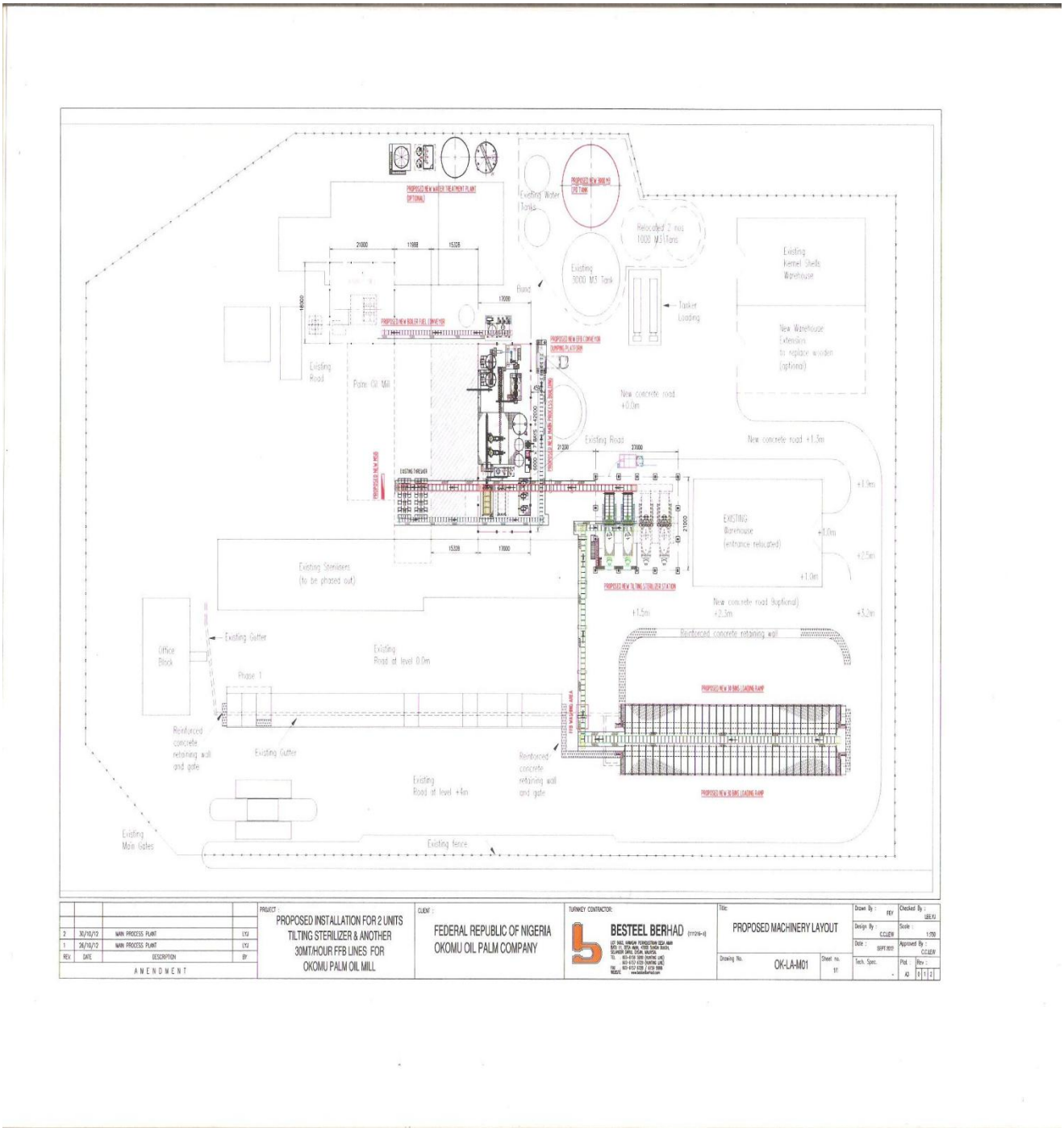


Figure 3-4: Technical Drawing of Proposed Machinery Layout

3.6 Mill Processing Line Mechanical Components

The mechanical components of the proposed mill processing line are presented in Table 3-1:

Table 3-1: Processing Line Mechanical Components

item	Description	Specification
LR	**FRUIT RECEPTION STATION**	
LR 1	Weighbridge	
LR 2 No 1	FFB Loading Ramp No.1 c/w Hydraulic System	Door
LR @ No 2	FFB Loading Ramp No.2 c/w Hydraulic System	Door
LR 3	Horizontal FFB Conveyor c/w walk way	1.2M (W) x 86.0M (L)
LR 4	Inclined FFB Conveyor c/w walk way	1.2M (W) x 55.0M (L)
LR 5	FFB Cleaning System	As per drawing
LR 6	FFB Cleaning System Pumpset	10m^3/hr at 15m head, 3kw
ST	**STERILIZATION STATION**	
ST 1	FFB Feeding Conveyor c/w inlet chute & walk way	1.2M (W) x 21.0M (L)
ST 2	Tilting Sterilizer system	Boiler Ø 3.2M x 7.20M (L) c/w M.S 9mm Liner
ST 3	Sterilizer Hydraulic & Steam control system	Manual Lever Control System
ST 4	Auto Feeder Hopper c/w Drive System	As per Drawing
ST 5	Blow-Down Chamber	Ø 1.9M x 9.0M (L)
ST 6	Sterilizer Pit Pump	10m^3/hr at 15m head, 3kw
ST 7	Sterilized Condensate Collection Pump	30m^3/hr at 25m head, 5.5kw
ST 8	All interconnection Platform & Staircase	As per Spec Sheets
ST 9	Air Compressor	7 bar, 7.5hp
TH	**THRESHING STATION**	
TH 1	Inclined Sterilized Fruit Bunch (SFB) Conveyor	1.2M (W) x 90.0M
TH 2	Cages Hoist (*)	
TH 3	Autofeeder for cages (*)	
TH 4	Thresher Drum	Ø 2.1m x 6.0m(L) Shaftless Type
TH 5	Bottom Thresher Conveyor	Ø 500mm x 8000mm (L)
TH 6	Top cross conveyor	Ø 600mm x 30000mm (L)
TH 7	USB Crusher	
TH 8	USB Conveyor	
TH 9 No 1	Horizontal Empty Bunch Conveyor No.1	750mm (W) x 47.0M (L)
TH 9 No 2	Horizontal Empty Bunch Conveyor No.2	
TH 10	Inclined Empty Bunch Conveyor No.3	750mm (W) x 32.0M (L)
TH 11	Incinerators (*)	
TH 12	Thresher Structures & Platform	For install 1 unit thresher drum
TH 13	Inclined empty bunch conveyor support structure c/w 'Y' Chute	As per Spec Sheets
PS	**PRESSING STATION**	
PS 1	Fruit Elevator	900WD x 14.0m (L)
PS 1a	Permanent Plate Magnets	12 inch (W) x 7inch (L)
PS 2	Top Cross Conveyor	
PS 3	Digesters Feeding Conveyor c/w manual rack & pinion	Ø 600mm x 12000mm(L)
PS 4	By Pass & Recycled Chutes	M.S 500mm S.Q x 8000mm (L)
PS 5	Excess Fruit Conveyor/Return Conveyor	Ø 500mm x 10000mm(L)
PS 6	Digester	4.0 m^3

PS 7	Screw Press	P 15 (Modiplam)
PS 8	Press Hot Water Tank	M.S 6mmt (4m^3)
PS 9	"V" Notch Dilution Tank	M.S 4.5mmt (200 Litre)
PS 10	Crude Oil Gutter	S.S 304 Sch 10 Ø 250 Pipe x 26.0M (L)
PS 11	Sand Trap Tank	M.S 6mmt (6m^3)
PS 12	Vibrating Screen	Ø 60" Double Deck
PS 13	Screen Reject Conveyor	Ø 250mm x 10000mm (L)
PS 14	Crude Oil Tank	M.S 6mmt (10m^3)
PS 15	Crude Oil Pump	35m^3/hr at 30m head, 7.5kw
PS 16	Crude Oil Vibrating Screen Platform	As per Drawing
PS 17	Pressing Station Structures & Platform	As per drawing
DS	**DEPERICARPING STATION**	
DS 1	Cake Breaker Conveyor c/w Steam Jacket, Steam trap and Catwalk	Ø 750m x 24000mm (L)
DS 2	Depericarper	As per Drawing
DS 3	Polishing Drum	Shaftless Ø 1.0m x 6.0m (L)
DS 4	Pneumatic Fibre Transport Ducting	As per drawing
DS 5	Fibre Cyclone	Ø 2300mm
DS 6	Fibre Cyclone Fan & Ducting	As per Drawing
DS 7	Fibre Cyclone Airlock	Ø 750mm
DS 8	Inclined Wet Nut Conveyor	Ø 300mm x 7000mm (L)
DS 9	Destoner c/w ducting &Airlock	
DS 10	Destoner Cyclone, Fan & Ducting	
DS 11	Fibre/Shell Cyclone Supporting Structure	As per Drawing
KS	**KERNEL RECOVERY PLANT**	
KS 1	Nut Conveyor	
KS 2	Wet Nut Elevator	450mm (W) x 10000mm (L)
KS 7	Nut Grading Drum	
KS 8	Nut Hopper c/w Drying System	M.S 6mmt (100m^3) 3 compartments
KS 9	Vibratory Feeder c/w Permanent Plate Magnets	5 Ton /Hr. Magnets 12 inch (W) x 7 inch (L)
KS 10	Ripple Mills	6 Ton /Hr
KS 11	Cracked Mixture Conveyor No.1 (Below Ripple Mill)	Ø 300mm x 9000mm (L)
KS 12	Cracked Mixture Conveyor No.2	
KS 13	Cracked Mixture Conveyor No 3	
KS 14	Cracked Mixture Elevator	450mm (W) x 12800mm (L)
KS 15	Primary Stage Winnower Cyclone	As per Drawing
KS 16	Primary Stage Winnower Fan & Ductings	As per Drawing
KS 17	Primary Stage Winnower Airlock	Ø 300mm x 9000mm (L)
KS 18	Secondary Stage Winnower Cyclone	As per Drawing
KS 19	Secondary Stage Winnower Fan & Ductings	As per Drawing
KS 20	Secondary Stage Winnower Airlock	Ø 300mm
KS 30	Kernel elevator	450mm (W) x 10000mm (L)
KS 31	Kernel distributing conveyor	Ø 300mm x 8000mm (L)
KS 32	Kernel Drying Silos c/w Fan & Heater	M.S (60m^3 each)
KS 33	Kernel Vibratory Feeder	
KS 34 No 1	Bottom Dried Kernel Conveyor No.1 (To Existing Mill)	Ø 300mm x 7000mm (L)
KS 34 No 2	Bottom Dried Kernel Conveyor No.2 (To Transport System)	Ø 300mm x 8000mm (L)
KS 35	Dried Kernel Transport System	As per Spec Sheets

KS 36	Distribution Dried Kernel Conveyor (To existing Mill)	Ø 300mm x 20000mm (L)
KS 37	Kernel Bulking Silo c/w Support Structure and Roofing	
KS 38	Kernel Recovery Station Structure and Platform	As per Drawing
CS	**CLARIFICATION STATION**	
CS 1	Crude Oil Buffer Tank	M.S 6mmt
CS 2	Oil Clarifier	M.S ($120m^3$)
CS 3	Pure Oil tank	M.S ($30m^3$)
CS 4	Pure Oil Pump	$20m^3$/hr at 25m head, 7.5kw
CS 5	Oil Purifier	
CS 6	Atmospheric Drier c/w Pumpstes	As per Drawing
CS 7	Oil Production Pump	$15m^3$/hr at 70m head, 7.5kw
CS 8	Sludge Tank	M.S ($30m^3$)
CS 9	Precleaner Pump	$20m^3$/hr at 25m head , 7.5kw
CS 10	precleaner	
CS 11	Precleaner Sand Collection Tank	M.S 6mmt
CS 12	Overhead Sludge Buffer tank	S.S 4.5mmt ($3m^3$)
CS 16	Light Phase Recycle Tank	M.S 6mmt
CS 17	Light Phase Pump	$10m^3$/hr at 25m head, 3kw
CS 18	Reclaim Oil Tank	M.S 6mmt ($4m^3$)
CS 19	Reclaim Oil Pump (to crude oil buffer tank)	$20m^3$/hr at 30m head, 5.5kw
CS 20	Sludge Vibrator Screen (Single deck)	
CS 21	Sludge Drain Tank	M.S 6mmt, $8m^3$
CS 22	Operating Liquid Tank / Hot well Tank	M.S 6mmt
CS 23	Drain collection pit pump (to recovery tank)	
CS 24	Fat pit /Sludge pit	Under Civil work
CS 25	Fat pit pump	
CS 26	Structure and Platform support	As per Drawing
SB	**SHELL BUNKER**	
SB 1	Shell Hopper	M.S 6mmt ($40m^3$)
SB 2	Dry Shell Conveyor	
SB 3	Boiler Fuel Conveyor c/w walk way & roofing No.1	0.75M (W) x 40.0M (L)
RW	**RAW WATER TREATMENT PLANT**	
RW 3	Raw water chemical dosing system	0.2 kw (Dosing) 0.18kw (Stirrer)
RW 4	Water clarifier tanks	M.S ($120m^3$/hr)
RW 5	Clarified water storage tank	M.S $600m^3$
RW 6	Pressure sand filters	$45m^3$/hr each
RW 7	Pressure sand filters pumps	$45m^3$/hr at 20m head, 15kw
RW 8	Overhead water tanks c/w washing tanks	M.S $80m^3$ / $60m^3$
RW 9	Overhead tank supporting structure	15m(H) x 10.5m (w) x 10.5m(L)
RW 10	Interconnection piping c/w valve	Dosing, drain and filter
RW 11	Main water pump	$30m^3$/hr at 25m head, 5.5kw
PW	**PIPING AND VALVES WORK FOR PROCESSING**	
PW 1	Water- Cold and Hot	G.I Pipe
PW 2	Steam- Low pressure and Condensate	API Pipe
PW 3	Crude Oil and Sludge	S.S 304 Pipe Sch 10
PW 5	Compressed Air	API / SGP Pipe
PW 6	Oil Recycle	S.S 304 / API / SGP Pipe
PW 7	Cold water to Housing Complex	Excluded

AW	**ANCILLARY WORK**	
AW 1	Insulation	60kg /M^3
AW 2	Painting	1 coat primer & 2coat final
AW 3	Lubricant	
AW 4	Motor cover and base motor frame	As per Spec sheets
AW 5	Inter connection station platform	As per drawing
FF	FIRE FIGHTING SYSTEM	
FF 1	Fire fighting diesel pumpset	
FF 2	Hosereel, quick coupling and plain jet	As per Spec Sheets
FF 3	Hydrant Piping System	As per Spec Sheets
FF 4	Fire Extinguisher	

3.7 Safety Devices

There are two safety switches on each machine including the sterilizer. The first can be used manually as a safety button to stop the machine and the ancillary machines. The second one is triggered off automatically by the machine if the operations limits are exceeded. Also, on each critical machine a reverse button is installed. Some of the critical machines have safety provisions as follows:

Oil Mill Machines and Component:

Sterilizer	Emergency switch
Thresher	Emergency switch
Press	Emergency switch
Clarification Machine	Emergency switch
Kernel Oil Machine	Emergency Stop

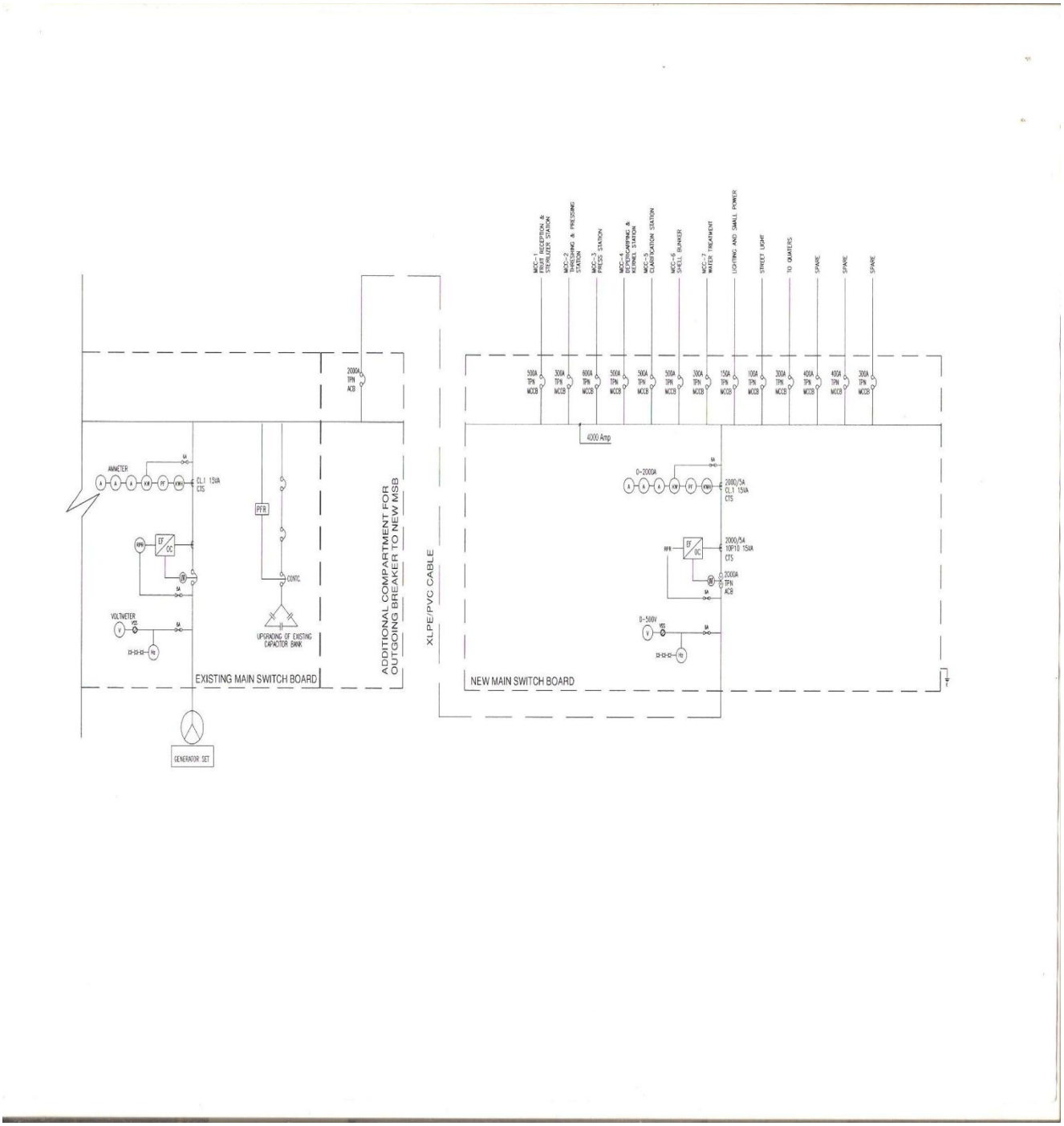


Figure 3-5: Electrical Drawing of the main switchboard

3.8 Tilting Sterilizer

The proposed sterilizer is tilting type. There will be two units of tilting sterilizer of combined capacity of 30 tons FFB per hour. The tilting sterilizer has many benefits and advantages over any other types. These include the following:

- **Lower Construction Cost with Less Machinery**
  No need for FFB cages, rail tracks, transfer carriages, capstans, bollards, winches, overhead-cranes, hoists, cage indexer system, cantilever bridges, tippers, p4shers and tractors, FFB press, EFB splitter and SFB post heating cooker.

- **High Throughput**
  Shortest steaming time in industry (45-50 minutes) and compacts with minimum dead space.

- **Low downtime**
  Reduces down time due to lesser machinery and human factors

- **Minimum oil Loss**
  Low oil loss in EFB. No oil drips, and condensate is directly used for dilution.

- **Lower power consumption and wastewater discharge**
  Due to lesser machinery, the tilting sterilizer uses more than 50% lower steam consumption when compared with conventional system.

- **Easy and Safe to Operate**
  Much easier to operate than conventional horizontal sterilizers. The automatic operation is equipped with safety inter lock, and cleaner working environment

- **Lower operation and maintenance costs**
  Only 2-3 operators can operate a multiple sterilizers station of this modern oil mill

- **Minimum damage to FFB**
  The tilted position allows FFB to slide/role down during filling.

- **Much Smaller sterilization station and much lower cost.**
  Needs only 30% of the space occupied by horizontal sterilizer (see Figure 3-6).

The schematic diagram of a modern palm oil mill with tilting sterilizer and a conventional palm oil mill with horizontal sterilizer is presented in Figure 3-7.

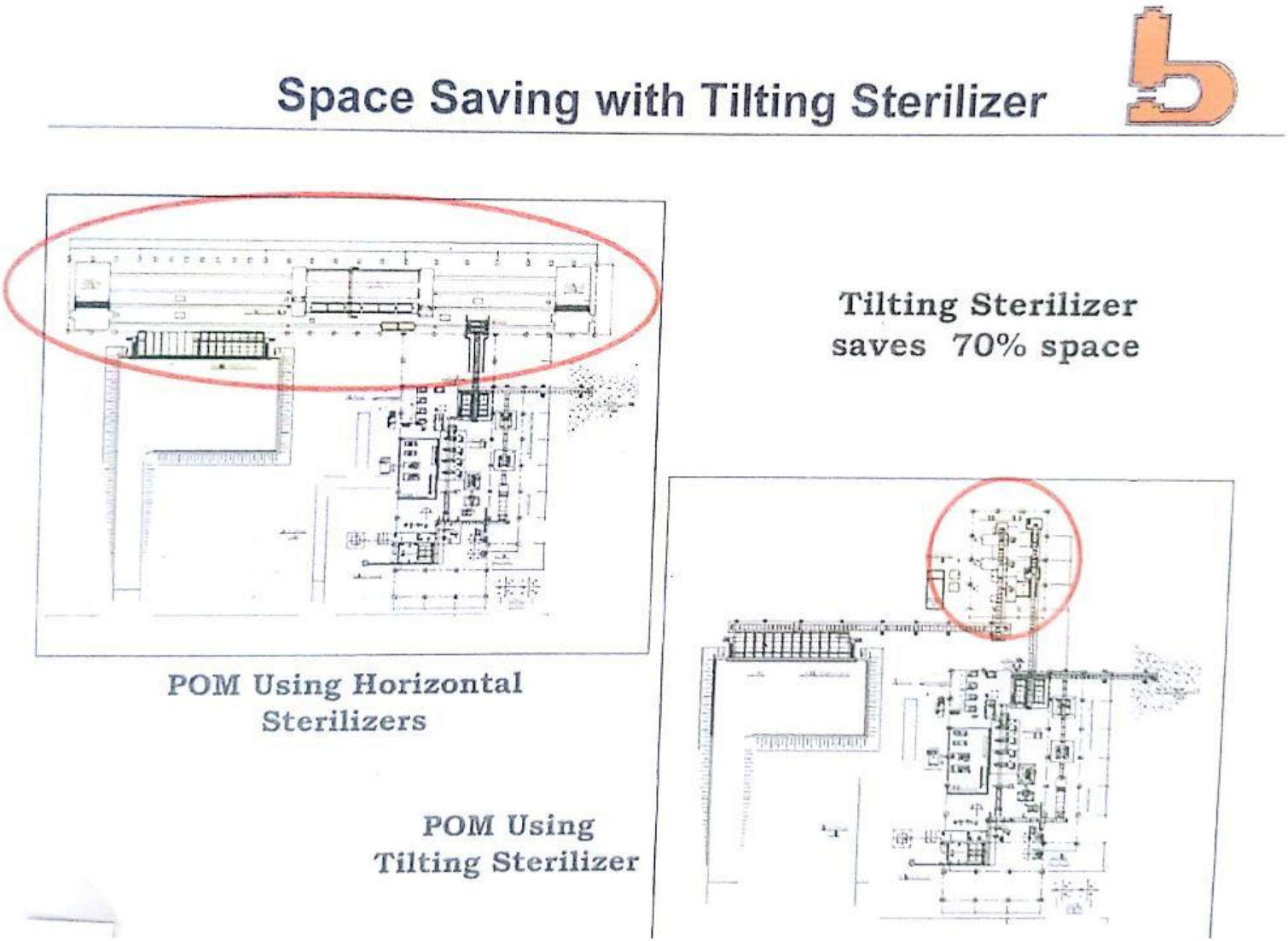


Figure 3-6: Technical drawings showing space saving (up to 70%) with Tilting Sterilizer

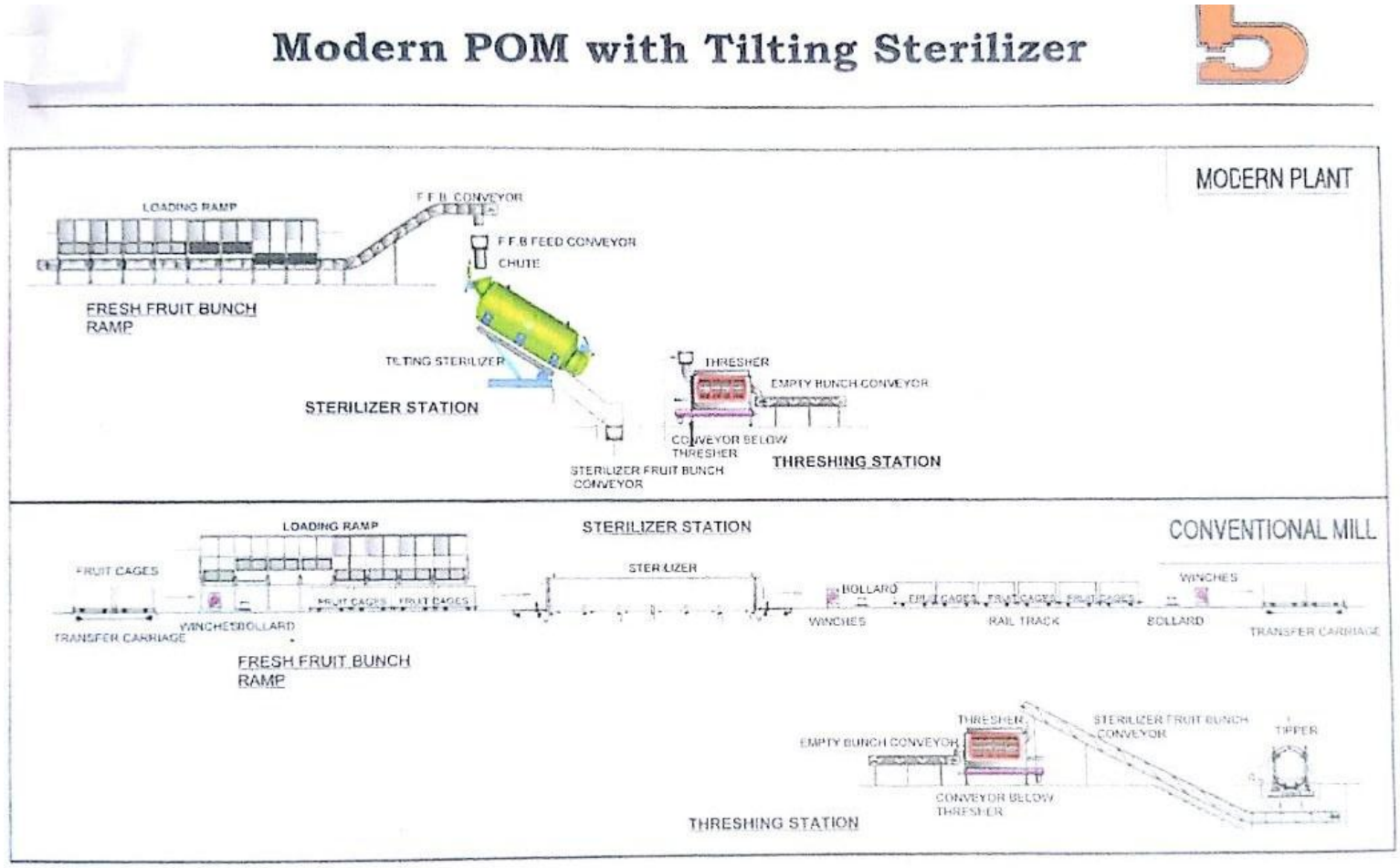


Figure 3-7: Schematic diagram showing Modern Palm Oil Mill with Tilting Sterilizer and Conventional Mill

3.8.1 Tilting Sterilizer vs Horizontal Sterilizer

The difference between tilting and horizontal sterilizer is presented in Table 3-2 below.

Table 3-2: Difference between Tilting and Horizontal sterilizer

Descriptions	Tilting Sterilizer	Horizontal Sterilizer	Vertical Sterilizer
No. of Peak	1	3	
Cycle Time	83 mins	100 mins	Longer. SFB discharge by auger, more dead space thereby leading to less efficient cooking
Oil Loss in FFB	Average 1.07%	<3.44% (Additional equipment required to recover oil loss)	<6% (Additional equipment required to recover oil loss)
Oil Recovery	Condensate is used for dilution and oil loss recovered	Oil dripping onto thefloor	
Unstripped Bunch	<1%	<2%	<3%
Operation Flexibility	1 to 3 peaks	2 to 3 peaks	
Steam Consumption	170 – 200 kg/t FFB	300 – 450 kg/t FFB	
Heat Loss	Minimal	High (large vessel)	
Number of Equipment	Less	More	
Number of Operator per shift (60 t/h mill)	18	32	
Cost of Investment	More than 20% lower than CMC type conventional mills	High	
Maintenance Requirement	Only scheduled maintenance of hydraulics	Many plant items to be maintained	Added maintenance of auger (some use water for cushoning)
Cost of Operation	Low	High	Fair (some use water for cushoning)
General Operation and Working Environment	Simple to operate, safer and cleaner environment	Complex and many human dependent factors and oily working floor	Added tasks like water filling system and auger discharge
Delay and Downtime	Minimal	Transferring of cages	
Waste water and Recovery	Minimum condensate	More steam condensate	
Upgrading Plant	Small space required provides many flexibilities in arrangement	Need more space	
Automation	Fully automation from filling of FFB to unloading of Sterilized Fruit Bunches (SFB)	Difficult for complete automation	

3.8.2 Tilting Sterilizer Specifications

The specifications are presented in Table 3-3 below;

Table 3-3: Tilting Sterilizer Specifications

Descriptions	Size (30T)
Holding Capacity (tonne)	28
Shell Length (mm)	7200
Diameter (mm)	3200
Vessel Volume (m^3)	58
Inlet/Outlet Door (mm)	1500/1700
Material Standard (Vessel)	JIS SS 400
Design Pressure (kg/cm^2)	3.5
Design Temperature (^0C)	150
Insulation (50mm thk rockwool c/w 0.7 mm Al cladding)	Yes
Vessel Design Approval to Malasia	Yes
Regulation	DOSH
Outlet Door Lining	Optional
Vessel Body Lining	Optional
Discharge Mechanism	Tilting
Hydraulic for Tilting and Door	Yes

3.9 Steam Boiler

A boiler can be defined as a closed vessel in which water or other fluid is heated under pressure. This fluid is then circulated out of the boiler for use in various processes or power generation. In the case of power generation, steam is taken out of the steam boiler at very high pressure and temperature.

Steam boilers are used where steam and hot steam is needed. Hence, steam boilers are used as generators to produce electricity in the energy business. Besides, steam boilers are used in many different application areas in the industry, for example in heating systems or for cement production, steam boilers are also used in agriculture as well for soil steaming.

Boiler Types

Boiler systems are classified in a variety of ways. They can be classified according to the end use, such as foe heating, power generation or process requirements. Or they can be classified according to pressure, materials of construction, size tube contents (for example, waterside or fireside), firing, heat source or circulation. Boilers are also distinguished by their method of fabrication. Accordingly, a boiler can be packaged or

field erected. Sometimes boilers are classified by their heat source. For example, they are often referred to as:

- Coal fired boilers
- Oil fired boilers
- Gas fired boilers
- Multi-fuel fired
- Industrial waste fired boilers
- Biomass fired boilers

The proposed steam boiler is Atmindo boiler of 40 tons per hour capacity. It is a waste fired steam boiler that would serve standby purposes, to complement the existing main steam boiler. The boiler would comprise Atmindo Bi-drum Model SFMW4025270SHPG bent tube site erected water tube boiler having the capacity to evaporate 40,000 kg/hr at 22 bar (g) MCR, 270^{o}C superheated steam (SH) when fired with palm waste fuel and drum working pressure of 25 bar (g).

The pressure parts of the boiler would be carried in a substantial structural steel frame to support the boiler fabric with due provision for thermal expansion between the pressure parts and supporting structure and the refractory and brickwork setting. The name and address of the manufacturers are as follows:

Atmindo
Lot 9683
Kawasan Perindustrian
Desa Aman
Meru
47000
Sungai Buloh
Malaysia

The major features of the steam boiler are presented in Table 3-4 below.

Table 3-4: Major Features of Steam Boiler

	Description
1	Atmindo Bi-drum Water Tube Steam Boiler
2	Modulating Fuel Feeding Conveyor
3	Air Cooled Reciprocating Grate (3% Cr)
4	Continuous Ash Disposal Conveyor System
5	Membrane Wall
6	Economizer (3% Gain)
7	Air Preheater (3% Gain)
8	Touch Screen PLC Boiler Control & Monitoring
9	Recommended Spare Parts

The specific technical information on the boiler is presented in Table 3-5.

Table 3-5: Steam Boiler Technical Information

Description	Details
Boiler Data	SFMW4025270SHPG
Application	Standby steam boiler for power kW and process steam production
Installation	In the premise of the existing oil mill processing line
Quality	Designed to operate under tropical conditions, i.e. hot, 25-40^{o}C, and humid, 80-90%
Electric Motors	Tropicalized
Induced Drought Fan	Frequency converter to limit the start Amps
Mass Flow	40,00 kg/hr
Pressure MCR	22 bar (g)
Steam Pressure	25 bar (g)
Steam Output	40 ton/hr
Temperature	270^{0}C SH

3.10 Palm Oil Mill Effluent Lagoon

The proposed effluent lagoon treatment is a natural depression of about 159,500m^2 capacities with an average depth of 2.5 meters and a holding capacity of 398,750m^3. The proposed effluent holding capacity will conveniently absorb the annual expected effluent of 220,000m3 from the mill expansion project. There are two surface lines of 5" steel pipe conveying effluent from the mill complex to the lagoon as illustrated in Figure 3-8.

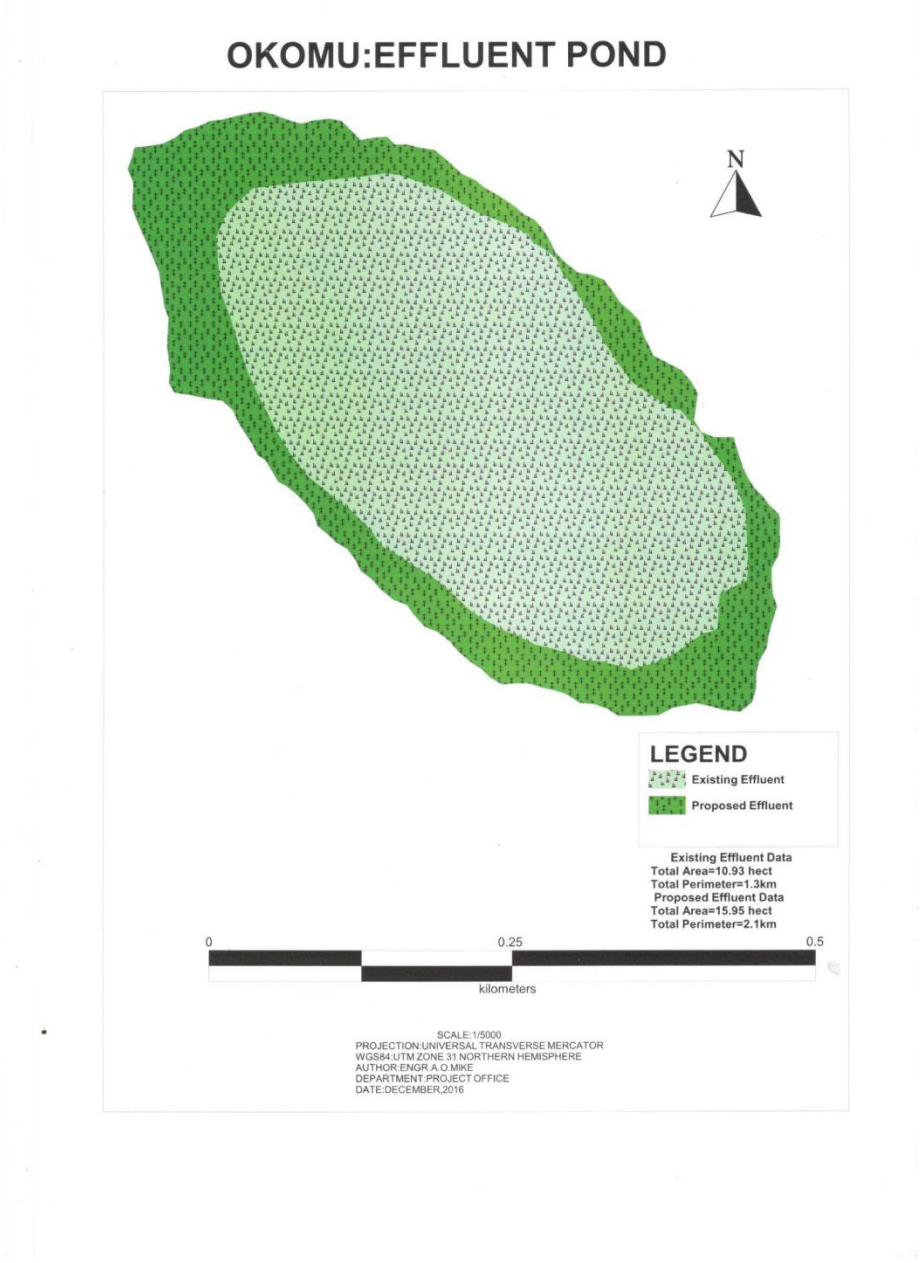


Figure 3-8: Proposed Expanded Palm Oil Mill Effluent Lagoon

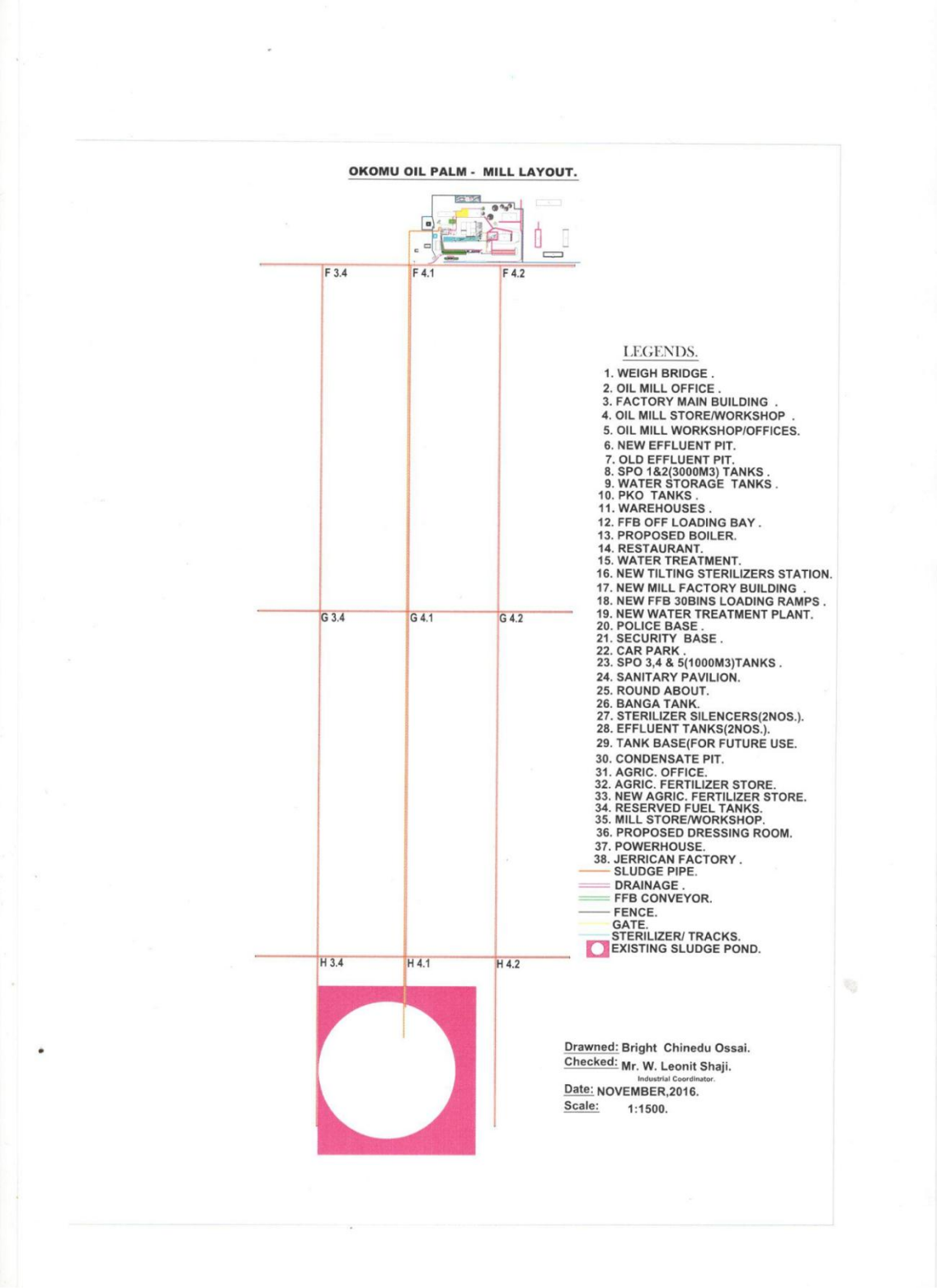


Figure 3-9: Technical Drawing of Pipelines conveying effluent to the Lagoon

The technical drawing of the palm oil mill expansion complex is presented in Figure 3-10, while the different stages of the construction and development are illustrated in Figure 3-10.

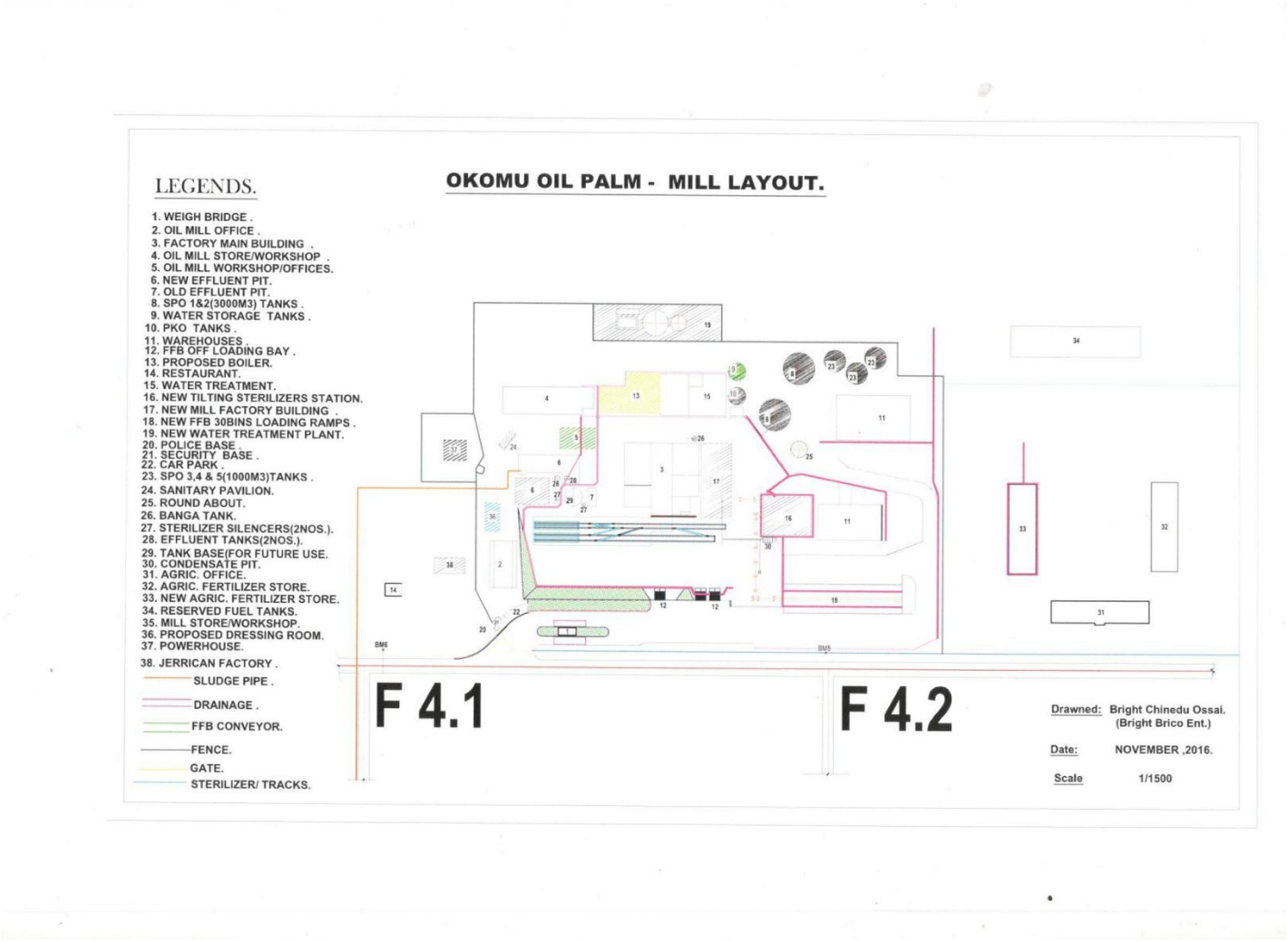


Figure 3-10: Technical Drawing of Expanded Palm Oil Mill Complex Layout

Plate 3-1: Different stages of mill expansion construction and development

3.11 Civil Structures

The major civil structures of the palm oil mill expansion project are listed in Table 3-6.

Table 3-6: Major Equipment and Structures of the mill expansion project

S/No.	Item	Specification	Remark
1	FFB Reception Station	Steel Structure	To be newly constructed
2	Sterilizer Station	Steel Structure	To be newly constructed
3	Processing Line	Steel structure	To be newly constructed
4	Boiler House	Steel Structure	Another boiler is to be installed to complement the one inside the existing mill complex.
5	Water Treatment House	Concrete Structure	Existing
6.	Ash Yard	Open Field	Existing, will be fenced.
7.	Effluent Lagoon	Earth Pond	Existing lagoon, but another serial pond will be constructed to be able to accommodate additional POME coming from the proposed processing line.

3.12 Mill Features and Facilities

The main mill features and facilities are described in Table 3-7.

Table 3-7: Mill Features and Facilities

Component	Description
FFB Storage cubicles	The FFB Storage cubicle is for the storage of FFB prior to processing. 400 tons FFB per ramp, 2 ramps (see Figure 3-2a).
Workshop	The workshop provides back-up repairs and maintenance services for the mill plant and machinery (Existing).
Power Supply	The power requirement of the mill expansion is the same as the present utilization which is estimated at about 1,369 kw. This power requirement is supplied from two industrial generators and a turbine as follows: i) CAT – 2000kVA ii) CAT – 500 kVA iii) Turbine – 1900kVA
Water Supply	The process water requirement is 270m³ per ton of FFB as is the present situation. The process water is sourced from a stream located behind the mill complex. The water supply system involves the extraction of water from the surface water with electrical pumps of 11.5 kw. The raw water is pumped into an overhead water tank. The water tank is also equipped with an automatic level switch, which turns on and off to maintain a constant water level. Water is fed into the processing line by gravity. The storage tank is also equipped with a flow meter to monitor and record water use and safety ladder for ease of maintenance.
Weighbridge	There are two (2 Nos.) weighbridge of 50 Tons capacity each with features including computers and control panels.
Laboratory/Admin Office	The laboratory/Admin office building is located within the mill office building. The building provides accommodation for the quality control laboratory and offices for the mill administration. The laboratory performs essentially quality control and quality assurance operations and is equipped with the appropriate equipment, machines and apparatus. The major laboratory equipment includes oil extractor and centrifuge.
Tank Farm	The finished product will be stored in the Tank Farm. There are four (4 Nos.) storage tanks of 2000 tons, 2800 tons, 1000 tons and 1000 tons each.
Communication	Presently, there are four communication systems to facilitate operations and handle emergencies as follows: **Local Intranet** – for internal communication (between the different offices) **VHF Handset**– for internal communication **Internet System** – for external communication **GSM** – for both internal and external communication.
Safety Devices	For the proposed mill expansion, all the machines would have their dangerous parts protected. Each machine would also have two safety switches including manual stop button and automatic stop button. In addition, critical machines will have reverse buttons installed.

3.13 Sizing of the Palm Oil Mill

3.13.1 Quantity of FFB to be Processed

The capacity of the existing mill is 30 MT FFB/hour with the proposed expansion at 30MT FFB/hour with each of the mill processing lines to process FFB alternately. The capacity utilization will rise gradually, as more plantation area becomes mature. The proposed sizing of the expanded mill is based on the following:

3.13.2 Throughput

- 60 tons FFB/hour
- 1200 tons/day [Average 24h/d]
- 150,000 tons/year

3.13.3 Capacity Utilization per Year

- 2015 to 2020 : 135,000 tons FFB
- 2021 to 2025 : 145,000 tons FFB
- 2026 : 150,000 tons FFB

3.13.4 Finished Products

CPO

- 2015 to 2020 : 27,000 tons
- 2021 to 2025 : 29,000 tons
- 2026 : 30,000 tons

PK

- 2015 to 2020 : 5,400 tons
- 2021 to 2025 : 5,800 tons
- 2026 : 6,000 tons

PKO

- 2015 to 2020 : 2,160 tons
- 2021 to 2025 : 2,320 tons
- 2026 : 2,400 tons

PKC

- 2015 to 2020 : 3,240 tons
- 2021 to 2025 : 3,480 tons
- 2026 : 3,600 tons

3.14 Installation & Commissioning

The equipment manufacturers and suppliers will be responsible for setting up and commissioning the mill plant and machinery. These activities include:

- Providing detailed drawings of mill's pre-installation requirements for foundations, structures, elevations, layout etc.
- General arrangements for all the plant and machinery in the processing hall together with installation pre-requirements
- On-site testing
- Instructions and training to users and maintenance technicians

3.14.1 Plant Installation and Construction Engineers

The installation and construction engineering companies are:

- UFT Engineering Ltd
  No. 8, Tarmac Rd, Adalemo, Lagos

- Austin Best O. Nigeria Limited
  310km 4, Idiroko Rd, P.O. Box 7594, Ikeja Lagos

- Pedrocchi + Co. Ltd
  187, Sapele Rd., P.O. Box 282, Benin City, Edo State

- Wilka Associates
  6, Akpakpava Rd., Benin City, Edo State

- Besteel Berhad
  Lot 9683, Kawasan Perindustrian Desa Aman, 47000, Sungai Buloh, Malasia.

3.15 Description of the Site

The mill expansion project is proposed to be constructed beside the existing one inside the mill complex. The other components of the project including the boiler and effluent lagoon will be installed within the existing mill and about 2.5km from the mill complex respectively.

3.16 Water Treatment Process

The water treatment process (Water treatment plant) is designed to ensure the desirable water quality for boiler feed water and auxiliary quality water needs. The existing water treatment source will service the proposed boiler.

3.17 Water Supply and Drainage System Facility

Water supply and drainage system facility will be designed in relation to water source; circulating water system; make-up water system; service water system; water supply and drainage of the entire mill complex.

Domestic water supply system is fed from domestic water supply system. Water supply and drainage systems include: domestic water supply; storm water drainage, domestic sewage and wastewater drainage.

3.18 Firefighting System

The existing fire prevention and control system includes water firefighting system, hydrant, as well as fire extinguishers installations. Water firefighting system is responsible for the firefighting of the mill, oil tank area, auxiliary and associated buildings.

3.19 Emissions Control Facilities

The existing boiler operation is achieved using biomass as fuel. The record of emission monitoring revealed that gaseous emission from the boiler and other facility operations including the residential quarters are within controlled limits as shown in Table 4-6.

However, emission control facilities will be provided, especially at the steam boiler. Such facilities will include:

- Electrostatic Precipitator (ESP)
- SO_2 Removal Facility
- NOx Control Equipment

3.20 Civil Engineering

The steam boiler will be integrated in the existing mill installations and layout. The civil engineering design will be sound to ensure well organized operation within the mill complex.

In addition, fire prevention and evacuation; sanitary facilities; drainage of floors and roofs; lighting and ventilation; decoration and finishing
requirements need to be considered in the designs.

Civil engineering designs will be completed in full consideration of the major technical parameters and safety standards.

3.21 Current Situation of Energy Supply

AGO-fired power plants installed in the powerhouse provide power generation for the mill operations. There are two main AGO-fired power plants with total installed capacity of 2,500 kVA and 1900 kVA turbine.

3.22 Training

3.22.1 Plant Operation

Training will also be provided by the manufacturer/supplier of the mill plant and machinery regarding their operations and maintenance requirements. Persons who should participate in this training include:

- The Mill Manager in charge of Engineering (Operations and Maintenance)
- The personnel that will operate the mill plant and machinery

Training of staff and services contractor in waste management practices of the mill is critical. Training programmes will include:

- Basic training in waste handling procedures for all new staff
- In-service training to revise and update the knowledge of mill and waste handling staff.

Pamphlets and signs are all useful materials to complement the formal training activities and they act as reminder for staff.

3.23 Environmental Considerations

3.23.1 Treatment of Solid Waste Products

In a well-run palm oil mill, it is expected that each 100 tonnes of FFB processed yields 20 to 24 tonnes of crude palm oil and about 4 tonnes of palm kernels. Thus between 72 to 76 percent of the FFB comes out at various stages of the process as waste.

The solid wastes that result from the milling operations are:

- Empty fruit bunches,
- Palm fibre, and
- Palm kernel shell.

In the large- and medium-scale mills the above-mentioned waste products are all put to economically useful purpose. They could therefore be referred to as by-products rather than waste products.

Wet, empty bunches are partly dried in the sun and later used as fuel. Another economic use for the empty bunches is to return them to the plantation as a mulch to enhance moisture retention and organic matter in the soil.

The palm kernel shell is also used as a source of fuel for the boilers. Unfortunately the shell contains silicates that form a scale in the boilers if too much shell is fed to the furnace, thus limiting the amount of shell that can be utilized in the boilers. Residual shell is disposed of as gravel for plantation roads maintenance. Blacksmiths also buy the shells to use as fuel material in their casting and forging operations.

The fibre recovered from the nut/fibre separation stage is a good combustible material and finds ready use as fuel to boil the fruit. The fibre constitutes the bulk of material used to fire the large boilers used to generate superheated steam to drive turbines for electrical power generation in large-scale plants.

Boiler ash is recycled as fertilizer and factory floor cleaning agent. The potash in the ashes reacts with the oil to form a weak potash soap that is washed away with water.

Small-scale mills also use the fibre and bunch waste as fuel material. Most small-scale mills do not undertake the shelling of recovered palm nuts. The nuts are sold to palm kernel processors.

Small-scale palm kernel processors use clay baths to separate kernels from shells. The shells are normally left in a pile to dry. Some of the shells are used for fuel but there are always residual amounts found around the palm kernel processing centres. Periodically the pile is removed and used as landfill.

Wood consumption of small-scale operations is relatively small because of the recycling of the fibre and bunch waste as the main fuel source. The medium-scale operators tend to supplement their internally generated solid waste fuel sources with wood for firing their boilers. The impact on the local tree population is significant enough to cause factories to close while foraging for wood supplies.

3.23.2 Treatment of Aqueous Effluent

Large- and medium-scale mills produce copious volumes of liquid waste from the sterilizer, clarifying centrifuges and hydro cyclones. This effluent must be treated before discharge to avoid serious environmental pollution.

Liquid waste treatment involves anaerobic fermentation followed by aerobic fermentation in large ponds until the effluent quality is suitable for discharge. In some of the mills the treated effluent is used on the farm as manure and source of water for

irrigation. The sludge accumulating in the fermentation ponds is periodically removed and fed to the land.

To manage the amount of oil entrained in the effluent, while at the same time improving the efficiency of oil recovery, the large mills use de-watering and decanting centrifuges at various locations in the process line.

When it comes to liquid waste management most traditional processors and small-scale palm oil processors do not adhere to any environmental protection practices. The environmental awareness level of the operators in this industrial area is low. Indeed much is desired of the hygiene of most facilities. Traditional processors operate so close to nature that they simply return liquids to the surrounding bushes. The discharged quantities are so small that the ground easily absorbs the waste matter and the operators have not yet seen their activities as injurious to their surroundings.

However in the more organized intermediate technology mills sludge from the clarifying tanks are carried in buckets or rudimentary gutters to sludge pits dug in the nearby bushes. When the sludge pit begins to give off a bad odour the pit is filled in and another one dug for the purpose. Charcoal from the cooking fires is dumped into the pits to absorb some of the odour.

Sometimes the oil in the sludge pit is recovered and mixed with fibre to make a fire-starting cake called 'flint'.

It has been observed that when the small-scale mill operators empty their sludge on the surrounding bushes the bushes slowly die. Operators say they use the sludge as a herbicide to clear their surroundings. It is, however, time to develop simple inexpensive aqueous pollution control systems for small-scale operators.

Environmental pollution considerations in small-scale palm oil milling need concentrated attention as this industrial segment assumes greater importance. It is hoped that as more educated people come into the industry they will bring increased awareness and a greater commitment to adopt improved environmental management practices in their operations.

3.24 Waste Management

Okomu Oil Palm Company Plc has put in place detailed waste management plans covering a comprehensive description of activities and waste handling at preconstruction, construction, operational and abandonment phases of this project. During site visits, the waste management practices were observed and the company's internal environmental management system (EMS) was ascertained.

Palm oil processing is carried out using large quantities of water in mills where oil is extracted from the palm fruits. During the extraction of crude palm oil from the fresh fruits, about 50% of the water results in palm oil mill effluent (POME). It is estimated that for 1 tonne of crude palm oil produced, 5-7.5 tonnes of water ends up as POME (Ahmed et al, 2003).

The solid waste products that result from the milling operation are empty fruit bunches, palm fibre and palm kernel. In both traditional and modern milling settings, these solid waste products are all put to economic use such as fuel material and mulch in agriculture. It is the POME that is usually discharged into the environment, either raw or treated.

Raw POME consisting of complex vegetative matter is thick, brownish, colloidal slurry of water, oil and solids including about 2% suspended soils originating mainly from cellulose fruit debris that is palm mesocarp (Bek Nelsen et al, 1999). The raw or partially treated POME has an extremely high content of degradable organic matter which is due in part to the presence of unrecovered palm oil (Ahmad et al, 2003).

This highly polluting wastewater can, therefore, cause pollution of waterways due to oxygen depletion and other related effects as reported by Ahmad et al. (2003). Thus, while enjoying a most profitable commodity, palm oil, the adverse environmental impact from the palm oil industry cannot be ignored.

Large and medium scale mills produce copious volumes of liquid waste (POME) from the processing lines, (Sterilizers, clarifying centrifuges and hydro cyclones) where POME is produced on a large and commercial level. However effective the system of oil recaptured from the sludge may be; the POME discharged from an oil mill is objectionable and could pollute streams, rivers or surrounding land (Hartley, 1988). While mills were comparatively few and mostly beside large fast flowing rivers, the problem was not a serious one but the situation in many countries including Nigeria is quite different with much attention being recently given to the subject of effective disposal and protection of the environment. Apart from the sludge water itself, which amounts to about 300 kg per tonne of bunches milled (or about 1.5 tonne per tonne of palm oil), there are also about 175 kg of sterilizer condensate and between 40 and 140 kg of POME from the hydrocyclone or clay bath separators/tonne of bunches (Hartley, 1988). The total amounts of POME is therefore more than a tonne/tonne bunches/hour, more than 200 tonnes of POME may be discharged over 24 hours and this may contain up to 1 tonne of oil and 9 tonnes of dissolved or suspended solids (Hartley, 1988).

POME is generated in the sterilization, digestion and clarification phases in the palm oil mills. POME has remained one of the largest liquid wastes generated in agro-industrial activities in Nigeria. Studies have shown (Ohimian, 2014) that Nigeria produces 3.950

to 4.650 million tonnes of FFB producing 790,000 to 930,00 metric tonnes of crude palm oil using 24.687 to 29.062 million tonnes of water for processing and generating 15.923 to 18.745 million tonnes POME in the past 10 years (2004–2014). The FFB production reached 4,650,000 crude palm oil, while utilizing 29,062,500 tonnes of water and releasing 18,745,312.5 metric tonnes of POME.

3.24.1 Ash Handling

Ash handing system is designed to consider ash quantity produced by the boiler; fly ash conveying system; bottom ash conveying system; and ash transportation off the site.

The bottom ash handling system will be used to collect and transport bottom ash from the furnace of boiler. The bottom ash from the furnace will be removed continuously by bottom ash coolers, after cooled, then discharged to bottom ash bin, it will further be transported by truck to the ash disposal yard east of the mill complex.

3.24.2 Ash Yard

The ash dumps of the existing operation are situated east of the mill complex. The available space is large and it has the capacity to accommodate the boiler ash to be generated from the proposed steam boiler. Trucks will be used for transporting ash to the ash yard. Seepage control (including concrete flooring and protective ground cover) and other environmental protection measures will be considered for the extra ash dumping.

3.24.3 Overall Waste Management

No waste shall be discharged into any surface river or wetland without adequate treatment. Table 3-8 shows the proposed waste management plan to be put in place.

Table 3-8: Summary of Okomu Oil Palm Company Plc Waste Management Plan.

Type of Waste	Waste From	Waste Management Option			Disposal	
		Reduce	Re-use	Recycle	Forest/	Land
Gaseous	Heavy duty machines (Land Preparation), Methane	Installation of appropriate filter to the exhaust pipe			-	-
Noise	Machinery and generators,	Installation of appropriate noise Reducin devices			-	-
Liquid	Residential Areas (Wastewater)	-	-	-	None	Soak-away attached to buildings.
	Sanitary from Toilets	-	Used in field	-	None	Appropriately designed Septic tanks
	Oil traps				None	Trapping o using retention tra
	Palm Oil Mill Effluent	-	Used in the field as irrigation water	-	-	-
Solid	Domestic waste, mill, workshop	Collected and taken to the dumpsite. Used as fuel for the mill boiler				-
	EFB, fibre, ash, plantation crop leaves, shrubs, fronds, tree back.	Retained in the field as manure				-
	Hazardous wastes such as empty agrochemical containers	Taken away by the manufacturers and/or suppliers as part of agreement deal.				-

None: Not discharged into/disposed off in the habitat − Not Applicable

3.24.3.1 Waste Classification

The wide range of waste that will be generated by the mill expansion project during construction and operation phases are classified into solid waste, liquid waste and gaseous emissions.

3.24.4 Waste Generation and Sources

Solid, liquid and gaseous wastes will be generated during construction and operational phases of the project. The waste profile is presented in Table 3-9.

Table 3-9: Waste Profile of the mill operation and proposed mill expansion at the Main Estate of OOPC

Project Phase	Waste Class		
	Solid	**Liquid**	**Gaseous**
Construction	❑ Soil and vegetation ❑ Cement bags ❑ Wood scraps ❑ Steel Scraps ❑ Rubble ❑ Food Waste ❑ Glass and Plastic Bottles ❑ Dust	❑ Wastewater ❑ Engine oil ❑ Spent oil	❑ Fugitive Dust ❑ Suspended Particulate ❑ Carbon dioxide ❑ Carbon monoxide ❑ Greenhouse Gases
Operation *(Mill)*	❑ EFB ❑ Sludge ❑ Paper ❑ Glass & Plastic Bottles ❑ Boiler ash ❑ Palm kernel shell	❑ Palm Oil Mill Effluent ❑ Wastewater ❑ Spent Oil	❑ Fugitive Dust ❑ Suspended Particulate ❑ Carbon dioxide ❑ Carbon monoxide ❑ Greenhouse Gases
Operation *(Laboratory)*	❑ Reagent bottles & cans ❑ Papers/plastics/glass	❑ Wastewater	❑ Carbon dioxide ❑ Carbon monoxide
Operation *(Offices)*	❑ Papers/plastics/glass ❑ Scrap office equipment	❑ Wastewater	❑ Carbon dioxide ❑ Carbon monoxide ❑ Fumes
Operation *(Workshop)*	❑ Metal scraps ❑ Empty cans ❑ Electric cables	❑ Spent oil ❑ Spilled Oil ❑ Wastewater ❑ Fuel ❑ Solvents	❑ Carbon dioxide ❑ Carbon monoxide ❑ Fume
Operation *(Offices)*	❑ Papers/plastics/glass ❑ Scrap office equipment	❑ Wastewater	❑ Carbon dioxide
Operation *(Powerhouse)*	❑ Plastics ❑ Empty cans ❑ Electric cables	❑ Wastewater ❑ Spilled Oil ❑ Spent Oil	❑ Suspended Particulate ❑ Carbon dioxide ❑ Carbon monoxide ❑ Greenhouse Gases
Operation *(Fuel Storage)*	❑ Plastic/metal Containers ❑ Papers	❑ Wastewater ❑ Spilled fuel	❑ Carbon dioxide ❑ Carbon monoxide ❑ Fume

3.24.4.1 Solid Waste Handling

Storage: At all the points of waste generation, waste bins will be provided for the immediate storage of solid waste. Provision would also be made for sorting and segregation of all solid waste at the point of generation. There are waste management plans where wealth shall be generated from wastes as much as practicable.

Collection and Transfer: Waste collection and transfer would include the provision of a truck to collect and transport the collected waste to a designated dumpsite.

Disposal: The solid waste collected would be transported and disposed of at the dumpsite. There is an existing solid waste dumpsite on the estate (see Plate 3-2). It has enough capacity (200m x 100m) to service the project. The solid waste dumpsite is primarily for domestic (organic) waste while the inorganic waste will either be sold or collected by the suppliers.

Plate 3-2: Solid waste dumpsite *(measures 200m×100m*)

3.24.4.2 Liquid Waste Handling

Wastewater: Wastewater will be channelled into soak-away pits of varying dimensions attached to the mill facilities.

Storm water: Rainstorm water will be collected in channels and led into natural drainage lines and vegetation.

Palm Oil Mill Effluent: Palm Oil Mill Effluent (POME) and wastewater will be channelled into anaerobic lagoon system for treatment via a stainless steel pipe. The lagoon is about 2.5km from the mill complex.

3.24.5 Waste Re-use/Re-cycling

As much as possible, waste will be minimized. There is an existing yard already designated for keeping all reusable waste.

3.25 Waste Manifest and Tracking

A manifest system will be established and record kept appropriately ensuring that the mill waste is tracked from "cradle to grave".

3.26 Effluent Treatment Facility

The discharge of untreated POME though creates adverse impact to the environment, the notion of nurturing POME and its derivatives as valuable resources should not be dismissed. Below are types of POME treatment.

3.26.1 Anaerobic Digestion System

Generally, Palm oil mill effluent treatment plants (ETPs) are operated on two-phase anaerobic digestion process followed by extended aeration process. In the anaerobic digestion process, the raw POME is first converted into volatile fatty acids by acid forming bacteria. The volatile acids are then converted into methane and carbon dioxide. The advantages of anaerobic digestion system are:

- The two phase system allows greater control of digester environmental conditions.
- Long solid retention times allow better biodegradation efficiencies.
- Additional settling of liquor ensures minimum loading to the aerobic process.
- There is capability to cope with full effluent load, regardless of fluctuation.

Anaerobic digestion also consist of breaking down of organic materials in the absence of oxygen. These materials are broken down biologically by a complex group of acid-forming and methanogenic bacteria which obtain their energy from the oxidation of organic compounds converting them into end products consisting of water, gases (mainly methane and carbon dioxide) and stabilized solids, (singh et al, 1999).

3.26.2 Extended Aerobic Process

In the extended aerobic system, the anaerobic liquor is aerated to further reduce the BOD content. In addition to providing oxygen, the floating aerators also ensure complete mixing is achieved and the pod contents are always in suspension. In this process, levels of beneficial micro-organisms are increased which in turn hasten the conversion of pollutants into carbon dioxide, water and energy. The aerobic suspension is allowed to settle in a settling tank to ensure production of a fairly clean supernatant. The main advantages of extended aerobics systems are its high BOD removal efficiency and low solid yield.

3.26.3 Ponding System

This is by far the most popular treatment system adopted by more than 85 percent of the palm oil mills in the country (Chooi 1984). Various design and configurations of raw effluent is treated using a ponding system comprising of three phases involved anaerobic, facultative, and aerobic processes. Although the system takes a longer retention time of 90 days, it Is less sensitive to environment changes, stable, efficient and could guarantee excellent pollutant biodegradation efficiency of above 95%. Dominion square Sdn Bhd is one of is also one of the crude palm oil supplier that use this kind of treatment for their palm oil mill effluent treatment before it can be released to the water system and comply with the standard B by the department of environmental.

Microorganism or microbe, is any organism too small to be seen by the naked eye and can only be seen under a microscope. Categories of microorganisms include Algae, Bacteria, Fungi, Protozoa, Viruses or Sub-viral agents. Effective microorganism (EM) technology has now become a major science, assisting in the creation of sustainable practices for agriculture, animal husbandry, nature farming, environmental stewardship, construction, human health and hygiene, industrial, community activities and more. Specially-cultured microbes are used in the biological treatment of sewage and Industrial waste effluent, a process known as bio augmentation. Treatment of POME involve the biodegrading by thermophilic and mesophilic anaerobic microbe. Lifecycle of microbe involved in the reduction of POME directly related to the temperature of the effluent. That is one of the parameters that is going to be investigated in this experiment. Some studies of the structure of mesophilic and thermophilic granules and biofilms have already been made. The structure of mesophilic granular sludge has been described as consisting of three distinct layers. The outer layer consists mainly of a heterogeneous population of acidogenic bacteria, the middle layer of syntrophic cocci- and rod-shaped bacteria, and the center of densely packed *Methanothrix with* many gas cavities. Such a structure would enable substrate to pass through the biomass, being degraded by the various types of bacteria to reach the methanogens that produce biogas. This could then diffuse outward via gas channels. Morganet et al used sequential staining to examine the internal architecture of mesophilic granules treating papermill

and sugar refinery effluents. Both types of granule had a heterogenous surface population of bacteria, with an abundance of *Methanothrix* being found internally. (Quarmby and Forster).

Chan (1982) and Chooi (1984) have reported that ponding system is reliable, stable and is capable of producing good quality discharge with BOD less than the DOE standard and meet the regulatory watercourse discharge standard. Ponding system is cheap to construct but requires a large land area. The anaerobic ponds are usually 5-7 meter deep while the facultative ponds are 1-1.5 meter in depth. The hydraulic retention times (HRT) for this system is 1, 4, 45 and 16 days for de-oiling tank, acidification, anaerobic and facultative ponds respectively.

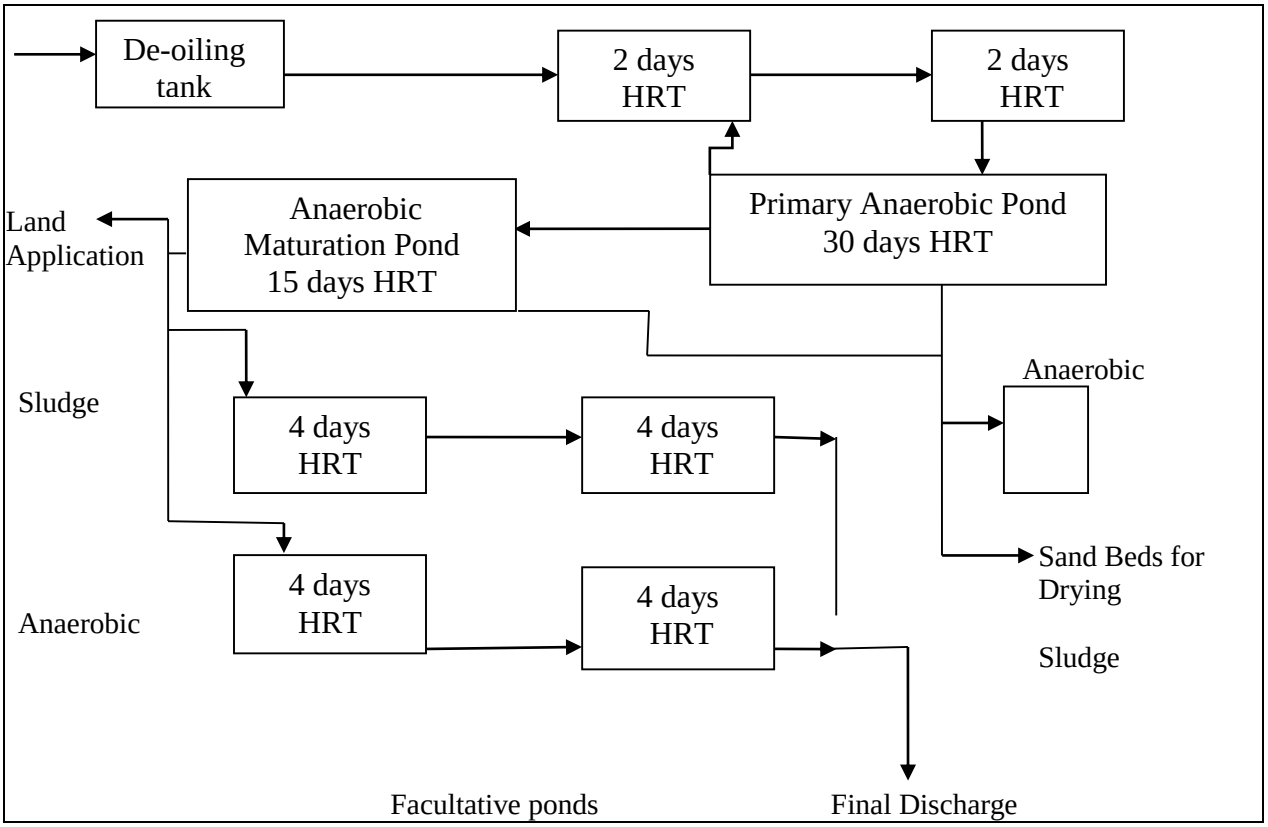


Figure 3-11: Schematic flow diagram for ponding system
Source: Chooi (1984)

Ponding system is normally operated at very low rate. The organic loading varies from 0.2 to 0.35kg BOD/m^3/day. Because of the size and configuration of the ponds, the processes are relatively difficult to control and monitor. Furthermore, there is no mechanical mixing in the ponds. Limited mixing is achieved through the bubbling of biogas generated during the anaerobic digestion process. Also, the rising biogas will bring along with it the fine suspended solid to the surface of the pond. If it is allowed to accumulate, it will develop into scum. Consequently, it is not uncommon to find

discrete islands floating on the surface of the pond resulting in the dead spots and short circulating in the ponds. Another feature of the ponding system is the build up of solids at the bottom of the pond. If these solids are allowed to accumulate to excessive levels, they together with the scum at the top will effectively reduce digester capacity and shorten the HRT. This will adversely affect the treatment efficiency of the process. Regular desludging (solid removal) is therefore recommended.

Energy required to operate the ponding system is minimum. It is only required to run the pumps. Gravity flow is exploited wherever possible. For a 30-tonne FFB/hour mill, the energy demand to operate the ponding system is about 20kwh. Figure 3-12 showed the schematic flow diagram for DDSB wastewater ponding treatment process use in DSSB.

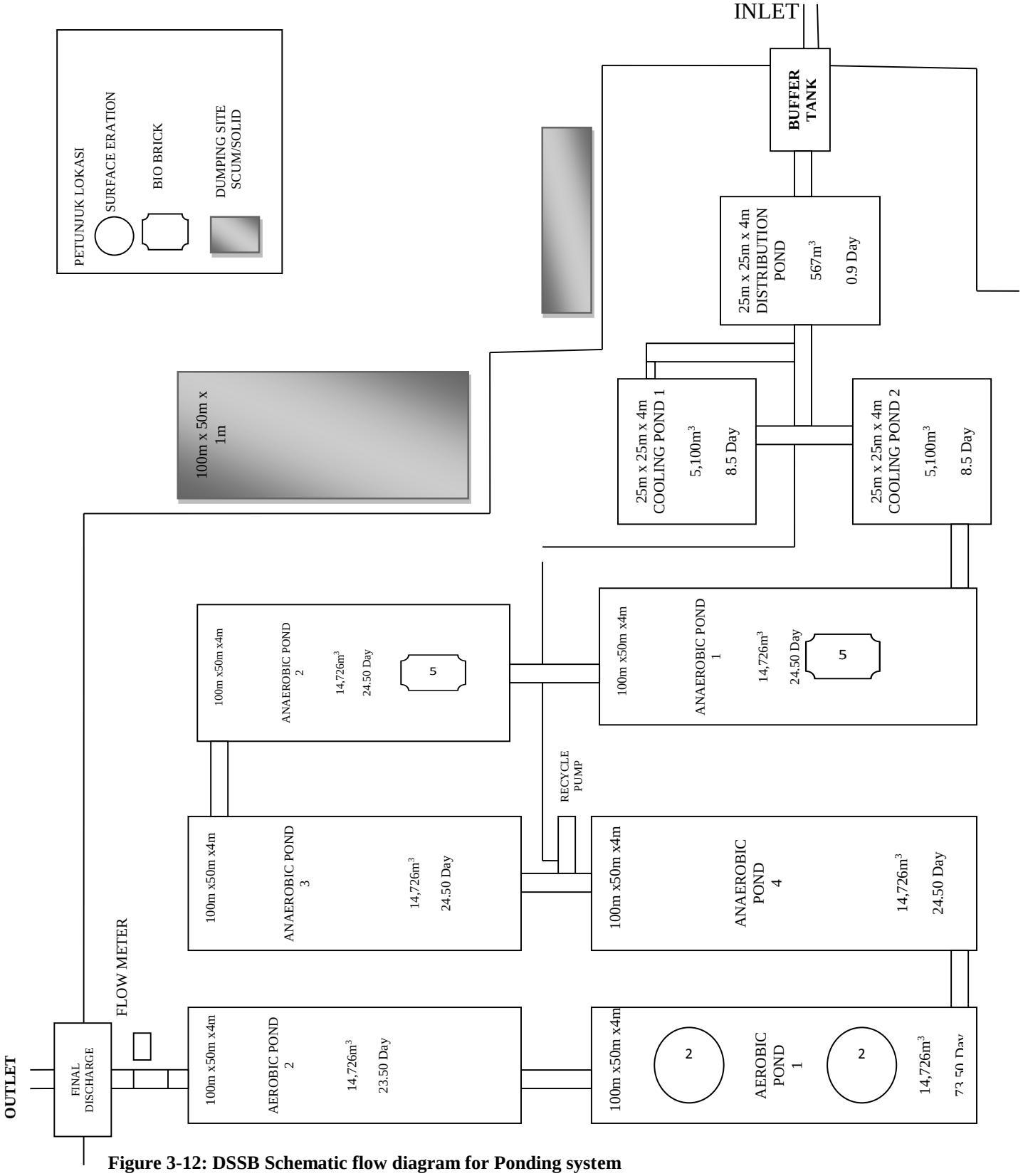


Figure 3-12: DSSB Schematic flow diagram for Ponding system

3.26.4 Lagoon System

It is no wonder that one of the most popular methods of wastewater treatment around the world is also of the simplest and least expensive. Lagoon systems use natural and energy-efficient processes to provide low-cost wastewater treatment. They are one of the most cost-effective wastewater treatment options for many homes and communities. In the U.S, most wastewater treatment lagoons are found in small and rural communities. Lagoons are especially well-suited to small communities because they can cost less to construct, operate and maintain than other systems. They also require more land than other wastewater treatment methods, and land is more likely to be available and inexpensive in rural areas. Lagoons can also be designed to serve individual households. They are sometimes good option for homes on large lots in areas where other onsite systems or sewers are too costly or otherwise impractical. Lagoons also work well for many seasonal rental properties and recreational areas, because they are able to handle intermittent periods of both light and heavy use.

There are several different types and names for lagoons and many possible system designs. Lagoon systems include one or more pond-like bodies of water or basins designed to receive, hold, and treat wastewater for a predetermined period of time. Lagoons are constructed and lined with material, such as clay or an artificial liner that will prevent leaks to the groundwater below. While in the lagoon, wastewater receives treatment through a combination of physical, chemical and biological processes. Much of the treatment occurs naturally, but some systems are designed to also use aeration devices that increase the amount of oxygen in the wastewater. Aeration makes treatment more efficient, so that less land area is necessary, and aerators can be used to upgrade some existing systems to treat more wastewater. Every lagoon system must be individually designed to fit its specific site and use. Designs are based on such factors as the type of soil, the amount of land area available, the climate, and the amount of sunlight and wind in an area. Other important design considerations for lagoon systems include the amount and type of wastewater to be treated and the level of treatment required by state and local regulations. Depending on local standards and the final method of disposal chosen, wastewater leaving lagoon systems often requires additional treatment, or "polishing," to remove disease causing organisms or nutrients from the wastewater before it can be returned to the environment.

Lagoons are not all the same, some employ different biological, chemical and physical processes to treat the wastewater, while others may play a different role in overall treatment. Some lagoon designs provide adequate treatment for certain methods of discharge, while others should be used in combination with other lagoons or with additional treatment. Complicating matters further, there can be several different names for the same type of lagoon, for example, the terms *lagoon and pond* are often used interchangeably, and names, such as *polishing, stabilization and maturation,* can refer to lagoons particular role in treatment. This can be very confusing for community

leaders and home owners trying to evaluate lagoon systems. The following is a brief overview of some of the more common types of lagoons and some of the terms used for them.

Anaerobic Lagoons

The word anaerobic means without oxygen, which describes the conditions inside this type of lagoon. Anaerobic lagoons are most often used to treat animal wastes from dairies and pig farms, commercial or industrial wastes, or as the first treatment step in systems using two or more lagoons in a series. Typically, anaerobic lagoons are designed to hold and treat wastewater from 20 to 50 days. They are relatively deep (usually 8 to 15 feet) and work much like septic tanks. Inside an anaerobic lagoon, solids in the wastewater separate and settle into layers. The top layer consists of grease, scum and other floating materials. This layer keeps oxygen out, allowing bacteria and other organisms that thrive in anaerobic conditions to work to treat the wastewater. As with septic tanks and most other lagoon designs, the layer of sludge that settles at the bottom of an anaerobic lagoon eventually accumulates and must be removed periodically. Also similar to a septic tank, the wastewater that leaves an anaerobic lagoon always requires further treatment. Odor can be a problem with anaerobic lagoons. However, in many cases odor can be managed through a variety of methods, such as adding sodium nitrate, recirculating pond effluent, and through regular maintenance.

Aerobic Lagoons

Dissolved oxygen is present throughout much of the depth of aerobic lagoons. They tend to be much shallower than other lagoons, so sunlight and oxygen from air and wind can better penetrate the wastewater. In general, they are better suited for warm, sunny climates, where they are less likely to freeze. Wastewater usually must remain in aerobic lagoons from 3 to 50days to receive adequate treatment. Wastewater treatment takes place naturally in aerobic lagoons with the aid of aerobic bacteria and algae. Because they are so shallow, their bottoms needs to be either paved or lined with materials that will prevent weeds from growing in them. Sometimes, wastewater in aerobic lagoons needs to be mixed to allow sunlight to reach all of the algae and to keep it from forming a layer that blocks out the air and sun completely.

Aerated Lagoons

Aerated lagoons are very common in small communities. These systems use aerators to mix the contents of the pond and add oxygen to the wastewater. They are sometimes referred to as partial-mix or complete-mix lagoons depending on the extent of aeration. Partial-mix aerated lagoons that have been adapted and upgraded to receive more wastewater. With the exception of wind-driven designs, most aerators require energy to operate. However, energy costs are almost always considerably less than those for other mechanical community treatment systems. Aeration makes treatment more efficient,

which offsets energy costs in some cases. Aerated lagoons require less land area and shorter detention times for wastewater than other lagoons.

Facultative Lagoons

Both aerobic and anaerobic conditions exist in facultative lagoons, which also are called stabilization ponds, oxidation ponds, photosynthetic ponds, and aerobic-anaerobic ponds. They are the most common type of wastewater treatment lagoon used by small communities and individual households. Facultative lagoons can be adapted for use in most climates, require no machinery, and treat wastewater naturally, using both aerobic and anaerobic processes.

3.26.5 Palm Oil Mill Effluent Quality and Monitoring

The lagoon system working efficiently treats and improves the quality of the wastewater to acceptable international levels for the critical elements. The characteristics of water leaving the outlet point of lagoon system with both National and International Norm requirements for wastewater discharge onto land are presented in Table 3-10.

Table 3-10: Characteristics of wastewater leaving the lagoon with both National and International required norms

Quality Element	Lagoon Outlet Point	Norms	
		FMENv. Standards	International Standards (Indonesia)
pH	9	6-9	6-9
Biological Oxygen Demand	89	30	<100
Chemical Oxygen Demand	248	80	<350

Source: Chan (1982) and Chooi (1984)

The quality of the effluent will be monitored routinely (quarterly basis) to ensure that it conforms to regulatory standards. This means that the discharge quality at points of discharge must not exceeds the FMEnv and/or International recommended values for discharge into the environment. In addition to routine monitoring of effluent, and surface water qualities, quarterly monitoring of groundwater and monitoring well will also be carried out to assess any changes in quality that may arise due to effluent discharge and seepage.

In recent time, OOPC Plc has been monitoring the Well that is located 100 meters radius to the existing lagoon where most critical quality elements are being monitored including oil and grease.

The summary of laboratory analyses results for critical monitoring well parameters in the first, second and third quarter 2016 is presented in Table 3-11 below.

Table 3-11: Summary of Laboratory Analyses Results for Critical Monitoring Well Parameters in the first, second and third quarters 2016

Quality Parameter	OKM_{MEMW} (Mill Effluent Monitoring Well) N06^{0}25.138' ; E005^{0}12.811'			FMEnv Limits
	1st Quarter 2016	2nd Quarter 2016	3rd Quarter 2016	
pH	5.13	5.43	5.14	**6-9**
Total Suspended Solids (mg/l)	13	<1.0	2	**30.0**
Biochemical Oxygen Demand (mg/l)	<1.0	<1.0	<1.0	**30**
Chemical Oxygen Demand (mg/l)	1.4	1.8	2.0	**80**
Oil and Grease (mg/l)	<1.0	<1.0	<1.0	**10.0**
Heavy Metals (mg/l)	<0.01	<1.0	<1.0	**<0.1**
Total Hydrocarbon (mg/l)	-			**-**
Total Coliform Count (MNL/ml)	4		6	**10^2**

The results revealed that the monitoring well complied with FMEnv limits for effluent quality except for low pH.

3.26.6 Choice of Lagoon System over Wastewater (Effluent) Treatment Plant

The choice of anaerobic lagoon system over other methods to treat the palm oil mill effluent includes the following.

- Lagoon systems can be cost-effective to design and construct in areas where land is inexpensive.
- They use less energy than most waste-water treatment methods.
- They are simple to operate and maintain and generally require only part-time staff
- They can handle intermittent use and shock loadings better than many systems, making them a good option for camp-grounds, resorts and other seasonal properties.
- They are very effective at removing disease-causing organisms (pathogens) from wastewater.
- The effluent from lagoon systems can be suitable for irrigation (where appropriate), because of its high-nutrient and low pathogen content.

3.27 GHG Emission

3.27.1 Estimation of Baseline Emission (for 60 tons/hour capacity mill):

Effluent produced in 60t/hr mill	
Max production per day	1200 tons FFB
Effluent produced per day	600 tons POME
Maximum expected production per year	220,000 tons FFB
Effluent produced per year	110,000 ton POME

Source: OOPC EIA Field work 2016 (Palm Oil Mill Department)

1 tonne FFB = 0.5 tonne POME
1 ton POME = 28 m^3 biogas (65% CH_4, 35% CO_2)
- 65% CH_4 = 18.72m^3 or 18720 liters
- 35% $C0_2$ = 10.08m^3 or 10080 liters

110,000 tons POME = 3,080,000 (65% CH_4, 35% CO_2)
- 65% CH_4 = 2,002,000m^3
- 35% $C0_2$ = 1,078,000m^3

- total baseline emission = 3,080,000 m^3/year

The proposed mill expansion project has the potential of emitting GHG equivalent to 2,002,000 m^3 methane and 1,078,000 m^3 CO_2 equivalent per annum as shown in Table 3-12.

Table 3-12: Baseline GHG Emission from the effluent lagoon of the Proposed Project

Item	**Unit/Year**	**2016**
Emission of CH_4	Cubic Meters CH_4 eq/yr	2,002,000
Emission of CO_2	Cubic Meters CO_2 eq/yr	1,078,000
Total Emission (65% CH_4, 35% CO_2)	Cubic Meters GHG eq/yr	3,080,000

3.28 GHG Emission Monitoring and Verification

For the evaluation of the effect of POME discharge from this project activity, Table 3-12 presents the types of data collection and monitoring plan that shall be performed.

Table 3-13: Data to be collected in order to monitor emission from the project activity

No	Data variable	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of Data to be monitored	For how long is archived data to be kept	Comment
1	FFB reception from plantation	t/year	m	Every FFB reception by truck	100%	15 years (project period)	Data will be aggregated monthly and yearly
2	FFB reception from other producers	t/year	m	Every FFB reception by truck	100%	15 years (project period)	Data will be aggregated monthly and yearly
3	POME yield from CPO produced	m^3POME/tons FFB	m	Once a day	100%	15 years (project period)	Data will be aggregated monthly and yearly

3.29 Decommissioning and Abandonment

Palm Oil Mill exist for many decades. The ownership of the mill may change but total abandonment is not frequent. However, the several factors that may cause decommissioning and abandonment include:

- Lack of experience and knowledge of operational activities
- Use of outdated management principles and practices
- Financial malpractices
- Non-payment of workers' salaries

3.30 Facilities that will be Decommissioned or Abandoned:

A. Equipment:

- Ramp
- Mill processing line building
- Sterilizer
- Machine components
- Platforms

B. Chemicals, mainly laboratory:

- Hezene
- Pepton-22
- Hydochloric Acid
- Tetraoxosulphate –vi- acid

C. Infrastructure:

- Workers' housing
- Tank Farm
- Powerhouse
- Workshop
- Water pipes
- Quality assurance laboratory equipment
- Earth roads
- Palm Oil Mill Effluent Pond

3.31 Project Schedule

Some of the activities to be carried out from first quarter 2015 to 4th quarter 2018 are provided in Chapter 5. The schedule and timing of the critical project activities are illustrated below:

Activities	2014	2015	2016	2017
EIA Process				
Mobilisation				
Heavy Machinery Use				
Civil, Electric and Mechanical Work				

CHAPTER FOUR

4.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 Location

The palm oil mill expansion project is situated beside the existing mill inside the mill complex of Okomu Oil Palm Company. The proposed mill expansion has the capacity to process 30 metric Tonnes of Fresh Fruit Bunch (FFB) per hour.

4.2 Methodology

4.2.1 Data Acquisition from Literature and Previous Studies

The preliminary information on the study area was obtained as follows:

a. Background information on the oil palm industry in Nigeria was obtained from the Nigerian Institute for Oil Palm Research (NIFOR) and other technical notes from the Plantation department of Okomu Oil Palm Company (OOPC) Plc.
b. The relevant institutional, legal and regulatory framework was obtained from publications by the regulatory agencies and ministries.
c. The most recent relevant meteorological records were obtained from OOPC Plc
d. The OOPC Rubber Factory Final EIA Report 2008 (Approved by the Environmental Assessment department of FMENv, Abuja)
e. The OOPC Extension 2 Final EIA Report 2016 (Approved by the Environmental Assessment department of FMENv, Abuja)
f. Other data sourced from literature included the rainforest and terrestrial swamp forest vegetation and associated wildlife of the study area. The company's environmental audit and environmental monitoring reports in the last five years.

4.3 Field Data Gathering

The preliminary field data gathering started on 16 June 2014. However, the actual dry season field data gathering was done from 23 February 2015 to 6 March 2015, both days inclusive, while the wet season field data gathering was undertaken from 14 September 2015 to 25 September 2015, both days inclusive.

4.3.1 Sampling Points and Control

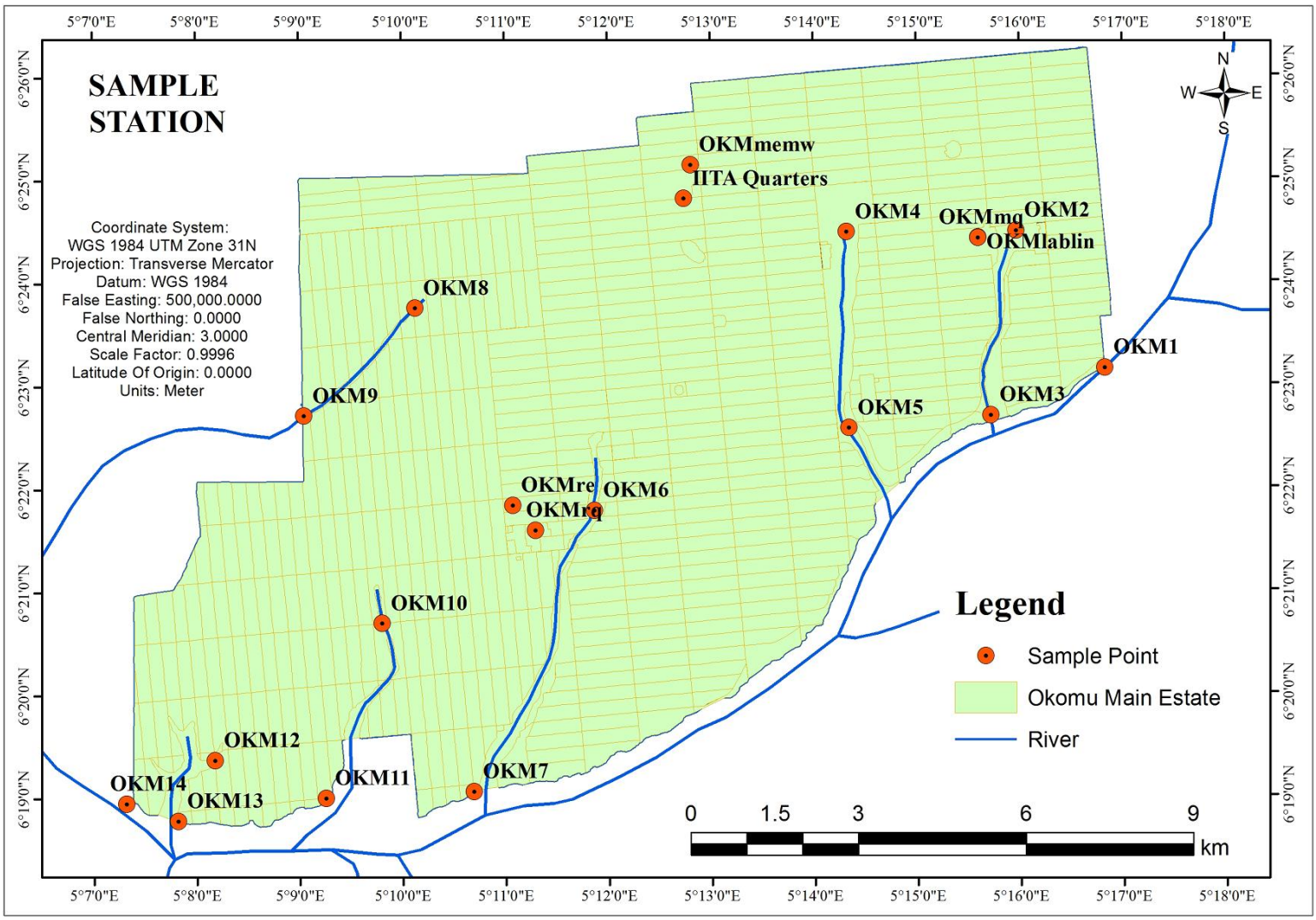
Sampling and observation points were established around the mill expansion area. At each sampling location, the GPS location was taken and all the relevant environmental parameters including water quality, air quality, noise level, temperature, soil, vegetation type, plant form/species and their densities, terrestrial fauna particularly invertebrate species and densities were sampled or observed. Wildlife, especially large mammals were also directly and indirectly observed.

The sampling points with their coordinates are presented in Table 4-1 and Map 4-1.

Table 4-1: Sampling Points and Control Location

Sample Points	Location	Coordinates – 31N		Environmental Component
		(UTM Easting)	(UTM Northing)	
Point 1	Rubber Quarters (OKM_{RQ})	733794.10	687543.17	Groundwater
Point 2 Control Point	**Management Quarters (OKM_{MQ})**	**738545.88**	**690688.52**	**Groundwater, Noise**
Point 3	Labour Line Quarters (OKM_{LL})	738549.19	690690.75	Groundwater, Air, Noise
Point 4	IITA Quarters (OKM_{IITA})	735384.89	691107.08	Groundwater, Air, Noise
Point 5	Okomu River Inlet (OKM_1)	739914.31	689294.76	Surface River, Ecology
Point 6 Control Point	**Stream 1 Source: (OKM_2)**	**738955.14**	**690767.63**	**Air, Noise, Stream, Ecology**
Point 7	Stream 1 Outlet: (OKM_3)	723029.70	688722.31	Stream, Ecology, Noise
Point 8	Stream 2 Source: (OKM_4)	737135.34	690749.13	Air, Noise, Stream, Ecology
Point 9	Stream 2 Outlet: (OKM_5)	737161.61	688644.12	Air, Noise, Stream
Point 10	Stream 3 Source: (OKM_6)	734428.66	687756.99	Air, Noise, Stream, Ecology
Point 11	Stream 3 Outlet: (OKM_7)	733137.74	684734.16	Stream, Ecology, Noise
Point 12	Stream 4 Source: (OKM_8)	732492.73	689927.33	Stream
Point 13	Stream 4 Outlet: (OKM_9)	731301.82	688767.75	Stream
Point 14	Stream 5 Source: (OKM_{10})	732147.53	686539.95	Stream, Ecology
Point 15	Stream 5 Outlet: (OKM_{11})	731548.30	684661.51	Stream
Point 16	Stream 6 Source: (OKM_{12})	730351.10	685067.19	Stream, Ecology
Point 17	Stream 6 Outlet: (OKM_{13})	729959.56	684413.02	Stream
Point 18	Okomu River Outlet: (OKM_{14})	729401.98	684600.00	Surface River, Ecology, Noise

Source: OOPC; Mill Expansion EIA Field Work, 2015



Map 4-1: OOPC Plantation Map showing the sample points of Proposed Mill Expansion Project.

4.3.2 Study Approach

The purpose of this environment description is to provide qualitative and quantitative baseline information on the existing status of the project area against which future studies and mill expansion of the existing mill will be weighed.

Quality Assurance/Control Procedure: The Quality Assurance/Control for laboratory analysis is in accordance with FMEnv recommended methods and it includes blank analysis to establish analytical level, duplicate analysis to establish analytical precision, spiked and blank sample analyses to determine analytical accuracy. It covers all aspects of the study, and includes sample collection, handling, laboratory analysis, data coding and manipulation, statistical analysis, presentation and communication of results. Sample chain of custody form was used for the registration and tracking of sample from the field to the laboratory. The name of laboratory used for all the analyses is on page xiii.

Sample Collection and Handling: This was carried out in accordance with Federal Ministry of Environment guidelines and standards (sampling and handling of samples). Where logistic and safety considerations precluded strict compliance with the above guidelines and standards, other proven, scientifically acceptable methods of sample collection and handling were used.

Laboratory Analysis: The methods of analysis used were as specified in the Federal Ministry of Environment guidelines and standards and other International Analytical Standards methods of analysis such as APHA for water quality. Trace metal analysis was done using Atomic Absorption spectrophotometer dully calibrated using standards, physicochemical parameters were determined using Thermoelectric Genesys 10 VIS Spectrophotometer and Orion ISE Meter Model 710A, dully calibrated with standards, as well as Flame Photometer.

Statistical Analysis: Errors in field data include those resulting from the instrument and those introduced by the observer. With proper sustained calibration of the instrument and the use of standardized observational procedures equipment errors were brought to acceptable minimum. However, other errors arise from the method of sampling. Errors often arise from two-stage sampling or sub sampling, or even from the fact that the samples collected are not representative samples of the medium. There are also spatial variations for the same medium, e.g., soil and water. Thus, it is taken, so as to establish a reasonable level of confidence in the results obtained. A good result is obtained when the variance is within 5% of the mean.

Data Coding and Manipulation: To ensure preservation of the integrity of data collected, data coding forms for use in the field, were designed in such a way that field data could be directly entered into computer data sheets. Since their analyses may be required in legal proceedings, it is essential to establish sample authenticity. Samples must be properly sealed and labelled. All data collected were labelled and the following information provided among others:

- Identification code or sample number
- Date and time of sampling
- Description of sample
- Methods of sampling
- Particulars of any photographs taken

All movements of the samples were included on the samples record. Basic information were recorded together with results of analysis, in a register.

4.4 Air Quality and Noise Level

a) Air Temperature

For air temperature and humidity of ambient conditions, a digital thermometer and Fisher Scientific Hygrometer were used respectively.

b) Gases

In-situ determination of the gases was carried out using portable gas analyzers. The ambient air was monitored using GasTech GT402 to measure the concentration of CO, O_2, Non-methane hydrocarbons, and H_2S. BWT Gas Alert was used to determine the concentration of NO_2 and Ogawa Passive Air Samplers were used for the sampling of SO_2 and subsequently analysed in the laboratory to determine the concentration of the gases.

c) Suspended Particulate Matter, (SPM)

PPM 1055 Hand-held Aerosol Monitor was used to determine Suspended Particulate Matter (SPM).

d) Noise level measurement

Sound level was measured at same point as that for air quality. A CEL-254 Sound level meter was first calibrated and re-checked before determining the sound level. The reading was allowed to stabilize before recording in decibel units {dB(A)}.

4.5 Climate

4.5.1 Rainfall

The average annual rainfall is over 1500mm (Table 4-2). The rainfall distribution is bi-modal, increasingly spread over 7 months, (April – October) with a decrease in August. Rain gauges (Pluviometer) was used to collect rainfall data. The average monthly (2004-2016) data of rainfall at the OOPC weather station is between 9.5 mm and 392.8 mm as presented in Table 4-2, while the graphical illustration is shown in Figures 4-1 and 4-2.

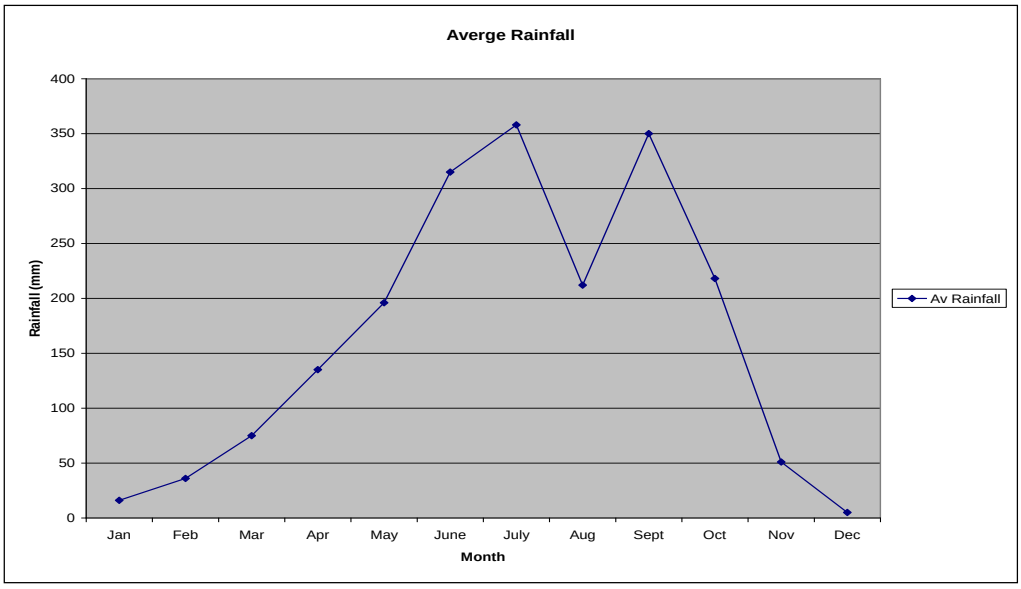


Figure 4-1: Mean Monthly Rainfall at OOPC Plc Estate (2004-2016)

Table 4-2: Monthly Rainfall at OOPC Estate (2004–September 2016)

Year (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	TOTAL
2004	4.3	32.3	46.3	156.2	174.4	175.3	233.9	239.0	253.0	92.3	103.4	0.0	**1,510.4**
2005	0.0	21.2	68.4	97.3	59.4	340.3	661.1	102.0	204.4	249.8	52.9	0.0	**1,856.8**
2006	13.4	11.4	80.2	107.9	330.5	274.6	331.4	277.9	425.6	326.6	13.3	0.0	**2,192.8**
2007	0.0	74.3	123.9	304.6	236.4	384.0	487.1	288.2	324.4	496.5	85.4	0.0	**2,804.8**
2008	0.7	6.7	59.8	159.7	237.0	305.1	409.7	190.4	270.0	179.0	22.0	0.0	**1,840.1**
2009	0.0	61.9	65.4	217.2	291.0	312.7	373.5	205.1	336.6	404.4	146.4	10.0	**2,424.2**
2010	120.2	84.4	72.5	134.6	198.1	341.0	299.3	452.1	332.8	233.3	89.0	41.9	**2,399.2**
2011	0.0	34.2	29.2	172.1	188.7	473.0	445.6	327.0	324.7	264.3	17.2	0.0	**2,276.0**
2012	0.0	38.7	67.3	137.4	129.6	321.5	544.6	78.3	226.0	155.2	74.6	11.0	**1,784.2**
2013	35.8	19.7	64.8	164.7	304.5	195.4	297.7	84.8	473.4	157.0	40.5	21.8	**1,860.1**
2014	3.5	23.9	152.9	88.5	190.5	142.2	345.5	388.8	411.8	520.0	84.6	0.5	**2,352.7**
2015	0.0	79.6	215.3	67.8	165.6	283.4	209.6	370.9	663.5	293.1	8.9	9.9	**2,367.6**
2016	4.4	3.3	182.2	179.4	189.8	330.1	308.3	321.1	567.1				**2,085.7**
Av.11years	**14.8**	**38.3**	**98.5**	**152.6**	**210.1**	**308.6**	**392.8**	**257.2**	**380.0**	**298.1**	**57.7**	**9.5**	**2,187.0**
Min	**0.0**	**3.3**	**29.2**	**67.8**	**59.4**	**142.2**	**209.6**	**78.3**	**204.4**	**155.2**	**8.9**	**0.0**	**-**
Median	**0.4**	**29.1**	**70.5**	**148.6**	**194.3**	**317.1**	**359.5**	**283.1**	**334.7**	**264.3**	**52.9**	**5.2**	**2,059.5**
Average	**14.8**	**38.3**	**98.5**	**152.6**	**210.1**	**308.6**	**392.8**	**257.2**	**380.0**	**298.1**	**57.7**	**9.5**	**2,218.3**
Max	**120.2**	**84.4**	**215.3**	**304.6**	**330.5**	**473.0**	**661.1**	**452.1**	**663.5**	**520.0**	**146.4**	**41.9**	**-**

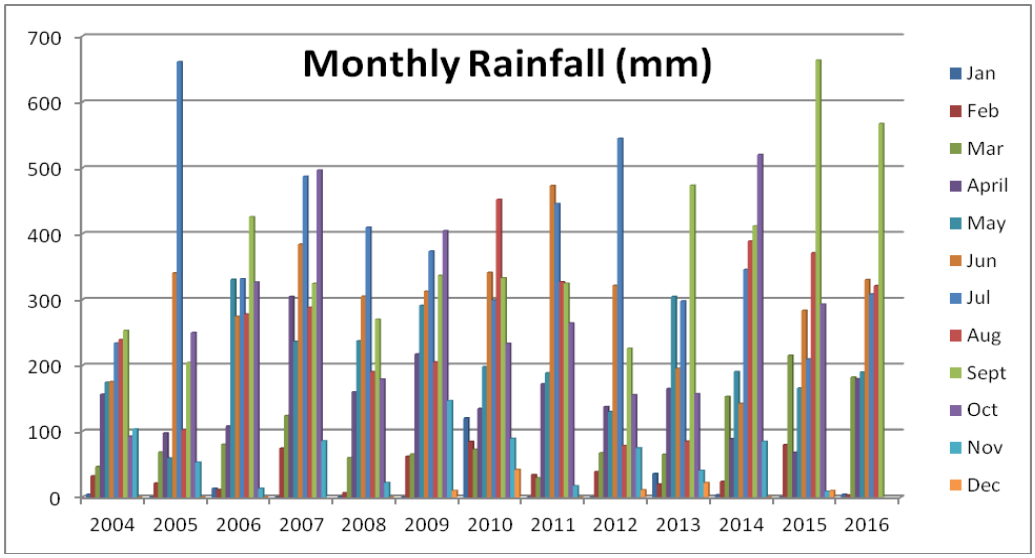


Figure 4-2: Monthly Rainfall at OOPC (2004 – September 2016)

4.5.2 Temperature

The apparent movement of the sun, wind direction and speed as well as land configuration influence the temperature of an area. The mean monthly ambient air temperatures at OOPC range from 18.61°C in January to 36.09°C also in January. The average annual (2016) data of temperature at the OOPC weather station range from 27.81^{0}C to 31.93^{0}C as presented in Table 4-3, while the graphical illustration is shown in Figure 4-3.

Table 4-3: Average Annual Temperatures (^{0}C) at OOPC Estate (2004–September 2016)

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Average Minimum	21	24	22	22	20	24	22	22	22	22	23	22	23
Average Maximum	30	30	32	33	27	30	32	31	30	32	31	32	29
Minimum Absolute	20	21	21	20	19	24	20	20	20	20	22	20	21
Maximum Absolute	32	33	35	38	36	31	36	35	34	37	33	34	32

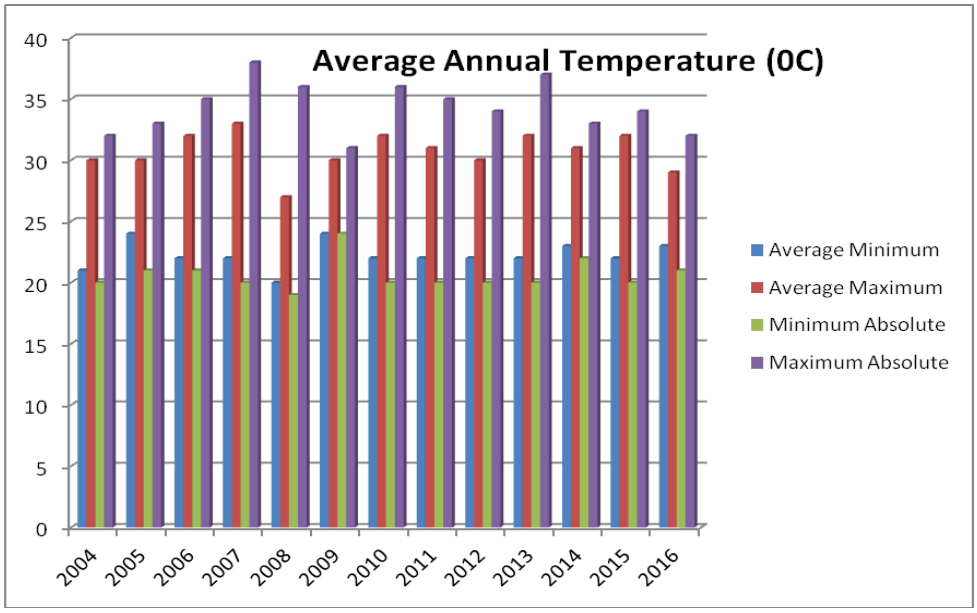


Figure 4-3: Average Annual Temperature at OOPC (2004 and 2016)

4.5.3 Sunshine Hours

The mean monthly sunshine hour at OOPC for the period 2004 to September 2016 range between 32 hours in August to 209 hours in December. The average annual (2004-August 2016) data of sunshine at the OOPC weather station is presented in Table 4-4, while the graphical illustration is shown in Figure 4-4.

Table 4-4: Monthly Sunshine (Hr) at OOPC Estate (2004-September 2016)

Year	J	F	M	A	M	J	J	A	S	O	N	D	AVG
2004	202	178	147	135	173	184	101	77	148	189	186	175	**158**
2005	135	140	141	139	66	119	53	94	114	155	216	171	**129**
2006	157	172	168	194	135	145	125	97	63	136	200	184	**148**
2007	138	199	142	152	224	112	101	98	65	135	215	217	**150**
2008	138	119	239	155	142	264	119	42	75	135	77	177	**147**
2009	157	195	169	158	155	123	126	66	120	130	159	199	**146**
2010	158	219	106	182	152	133	121	87	73	121	197	197	**146**
2011	105	203	176	205	139	79	38	84	97	102	223	196	**137**
2012	134	149	168	132	163	111	73	96	101	153	184	199	**139**
2013	172	195	192	145	132	81	59	68	67	161	157	209	**137**
2014	186	137	138	139	131	74	52	56	57	123	185	200	**123**
2015	164	170	118	119	144	68	62	43	36	148	190	175	**120**
2016	139	75	149	144	120	73	59	32	105				**100**
Av.11years	**148.6**	**164.4**	**158.8**	**155.3**	**141.9**	**115.2**	**82.3**	**71.9**	**81.6**	**136.4**	**182.1**	**193.1**	**135.0**
Min	**105.0**	**75.0**	**106.0**	**119.0**	**66.0**	**68.0**	**38.0**	**32.0**	**36.0**	**102.0**	**77.0**	**171.0**	**-**
Median	**148.0**	**171.0**	**158.5**	**148.5**	**140.5**	**111.5**	**67.5**	**76.0**	**73.0**	**135.5**	**190.0**	**197.0**	**1,617.0**
Average	**148.6**	**164.4**	**158.8**	**155.3**	**141.9**	**115.2**	**82.3**	**71.9**	**81.6**	**136.4**	**182.1**	**193.1**	**1,631.7**
Max	**186.0**	**219.0**	**239.0**	**205.0**	**224.0**	**264.0**	**126.0**	**98.0**	**120.0**	**161.0**	**223.0**	**217.0**	**-**

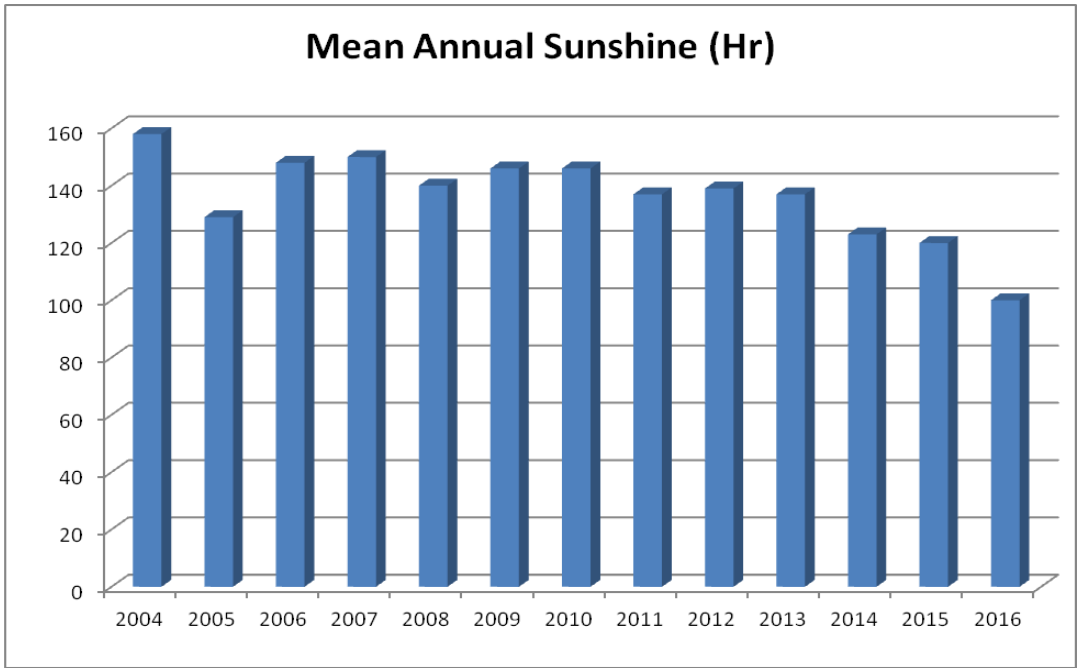


Figure 4-4: Mean Annual Sunshine hour at OOPC (2004-September 2016)

Source: OOPC – Agric Department

4.6 Ambient Environment

4.6.1 Groundwater Quality

The groundwater quality is good and free from pollution. Except for the pH that is generally low. All the water samples from the project's water sources have all physico-chemical and microbiological parameters within the permissible limits recommended by WHO and FMENV for wholesome water.

The results of laboratory analyses of three groundwater and control samples over two (wet and dry) seasons are presented in Table 4-5.

Table 4-5a: Results of Physico-chemical Laboratory Analysis of Groundwater samples at OOPC Plc

Parameter/Unit	Reference Standard NIS554:2007	Sample 1 (UTM 31N) E733794.10 ; N687543.17		Sample 2 (UTM 31N) E738549.19 : N690690.75		Control Sample (UTM 31N) E738545.88 ; N690688.52	
		Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season
Appearance	Clear and colourless liquid	Clear and Colourless liquid	Clear and Colourless liquid	Clear and Colourless liquid	Clear and Colourless liquid	Clear and Colourless liquid	Clear and Colourless liquid
Odour	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
Taste	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
pH	6.5-8.5	7.55	5.3	7.80	5.83	6.52	5.6
Temperature, ^{o}C	Ambient	27.9	25.5	26.9	25.3	29.0	25.3
Conductivity, µS/cm	1000	25.8	24.2	60.4	15.2	21.3	16.1
Electrode Potential, mV	-	98	195	56	162	113	180
Colour, Pt-Co	15	<1.0	<1	<1.0	<1	<1.0	<1
Turbidity, NTU	5	<1.0	<1	<1.0	<1	<1.0	<1
Total Solids, mg/L	-	12.9	12.0	30.1	7.6	10.6	8.0
Total Dissolved solids, mg/L	500	12.9	12.0	30.1	7.6	10.6	8.0
Total Suspended Solids, mg/L	-	<1.0	<1	<1.0	<1	<1.0	<1
Total Hardness, mg/L $CaCO_3$	150	3.0	2.5	23.0	2.0	4.0	3.0
Total Alkalinity, mg/L	-	4.6	7.36	24.8	11.0	8.28	9.2
Total acidity, mg/L	-	8.7	33.1	6.96	38.3	8.70	40.0
Calcium, mg/L as Ca	-	0.8	0.4	6.8	0.4	0.8	0.4
Magnesium, mg/L as Mg	2.0	0.24	0.36	1.46	0.24	0.49	0.49
Chloride, mg/L	250	4.43	0.88	4.43	4.43	4.43	4.43
Residual chlorine, mg/L	0.2-0.25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoride, mg/L	1.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrate, mg/L	50	0.11	0.40	0.12	0.27	0.11	0.44
Nitrite, mg/L	0.2	0.03	0.06	0.02	0.04	0.02	0.04
Sulphate, mg/L	100	3	<1	3	<1	4	<1
Phosphate, mg/L	-	<0.1	0.3	<0.1	<0.1	<0.1	0.2
Free carbon dioxide,mg/L	-	7.66	29.1	6.12	33.7	7.66	35.2
Iron (total), mg/L	0.3	<0.01	0.03	<0.01	0.03	<0.01	0.04
Lead, mg/L	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic, mg/L	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese, mg/L	0.2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper, mg/L	1.0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/L	0. 03	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium, mg/L	0.05	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hydrogen Sulphide, mg/L	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 4-5a Contn'd: Results of Physico-chemical Laboratory Analysis of Groundwater samples at OOPC Plc Cont'd

Parameter/Unit	Reference Standard NIS554:2007	Sample 3 (UTM 31N) E735384.89 ; N691107.08		Control Sample (UTM 31N) E738545.88 ; N690688.52	
		Dry Season	Wet Season	Dry Season	Wet Season
Appearance	Clear and colourless liquid	Clear and Colourless liquid	Clear and Colourless liquid	Clear and Colourless liquid	Clear and Colourless liquid
Odour	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
Taste	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
pH	6.5-8.5	6.92	5.4	6.52	5.6
Temperature, ^oC	Ambient	28.0	25.5	29.0	25.3
Conductivity, µS/cm	1000	20.6	16.9	21.3	16.1
Electrode Potential, mV	-	111	130	113	180
Colour, Pt-Co	15	<1.0	<1	<1.0	<1
Turbidity, NTU	5	<1.0	<1	<1.0	<1
Total Solids, mg/L	-	10.3	8.4	10.6	8.0
Total Dissolved solids, mg/L	500	10.3	8.4	10.6	8.0
Total Suspended Solids, mg/L	-	<1.0	<1	<1.0	<1
Total Hardness, mg/L $CaCO_3$	150	4.0	2.0	4.0	3.0
Total Alkalinity, mg/L	-	6.44	11.0	8.28	9.2
Total acidity, mg/L	-	8.70	29.6	8.70	40.0
Calcium, mg/L as Ca	-	0.8	0.4	0.8	0.4
Magnesium, mg/L as Mg	2.0	0.49	0.24	0.49	0.49
Chloride, mg/L	250	4.43	2.65	4.43	4.43
Residual chlorine, mg/L	0.2-0.25	<0.1	<0.1	<0.1	<0.1
Fluoride, mg/L	1.5	<0.1	<0.1	<0.1	<0.1
Nitrate, mg/L	50	0.13	0.13	0.11	0.44
Nitrite, mg/L	0.2	0.02	0.003	0.02	0.04
Sulphate, mg/L	100	2	<1	4	<1
Phosphate, mg/L	-	<0.1	<0.1	<0.1	0.2
Free carbon dioxide,mg/L	-	7.66	26.0	7.66	35.2
Iron (total), mg/L	0.3	<0.01	0.02	<0.01	0.04
Lead, mg/L	0.01	<0.001	<0.001	<0.001	<0.001
Arsenic, mg/L	0.01	<0.001	<0.001	<0.001	<0.001
Manganese, mg/L	0.2	<0.001	<0.001	<0.001	<0.001
Copper, mg/L	1.0	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/L	0. 03	<0.001	<0.001	<0.001	<0.001
Chromium, mg/L	0.05	<0.001	<0.001	<0.001	<0.001
Hydrogen Sulphide, mg/L	0.05	<0.01	<0.01	<0.01	<0.01

Source: OOPC – Mill Expansion EIA Field work, 2014-2015

Table 4-5b: Results of Microbiological Laboratory Analysis of Groundwater samples at OOPC Plc

PARAMETER (CFU/100mL)	Reference Standard	Sample 1 (UTM 31N) E733794.10 N687543.17		Sample 2 (UTM 31N) E738549.19 N690690.75		Sample 3 (UTM 31N) E735384.89 N691107.08		Control Sample (UTM 31N) E738545.88 N690688.52	
		Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season
Total coliform count*	10	0	0	0	0	0	0	0	0
Faecal coliform (E.coli)	Nil	0	0	0	0	0	0	0	0
Clostridium perfringens,	Nil	0	0	0	0	0	0	0	0
Salmonella/Shigella sp.	Nil	0	0	0	0	0	0	0	0
Staphylococcus sp.	Nil	0	0	0	0	0	0	0	0
Pseudomonas aureus	Nil	0	0	0	0	0	0	0	0
Total plate count,	10^2	0	0	4	0	0	0	0	0

Source: OOPC – Mill Expansion EIA Field work, 2014-2015

4.6.2 Ambient Air Quality Measurements

4.6.2.1 In-situ Measurements

In-situ determination of the gases was carried out using portable gas analyzers. The ambient air was monitored using Mattheson IQ-1000 gas analyzer (with mega and electrochemical sensors) to measure the concentrations of carbon monoxide, Oxygen, Non-methane hydrocarbons, hydrogen sulphide, Sulphur dioxide. BWT Gas Alert was used to determine the concentration of NO_2. PPM 1055 Handheld Aerosol Monitor was used to determine Suspended Particulate Matter (SPM). Fisher Scientific Hygrometer was used to determine the temperature and humidity of ambient conditions during the sampling period.

4.6.2.2 Results of Ambient Air Quality Measurements

The results of ambient air quality determinations at six different locations plus the control location are presented in Tables 4-6a and 4-6b. The results show that the ambient air quality is good with all the quality parameters within acceptable regulated limits.

Table 4-6a: Results of Air Quality (Dry Season, 25-26 February 2015)

Parameter	LOCATION							FMEnv. Limit
	CONTROL POINT	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	
Coordinate (UTM 31N)	N738955.14	N 738545.88	N 738549.19	N 735384.89	N 737135.34	N 737161.61	N 734428.66	
	E690767.63	E 690688.52	E 690690.75	E 691107.08	E 690749.13	E 688644.12	E 687756.99	
Elevation (m)								
SPM, (µg/m3)	27	26	28	25	10	9.0	13	**250**
Temp (°F)	32.2	29.4	35.3	32.0	92	58	56	**Ambient**
Humidity	54	66.5	54	66	15.8	32.2	32.0	**Ambient**
Carbon monoxide (ppm)	0.5	1.0	<0.1	<0.1	1.0	0.5	<0.1	**10-20**
Carbondioxide (%)	0.01	0.03	0.02	0.02	0.06	0.20	<0.1	**Ambient**
Hydrogen sulphide, ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-
Hydrocarbon (%)	<1.0	<1.0	<1.0	<1.0	<0.1	<0.1	<0.1	-
Oxygen, %	21.0	21.0	21.0	21.0	21.0	20.8	21.0	21.0
Sulphur dioxide, ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.6
Nitrogen oxides, ppm	<0.01	<0.1	<0.01	<0.01	<0.1	<0.01	<0.01	0.1
VOC, ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	

Source: OOPC – Mill Expansion EIA, Fieldwork 2015

Table 4-6b: Results of Air Quality (Wet Season, 16-18 September 2015)

Parameter	LOCATION							FMEnv. Limit
	CONTROL POINT	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	
Coordinate (UTM 31N)	N738955.14	N 738545.88	N 738549.19	N 735384.89	N 737135.34	N 737161.61	N 734428.66	
	E690767.63	E 690688.52	E 690690.75	E 691107.08	E 690749.13	E 688644.12	E 687756.99	
Elevation (m)								
SPM (µg/m^3)	24.0	63.0	13.6	23	27	26	28	250
Humidity (%)	54	57	74	65.0	32.2	29.4	35.3	Ambient
Temperature (^{0}C)	18.3	19.2	20.2	21.0	54	66.5	54	Ambient
Carbon monoxide, ppm	1.0	2.0	1.0	<0.1	0.5	1.0	<0.1	10-20
Carbon dioxide, %	0.37	0.64	0.31	0.02	0.01	0.03	0.02	Ambient
Hydrogen sulphide, ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-
Hydrocarbon, %	<1.0	<0.1	<0.1	<1.0	<1.0	<1.0	<1.0	-
Oxygen, %	21.0	21.0	21.0	21.0	83.0	96.5	103.3	21.0
Sulphur dioxide, ppm	<0.1	<0.1	<0.1	<0.1	21.0	21.0	21.0	0.6
Nitrogen oxides, ppm	<0.01	<0.1	<0.01	<0.01	0.05	0.1	<0.01	0.1
VOC, ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	

Source: OOPC – Mill Expansion EIA, Fieldwork 2015

4.6.3 Noise Level Measurement

Sound level was measured at same point as that for air quality. A CEL-254 Sound level meter was first calibrated and re-checked before determining the sound level. The reading was allowed to stabilize before recording in decibel units dB(A).

4.6.3.1 Results of Noise Level Measurements

Generally, the proposed mill expansion project area and its environs are serene with no abnormal noise level recorded except at the existing mill complex. A digital sound level meter was used to measure the noise levels at different locations in the proposed project site. The measurement taken at different workplaces including the existing mill area showed that the noise levels range from 50.1 dB(A) to 99.2 dB(A). The noise levels at different workplaces and its environs are within Federal Ministry of Environment permissible limit of 90 dB(A) for 8 hours exposure except at point 1 which is the mill powerhouse as presented in Table 4-7 below.

Table 4-7: Noise Levels Measurements around the project area including the existing Mill Complex

Facility/ Workplace	**CONTROL POINT**	**Point 1**	**Point 2**	**Point 3**	**Point 4**	**Point 5**	**Point 6**	**Point 7**	**Point 8**
Coordinate (UTM 31N)	E738955.14	E738545.88	E738549.19	E735384.89	E737135.34	E737161.61	E734428.66	E723029.70	E733137.74
	N690767.63	N690688.52	N690690.75	N691107.08	N690749.13	N688644.12	N687756.99	N688722.31	N684734.16
Elevation (m)									
Noise, dB(A) Wet Season, 17 June 2014	51	99.2	75.1	66.7	54.4	56.2	52.6	51.0	58.7
Noise, dB(A) Dry Season, 3 February 2015	50.2	91.6	72.5	63.3	52.7	54.1	50.1	50.7	54.4
FMEnv Limits (8-hr. Exposure)	**90dB(A)**								

Source: OOPC – Mill Expansion EIA Fieldwork, 2014-2015

4.6.4 Aquatic Biology (Surface Water Quality and Bottom Sediment Studies):

This section focuses on the water and bottom sediment characteristics within and around the area. This component of the study is aimed at monitoring surface water and bottom sediment parameters which, when altered, can easily affect the ability of the concerned attributes to perform their natural functions.

There are six (6 Nos.) small streams inside the proponent plantation estate, which discharge into Okomu River. The Okomu River is about 10 km from the project site. Two (2 Nos.) representative samples each of surface water including Okomu River totaling fourteen (14 Nos.) were collected and then taken to the laboratory for analysis.

4.6.4.1 Methodology

Field and laboratory studies were carried out, in addition to literature studies. During the fieldwork, present situation of salient environmental parameters with regards to water resources quality was carried out. Sampling and laboratory analyses of water were aimed at determining the magnitude and pattern of variation of appropriate physico-chemical and microbiological parameters within the study area.

4.6.4.2 Field Work

At the sampling station, water sample was collected and stored in 2 liter polyethylene bottle, and pre-treated as suggested by Battley and Gardner (1977). Samples for heavy metal determinations were fixed with concentrated H_2SO_4 and refrigerated. Samples for microbiological analyses were stored in sterile Macarthy bottles and also refrigerated. In-situ measurements for pH, DO, Conductivity, Salinity, TDS and Temperature were determined using various digital meters.

4.6.4.3 Laboratory Analysis

a) **Biochemistry of Water Sample:**
The parameters determined, were Biochemical Oxygen Demand (BOD) by incubation method for 5 days and Chemical Oxygen Demand (COD) by Closed reflux digestion and spectrophotometric (HACH) method recommended by the American Public Health Association (APHA).

b) **Chemistry:**
The parameters determined include:

- Nitrate and ammonium (NO^3- and HN_4-N) which were determined using ion chromatography.
- Exchangeable cations, which were determined using atomic absorption spectrophotometry. The exchangeable metals tested for are, Na^+, K^+, Ca^{2+}, Mn^{2+}, phenols, cyanides, chloride and sulfides were determined using appropriate

methodology. Chloride by the Mohr method, cyanide using reagent supplied by E. Merck, Darmstadt, Germany.

- Heavy metals (Fe, Zn, Cr, Pb, Cu, V, Ni, Hg, Ba, etc) were to be determined using Atomic Absorption Spectrophotometry.

c) **Microbiology:**
The microbial flora of surface water and bottom sediments sample usually consist of autochthonous and indigenous microbial species which are the true residents and the foreign residents which are regarded as invaders. The true residents are well adapted to their native environment and are able to survive under certain conditions which may be unfavorable to the invaders. For example, E. Coli is known to die quickly in water whereas aquatic indigenous species such as *achromobacter* and *Pseudomonas* do not.

Salinity, pH, Organic carbon and nutrient level play very vital roles in the determination of population density and diversity of the indigenous microbial flora of the water and bottom sediment. The bacterial population for instance thrives better at neutral or alkaline pH, while the fungal, microflora, proliferate more in acidic pH. Generally, the population density of the indigenous microbial flora is high when the nutrient level and the organic carbon load are high. Since the aquatic environment is transitory in nature, a much higher variation in the concentration of nutrients and the indigenous microbial flora are expected in the surface waters than the sediment. Sediments are also known to contain more nutrients and organic matter than the surface water.

The major objective of the microbiological study therefore is to identify various microbial species present in the surface water and sediment, study their diversity and population density within the project site. This will enable us to understand the roles played by the microbial flora both collectively and individually in relation to the project in question.

Water samples were subjected to microbiological tests as follow:

- Total heterotrophs were isolated using the standard plate count (SPC) technique.
- Total pathogens were isolated using three (3) selective media (Mac Conkey agar, blood agar and decoxychocolate citate agar).
- Fungi were isolated using minimal salts agar.
- Hydrocarbon utilizing microorganisms were determined using minimal salt agar, and a single source of carbon (crude

petroleum) according to the method described by Raymond et al (1976).

4.6.5 Sediment Studies

4.6.5.1 Methodology

Two (2Nos.) sediment samples from the closest stream to the project site were taken during fieldwork exercise, Sediment samples were taken at location where water sample was collected. The sediment samples were taken using a Van-Veen type grab sampler and sediment samples for Total Hydrocarbon estimations, Poly Aromatic Hydrocarbons and phenols were stored in aluminum foils and refrigerated prior to laboratory analyses, while samples for microbiological analyses were stored in sterile Teflon bags and equally refrigerated. Samples for others were stored in labeled polyethylene bags prior to laboratory analysis.

4.6.5.2 Laboratory:

The collected sediment samples were used for the laboratory analyses at Environmental Laboratory Limited, 15A Niyi Ayeye Street off channels TV Avenue, OPIC Estate (Via Berger), Isheri, Ogun-state). The analyses undertaken were as follows:

a. Physico-chemical Characteristics:

- Particle size, soil texture, moisture content and organic content. Particle size was determined using the standard Bouycous hydrometer, while organic content were determined using sodium hexametaphosphate solution method.

- Major and trace metals Mg^{2+}, Ca^{2+}, Na^{+}, Zn^{2+}, K^{+}) were determined using the X-Ray Fluorescence (XRF) method.

- Heavy metal (Cu, Fe, Pb, Cd, V, Ni, Hg, etc) were determined using atomic absorption spectrophotometry method.

- pH, oil and grease, Total Hydrocarbon Content (THC) using standard methods.

b. Geotechnical Studies:

Geotechnical studies were conducted for engineering characteristics of the sediments. In order to achieve this, the following classification tests were conducted using standard engineering methods.

- Moisture content determination
- Grain size analysis
- Specific gravity

- Permeability
- Bulk density
- Strength test

c. Microbiology:

Soil and bottom sediment samples were subjected to microbiological tests as follows:

- Total heterotrophs, were isolated using the standard plate count (SPC) technique.
- Total pathogens were isolated using three (3) selective media (MacConkey agar, blood agar and decoxycholocate agar.
- Fungi were isolated using minimal salts agar.
- Hydrocarbon utilizing micro-organisms were determined using minimal salt agar, and a single source of carbon (crude petroleum) according to the method described by Raymond et al (1976).

g. Identification of Micro Organisms

Hydrocarbon utilizing bacteria was first purified to obtain a pure culture, stained by grain staining technique to differentiate gram positive from gram negative organisms. The organisms were then passed through series of biochemical tests which include glucose/gas production, lusive/omitare, hydrogen sulfide and indole, oxidize, adonitol, arabinose, sorbitol, ducitol, motility, phenyl alanine, urea, citate utilization. All these reagents were packaged in three sets.

1. BBL minitech for identification of gram positive organisms.
2. BBL. Enterotubes I and H for identification of gram negative bacteria (oxidize negative).
3. BBL oxiferm tubes I and H for identification of gram negative, oxidize positive bacteria.

The BBL identification kit is latest technology in numerical identification of microorganisms. It is packaged by Becton Dickinson Microbiology Systems, USA. The bicode manual used for identification is the 1993 version. Fungal and yeast identification was at specie level by microscopic examination and sugar fermentation.

h. Total Hydrocarbon Contents

Sampling and subsequent laboratory analyses of sediment samples were aimed at checking if the proposed site area has been impacted. At each sampling point, sediment was collected

in aluminum foil and kept in a refrigerator prior to the time of analysis. The hydrocarbon content of the samples was extracted using the Soxhlet apparatus with methylene chloride under reflux for a minimum of 6 hours as suggested by Brown et al (1983). The extract, which was concentrated with a rotary evaporator was analyzed by Gas Chromatography with flame ionization Detector (GC-FID) and quantified by comparison with the appropriate THC standard.

4.6.5.3 Results and Discussions

a) Surface Water Quality

The results of the water quality survey of the streams and Okomu River for dry and wet seasons are presented in Tables 4-8a and 4-8b respectively. In-situ physio-chemical parameters measured were pH, Electrical conductivity, Dissolved Oxygen, salinity and temperature.

Table 4-8a: Physico-chemical and Biochemical Analyses Results of Streams and Okomu River at OOPC Plantation (Dry Season, 6 March 2015) .

OKOMU											
PARAMETER/UNIT	**FMENv. Limits**	**OKM_1 OKOMU RIVER (INLET) N 739914.31 E 689294.76**	**OKM_2 N 738955.14 E 690767.63 CONTROL**	**OKM_3 OUTLET (STREAM 1) N 723029.70 E 688722.31**	**OKM_4 SOURCE (STREAM 2) N 737135.34 E 690749.13**	**OKM_5 OUTLET (STREAM 2) N 737161.61 E 688644.12**	**OKM_6 SOURCE (STREAM 3) N 734428.66 E 687756.99**	**OKM_7 OUTLET (STREAM 3) N 733137.74 E 684734.16**	**OKM_8 SOURCE (STREAM 4) N 732492.73 E 689927.33**	**OKM_9 OUTLET (STREAM 4) N 731301.82 E 688767.75**	**OKM_{10} SOURCE (STREAM 5) N 732147.53 E 686539.95**
Appearance	Colourless	Colourless liquid with particles	Clear and colourless liquid	Colourless liquid with particles	Colourless liquid with particles	Colourless liquid with particles	Colourless liquid with particles	Colourless liquid with particles	Light brown liquid with particles	Colourless liquid with particles	Colourless liquid with particles
Odour	Unobjectionable	Unobjection-able	Unobjection-able	Unobjection-able	Unobjectio-nable	Unobjection-Able	Unobjection-able	Unobjection-able	Unobjection-able	Unobjection-able	Unobjection-able
pH	6-9	6.11	6.02	6.93	6.50	6.32	6.56	6.68	7.10	6.63	6.92
Temperature, ^oC	Ambient	24.9	25.9	25.2	26.2	24.1	25.9	25.5	24.1	25.1	25.9
Conductivity, µS/cm	2000	16.0	45.4	22.7	18.7	20.2	17.5	22.6	28.9	29.5	17.8
Electrode Potential, mV	-	148	209	156	161	187	176	171	87	117	160
Colour, Pt-Co	7.0	56	<1	51	<1	10	<1	64	170	69	<1
Turbidity, NTU	10	16	<1	8	<1	5	<1	11	29	20	<1
Total Solids, mg/L	-	90	22.6	16.3	9.2	12	8.7	24.2	30.4	18.7	8.9
Total Dissolved solids, mg/L	1000	8.0	22.6	11.3	9.2	10.0	8.7	11.2	14.4	14.7	8.9
Total Suspended Solids, mg/L	30	10	<1	5	<1	2	<1	13	16	4	<1
Total Hardness, mg/L $CaCO_3$	-	3.5	7.5	4.0	3.0	3.0	2.5	8.5	7.5	5.0	4.0
Total Alkalinity, mg/L	-	9.2	5.52	7.36	7.36	12.9	5.52	11.0	14.7	7.36	7.36
Total acidity, mg/L	-	20.9	34.8	19.1	17.4	13.9	24.4	26.1	12.2	15.7	29.6
Calcium, mg/L as Ca	-	0.6	1.0	0.6	0.6	0.8	0.6	1.4	1.6	0.8	0.6
Magnesium, mg/L as Mg	-	0.49	1.22	0.61	0.36	0.24	0.24	0.73	0.85	0.73	0.61
Chloride, mg/L	200	2.65	0.88	2.65	0.88	0.88	0.88	4.43	1.77	0.88	0.88
Nitrate, mg/L	50	0.31	0.35	0.27	0.27	0.35	0.31	0.35	0.35	0.31	0.33
Nitrite, mg/L	0.3	0.07	0.05	0.07	0.01	0.02	0.03	0.04	0.04	0.02	0.01
Sulphate, mg/L	250	<1	1	4	<1	2	2	5	8	2	<1
Phosphate, mg/L	-	<0.1	<0.1	0.3	<0.1	<0.1	<0.1	0.9	1.9	0.4	<0.1

Parameter/Unit	FMENv. Limits	OKM_1 OKOMU RIVER (INLET) N 739914.31 E 689294.76	OKM_2 N 738955.14 E 690767.63 CONTROL	OKM_3 OUTLET (STREAM 1) N 723029.70 E 688722.31	OKM_4 SOURCE (STREAM 2) N 737135.34 E 690749.13	OKM_5 OUTLET (STREAM 2) N 737161.61 E 688644.12	OKM_6 SOURCE (STREAM 3) N 734428.66 E 687756.99	OKM_7 OUTLET (STREAM 3) N 733137.74 E 684734.16	OKM_8 SOURCE (STREAM 4) N 732492.73 E 689927.33	OKM_9 OUTLET (STREAM 4) N 731301.82 E 688767.75	OKM_{10} SOURCE (STREAM 5) N 732147.53 E 686539.95
Iron (total), mg/L	20	0.26	0.05	0.18	0.03	0.09	0.31	0.08	0.71	0.27	0.08
Lead, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese, mg/L	0.10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic, mg/L	<1.0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Dissolved Oxygen, mg/L	>2.0	5.54	2.93	11.1	8.71	7.92	11.9	5.54	7.13	9.50	11.9
Total Hydrocarbon, mg/L		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Salinity, ‰	-	0.005	0.002	0.005	0.002	0.002	0.002	0.008	0.003	0.002	0.002
Pesticides		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Total coliform count, CFU/mL	10	0	0	0	2	0	0	2	0	0	3
Faecal coliform (E.coli CFU/100 mL	Nil	0	0	0	0	0	0	0	0	0	0
Total plate count, CFU/100 mL	10^2	4	0	0	4	4	0	4	2	0	4

Source: OOPC – Mill Expansion EIA Field work, 2014-2015

Table 4-8a: Physico-chemical and Biochemical Analyses Results of Streams and Okomu River at OOPC Plantation (Dry Season, 6 March 2015) Cont'd.

OKOMU					
PARAMETER/UNIT	**FMENv. Limits**	**OKM_{11} OUTLET (STREAM 5) N 731548.30 E 684661.51**	**OKM_{12} SOURCE (STREAM 6) N 730351.10 E 685067.19**	**OKM_{13} OUTLET (STREAM 6) N 729959.56 E 684413.02**	**OKM_{14} OKOMU RIVER (OUTLET) N 729401.98 E 684600.00**
Appearance	Colourless	Colourless liquid with particles	Colourless liquid with particles	Light brown liquid with particles	Colourless liquid with particles
Odour	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
pH	6-9	5.54	6.60	5.65	6.30
Temperature, ^oC	Ambient	25.5	25.6	25.4	24.5
Conductivity, µS/cm	2000	20.4	27.1	21.1	28.4
Electrode Potential, mV	-	177	197	184	137
Colour, Pt-Co	7.0	22	62	106	62
Turbidity, NTU	10	8	15	5	12
Total Solids, mg/L	-	12.1	19.5	11.5	19.1
Total Dissolved solids, mg/L	1000	10.1	13.5	10.5	14.1
Total Suspended Solids, mg/L	30	2	6	1	5
Total Hardness, mg/L $CaCO_3$	-	6.0	11.3	5.0	5.5
Total Alkalinity, mg/L	-	11.0	9.2	9.2	9.2
Total acidity, mg/L	-	36.5	33.1	34.8	24.4
Calcium, mg/L as Ca	-	0.8	0.8	0.8	0.8
Magnesium, mg/L as Mg	-	0.97	2.25	0.73	0.85
Chloride, mg/L	200	0.88	0.88	2.65	4.43
Nitrate, mg/L	50	0.22	0.13	0.13	0.18
Nitrite, mg/L	0.3	0.01	0.01	0.04	0.03
Sulphate, mg/L	250	2	3	3	5
Phosphate, mg/L	-	0.5	0.2	1.0	0.8
Iron (total), mg/L	20	0.06	0.15	0.29	0.12
Lead, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01
Copper, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01
Manganese, mg/L	0.10	<0.01	<0.01	<0.01	<0.01
Cadmium, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01
Nickel, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01
Cobalt, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01
Arsenic, mg/L	<1.0	<0.001	<0.001	<0.001	<0.001
Dissolved Oxygen, mg/L	>2.0	6.33	7.13	12.7	4.75
Total Hydrocarbon, mg/L		<0.01	<0.01	<0.01	<0.01
Salinity, $^o/_{oo}$	-	0.002	0.002	0.005	0.008
Pesticides, mg/L		<0.01	<0.01	<0.01	<0.01
Total coliform count, CFU/mL	10	2	0	0	3
Faecal coliform (E.coli), CFU/100 mL	Nil	0	0	0	0
Total plate count, CFU/100 mL	10^2	10	2		8

Source: OOPC – Mill Expansion EIA Fieldwork, 2015

Table 4-8b: Physico-chemical and Biochemical Analyses Results of Streams and Okomu River at OOPC Plantation (Wet Season, 23 September 2015).

OKOMU											
PARAMETER/UNIT	**FMENv. Limits**	**OKM_1 OKOMU RIVER (INLET) N 739914.31 E 689294.76**	**OKM_2 CONTROL N 738955.14 E 690767.63**	**OKM_3 (STREAM 1) OUTLET N 723029.70 E 688722.31**	**OKM_4 (STREAM 2) SOURCE N 737135.34 E 690749.13**	**OKM_5 (STREAM 2) OUTLET N 737161.61 E 688644.12**	**OKM_6 (STREAM 3) SOURCE N 734428.66 E 687756.99**	**OKM_7 (STREAM 3) OUTLET N 733137.74 E 684734.16**	**OKM_8 (STREAM 4) SOURCE N 732492.73 E 689927.33**	**OKM_9 (STREAM 4) OUTLET N 731301.82 E 688767.75**	**OKM_{10} (STREAM 5) SOURCE N 732147.53 E 686539.95**
Appearance	Colourless	Colourless liquid with particles	Clear and colourless liquid	Colourless liquid with particles	Colourless liquid with particles	Colourless liquid with particles	Colourless liquid with particles	Colourless liquid with particles	Light brown liquid with particles	Colourless liquid with particles	Colourless liquid with particles
Odour	Unobjectionable	Unobjection-able	Unobjection-able	Unobjection-able	Unobjectio-nable	Unobjection-Able	Unobjection-able	Unobjection-able	Unobjection-able	Unobjection-able	Unobjection-able
pH	6-9	6.11	6.02	6.93	6.50	6.32	6.56	6.68	7.10	6.63	6.92
Temperature, ^oC	Ambient	24.9	25.9	25.2	26.2	24.1	25.9	25.5	24.1	25.1	25.9
Conductivity, µS/cm	2000	16.0	45.4	22.7	18.7	20.2	17.5	22.6	28.9	29.5	17.8
Electrode Potential, mV	-	148	209	156	161	187	176	171	87	117	160
Colour, Pt-Co	7.0	56	<1	51	<1	10	<1	64	170	69	<1
Turbidity, NTU	10	16	<1	8	<1	5	<1	11	29	20	<1
Total Solids, mg/L	-	90	22.6	16.3	9.2	12	8.7	24.2	30.4	18.7	8.9
Total Dissolved solids, mg/L	1000	8.0	22.6	11.3	9.2	10.0	8.7	11.2	14.4	14.7	8.9
Total Suspended Solids, mg/L	30	10	<1	5	<1	2	<1	13	16	4	<1
Total Hardness, mg/L $CaCO_3$	-	3.5	7.5	4.0	3.0	3.0	2.5	8.5	7.5	5.0	4.0
Total Alkalinity, mg/L	-	9.2	5.52	7.36	7.36	12.9	5.52	11.0	14.7	7.36	7.36
Total acidity, mg/L	-	20.9	34.8	19.1	17.4	13.9	24.4	26.1	12.2	15.7	29.6
Calcium, mg/L as Ca	-	0.6	1.0	0.6	0.6	0.8	0.6	1.4	1.6	0.8	0.6
Magnesium, mg/L as Mg	-	0.49	1.22	0.61	0.36	0.24	0.24	0.73	0.85	0.73	0.61
Chloride, mg/L	200	2.65	0.88	2.65	0.88	0.88	0.88	4.43	1.77	0.88	0.88
Nitrate, mg/L	50	0.31	0.35	0.27	0.27	0.35	0.31	0.35	0.35	0.31	0.33
Nitrite, mg/L	0.3	0.07	0.05	0.07	0.01	0.02	0.03	0.04	0.04	0.02	0.01
Sulphate, mg/L	250	<1	1	4	<1	2	2	5	8	2	<1
Phosphate, mg/L	-	<0.1	<0.1	0.3	<0.1	<0.1	<0.1	0.9	1.9	0.4	<0.1

Parameter/Unit	FMENv. Limits	OKM_1 OKOMU RIVER (INLET) N 739914.31 E 689294.76	OKM_2 CONTROL N 738955.14 E 690767.63	OKM_3 (STREAM 1) OUTLET N 723029.70 E 688722.31	OKM_4 (STREAM 2) SOURCE N 737135.34 E 690749.13	OKM_5 (STREAM 2) OUTLET N 737161.61 E 688644.12	OKM_6 (STREAM 3) SOURCE N 734428.66 E 687756.99	OKM_7 (STREAM 3) OUTLET N 733137.74 E 684734.16	OKM_8 (STREAM 4) SOURCE N 732492.73 E 689927.33	OKM_9 (STREAM 4) OUTLET N 731301.82 E 688767.75	OKM_{10} (STREAM 5) SOURCE N 732147.53 E 686539.95
Iron (total), mg/L	20	0.26	0.05	0.18	0.03	0.09	0.31	0.08	0.71	0.27	0.08
Lead, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese, mg/L	0.10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic, mg/L	<1.0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Dissolved Oxygen, mg/L	>2.0	5.54	2.93	11.1	8.71	7.92	11.9	5.54	7.13	9.50	11.9
Total Hydrocarbon, mg/L		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Salinity, ‰	-	0.005	0.002	0.005	0.002	0.002	0.002	0.008	0.003	0.002	0.002
Pesticides		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Total coliform count, CFU/mL	10	0	0	0	2	0	0	2	0	0	3
Faecal coliform (E.coli CFU/100 mL	Nil	0	0	0	0	0	0	0	0	0	0
Total plate count, CFU/100 mL	10^2	4	0	0	4	4	0	4	2	0	4

Source: OOPC – Mill Expansion EIA Field work, 2014-2015

Table 4-8b: Physico-chemical and Biochemical Analyses Results of Streams and Okomu River at OOPC Plantation, (Wet Season, 23 September 2015) Cont'd.

OKOMU					
PARAMETER/UNIT	**FMENv. Limits**	**OKM_{11} (STREAM 5) OUTLET N 731548.30 E 684661.51**	**OKM_{12} (STREAM 6) SOURCE N 730351.10 E 685067.19**	**OKM_{13} (STREAM 6) OUTLET N 729959.56 E 684413.02**	**OKM_{14} OKOMU RIVER (OUTLET) N 729401.98 E 684600.00**
Appearance	Colourless	Colourless liquid with particles	Colourless liquid with particles	Light brown liquid with particles	Colourless liquid with particles
Odour	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
pH	6-9	5.54	6.60	5.65	6.30
Temperature, ^oC	Ambient	25.5	25.6	25.4	24.5
Conductivity, µS/cm	2000	20.4	27.1	21.1	28.4
Electrode Potential, mV	-	177	197	184	137
Colour, Pt-Co	7.0	22	62	106	62
Turbidity, NTU	10	8	15	5	12
Total Solids, mg/L	-	12.1	19.5	11.5	19.1
Total Dissolved solids, mg/L	1000	10.1	13.5	10.5	14.1
Total Suspended Solids, mg/L	30	2	6	1	5
Total Hardness, mg/L $CaCO_3$	-	6.0	11.3	5.0	5.5
Total Alkalinity, mg/L	-	11.0	9.2	9.2	9.2
Total acidity, mg/L	-	36.5	33.1	34.8	24.4
Calcium, mg/L as Ca	-	0.8	0.8	0.8	0.8
Magnesium, mg/L as Mg	-	0.97	2.25	0.73	0.85
Chloride, mg/L	200	0.88	0.88	2.65	4.43
Nitrate, mg/L	50	0.22	0.13	0.13	0.18
Nitrite, mg/L	0.3	0.01	0.01	0.04	0.03
Sulphate, mg/L	250	2	3	3	5
Phosphate, mg/L	-	0.5	0.2	1.0	0.8
Iron (total), mg/L	20	0.06	0.15	0.29	0.12
Lead, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01
Copper, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01
Manganese, mg/L	0.10	<0.01	<0.01	<0.01	<0.01
Cadmium, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01
Nickel, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01
Cobalt, mg/L	<1.0	<0.01	<0.01	<0.01	<0.01
Arsenic, mg/L	<1.0	<0.001	<0.001	<0.001	<0.001
Dissolved Oxygen, mg/L	>2.0	6.33	7.13	12.7	4.75
Total Hydrocarbon, mg/L		<0.01	<0.01	<0.01	<0.01
Salinity, $^o/_{oo}$	-	0.002	0.002	0.005	0.008
Pesticides, mg/L		<0.01	<0.01	<0.01	<0.01
Total coliform count, CFU/mL	10	2	0	0	3
Faecal coliform (E.coli), CFU/10 mL	Nil	0	0	0	0
Total plate count, CFU/100 mL	10^2	10	2		8

Source: OOPC – Mill Expansion EIA Fieldwork, 2015

b) **Bottom Sediments**

The results of the laboratory analyses of the bottom sediment samples collected during the field exercise are presented in Table 4-9. The pH value of the sediment samples for dry and wet seasons were within the range of 6.14 and 6.74 respectively with an average of 6.27 and 6.62 for dry and wet seasons respectively. Results of grain size analyses showed that the sediment samples were predominantly made up of sand with an average content value of 85.0% followed by silt having an average content value of 2.15% and lastly clay with 2.0% average content value for dry season. Similarly for wet season, the sediment samples were predominantly made up of sand with an average content value of 87.0% followed by silt having an average content value of 2.18% and lastly clay with 2.0% average content value.

Table 4-9: Bottom Sediment Analysis Result

Sample Code	pH	E.C (µS/cm)	O.C (%)	THC (mg/kg)	SAND (%)	CLAY (%)	SILT (%)
March 2015							
OKM_4 N 738955.14 E 690767.63	6.14	695.30	0.05	0.001	85.00	2.00	2.15
OKM_5 N 723029.70 E 688722.31	6.40	846.20	0.07	0.002	85.00	2.00	2.15
September 2015							
OKM_4 N 738955.14 E 690767.63	6.50	678.50	0.03	0.001	87.00	2.00	2.18
OKM_5 N 723029.70 E 688722.31	6.74	760.80	0.05	0.002	87.00	2.00	2.18

Source: OOPC – Mill Expansion EIA Fieldwork, 2015

4.7 Settlements

There are no settlements in the immediate vicinity of the project. The remote settlements from the project site include Udo community located about 25 kilometres southeast of the estate and Utesi settlement which is about 13.25 kilometres also southeast of the estate.

The company's workforce and their families reside on the estate and constitute the estate community. The estate population is about 3000 people. The company provides social infrastructure including pipe borne water and electricity for the estate community. The estate is also serviced by two GSM networks (Globacom and MTN).

4.7.1 Human Resources

The majority of adults on the estate community constitute the workforce at different cadres, working on the oil palm plantation, rubber plantation, existing palm oil mill, workshop, administration etc. The others are part of the household that are engaged in trading and farming. The children attend schools located on the estate.

4.8 Geology and Geomorphology

4.8.1 Geophysical Investigation

The geophysical investigations for the sitting of the POME treatment lagoon for the oil mill expansion project were conducted on Saturday 12th of September 2015 at a palm plantation belonging to Okomu Oil Palm Company, in Okomu, Edo State. The direct current electrical resistivity method was employed using the Vertical Electrical Sounding (VES) technique and eight VES were carried out; using the Schlumberger electrode configuration. Current electrode separation was varied between 2m and 200m in order to obtain a sufficient characterization of the subsurface.

The objectives of the investigations were:

(a) To carry out reconnaissance survey of the geomorphology hydrogeology of the proposed site with a view of locating a suitable area for geophysical investigations.

(b) To carry out geo-electric survey in the chosen area and consequently delineate the sub- soil structures, as well as provide indication of the topsoil profile.

(c) To determine from surface electrical resistivity measurements, zones with relatively thick impermeable layers beneath the site.

(d) To locate from the above, a suitable point for the effluent/wastewater treatment lagoon siting and construction.

4.8.2 Materials

The following instruments and materials were used for the investigation:

- PASI 16GL Earth Resistivity Meter
- Garmin GPS
- Cables for spreading
- Hand Hammers
- Stainless Steel Electrodes
- Measuring tapes
- Geological Map
- Recording materials

4.8.3 Methodology

The geophysical survey was carried out via the Electrical Resistivity Method (ERM) using the highly sensitive digital PASI 16GL Earth Resistivity Meter model for field data collection. It is a digital meter with displays of injected current, resultant potential difference and subsequent resistance of the medium. The equipment is highly sensitive measuring voltage up to 600nV and can be powered by a lead acid 12V dry cell battery.

Eight (8) soundings were conducted, spread around the site in order to achieve a relatively even distribution. This was to enable the delineation of regions with thicker and shallower low resistivity materials, which should correspond to zones with relatively lower permeability.

A site sketch showing the distribution of the test points around the site is shown in Figure 4-5.

The obtained apparent resistivity was interpreted via partial curve matching, by employing the use of master and auxiliary curves produced by Mooney and Orellana. The interpretation obtained was compared to interpretation by model calculation using the WingLink software. Finally, the quantitative interpretations were used to generate sounding curves and 1-D resistivity models of the subsurface.

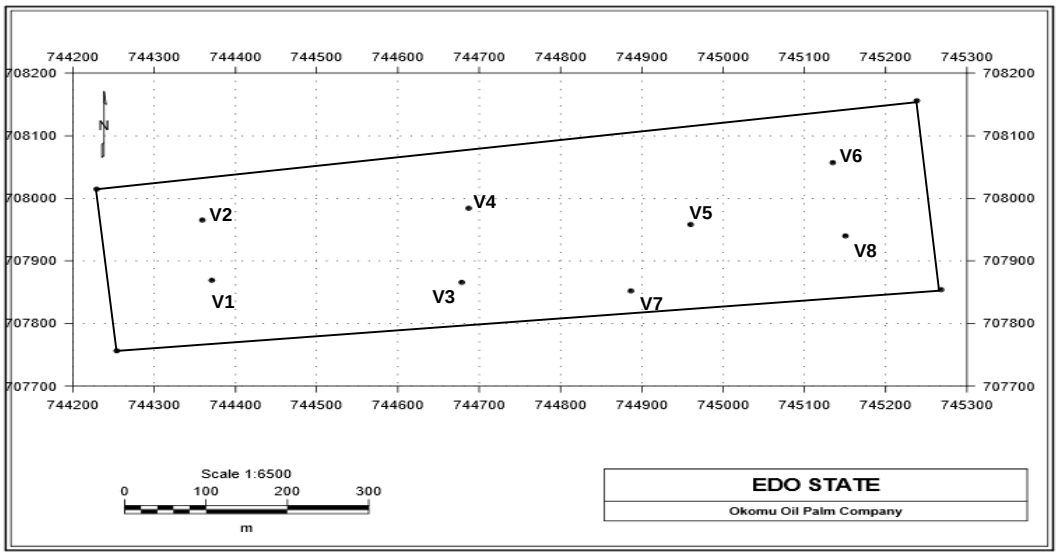


Figure 4-5: Site Sketch Map

4.8.4 Biophysical Elements

4.8.4.1 Topography

The land around the proposed mill expansion is relatively flat. Relief is generally flat to undulating with very gentle slopes. The elevation increases from 41m to 54m westward with +/- 6m.

4.8.4.2 Geology/Hydrogeology

The site falls within a region underlain by sedimentary deposits of the Coastal Plains Sand (Figure 4-6) which is a member of the Dahomey Basin; the sedimentary basin underlying South-West Nigeria and extending from Ivory Coast in the west, through Ghana, Togo, Benin Republic and terminating by the Okitipupa ridge in Nigeria. Other members of the basin in succession are the overlying Alluvial Deposits, the underlying Ilaro Formation, Ewekoro Formation and the Abeokuta Formation which unconformably overlies the basement complex. The Coastal Plains Sand is composed essentially of sands, silts and clays with traces of peat.

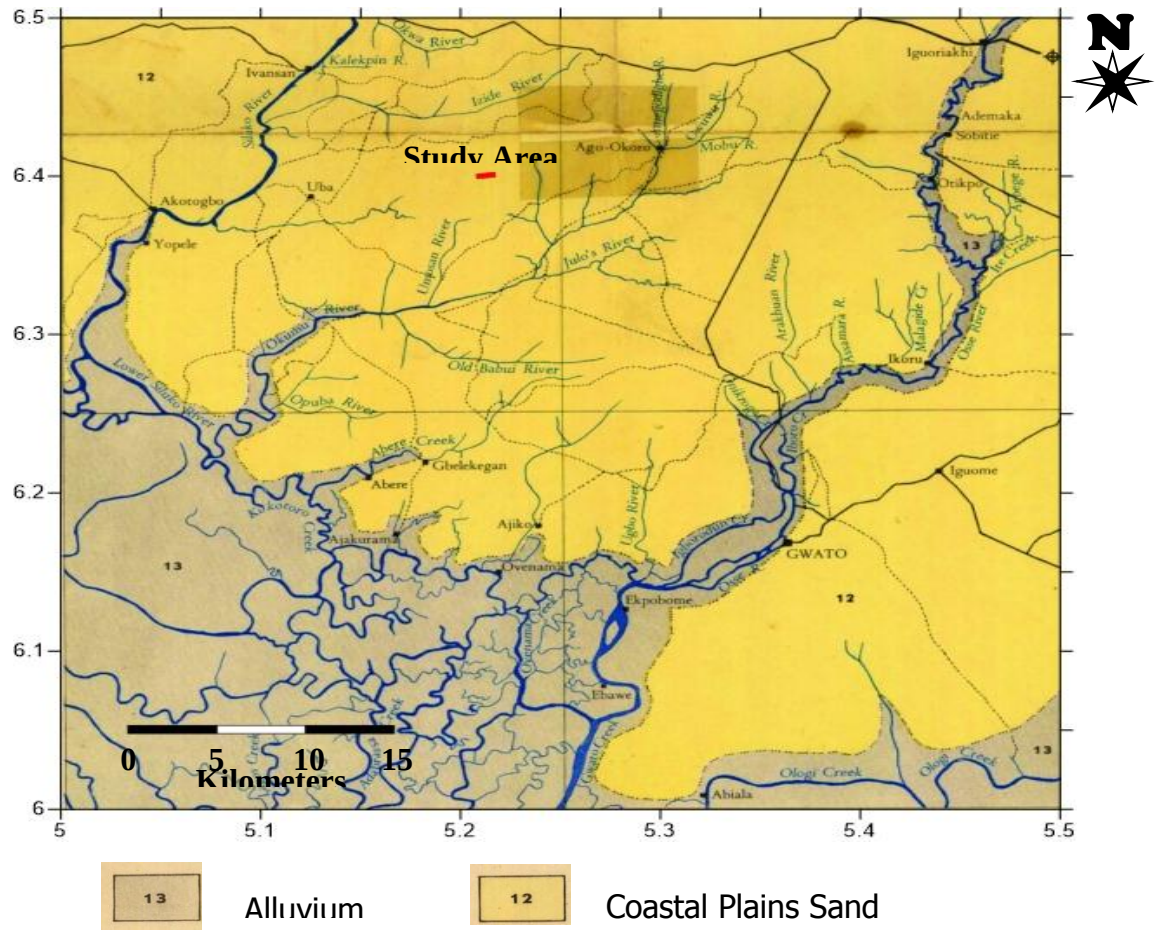


Figure 4-6: Area Geological Map of Part of Edo State Sheet 70 Showing the Study

4.8.4.3 Drainage

The area appears generally well drained. The entire area drains into Okomu River, although there are localized swamps and wetlands in the north and south. The river intake to the site lies north of the proposed mill expansion location and the direction of river flow is southward. The distance of the site to the river westward is 2.5 km while the site distance to the river southward is about 9 km.

4.8.4.4 Soil

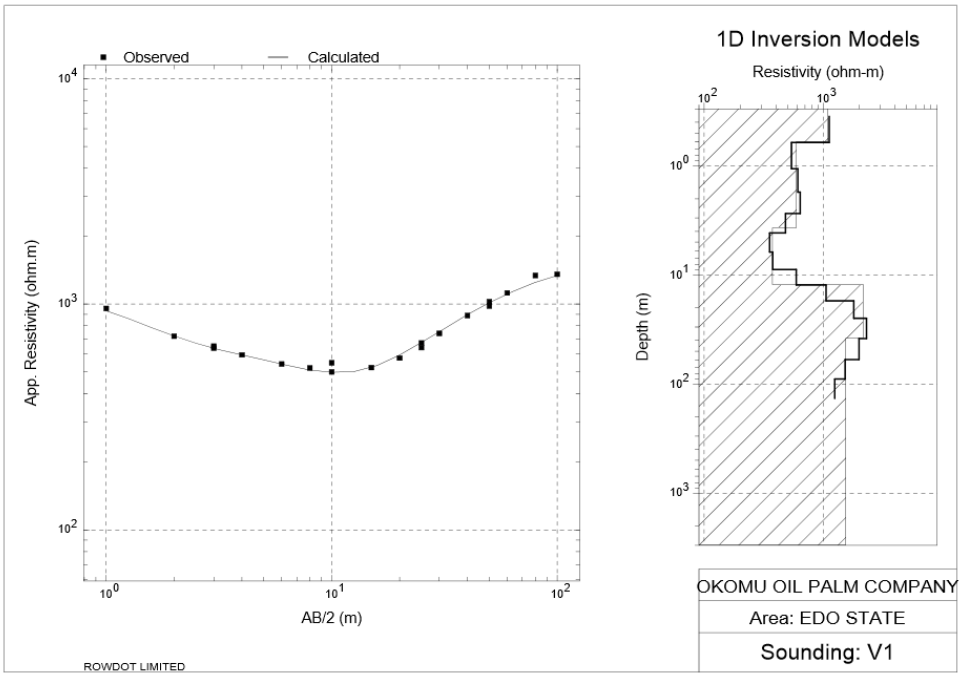
The soils are very deep, well drained sandy loam and loamy sand. Wetland soils occur at localized wet spots and swamps.

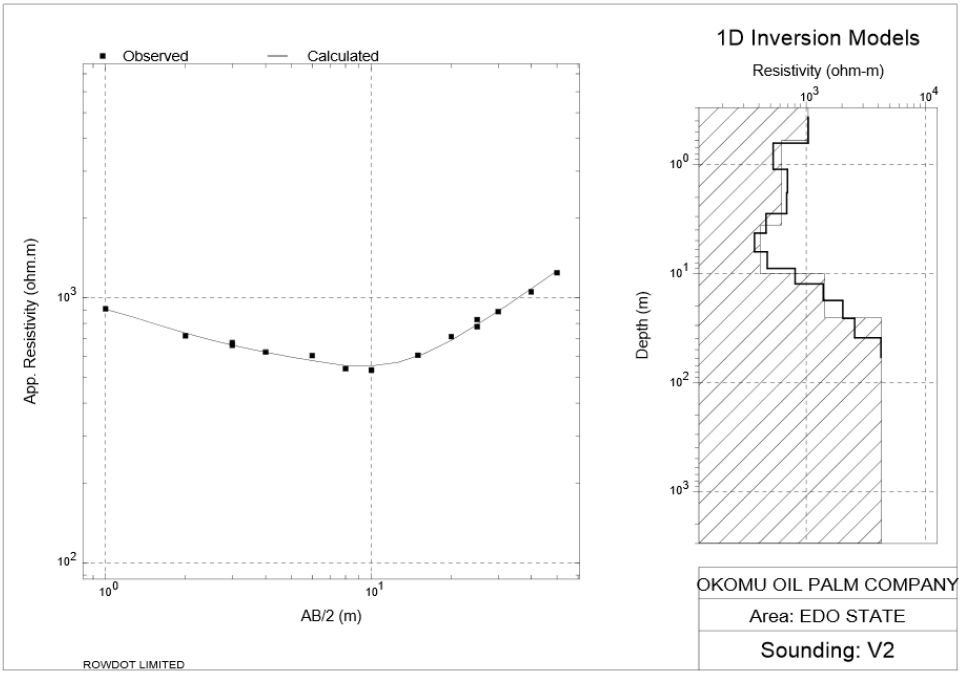
4.8.4.5 Field Data

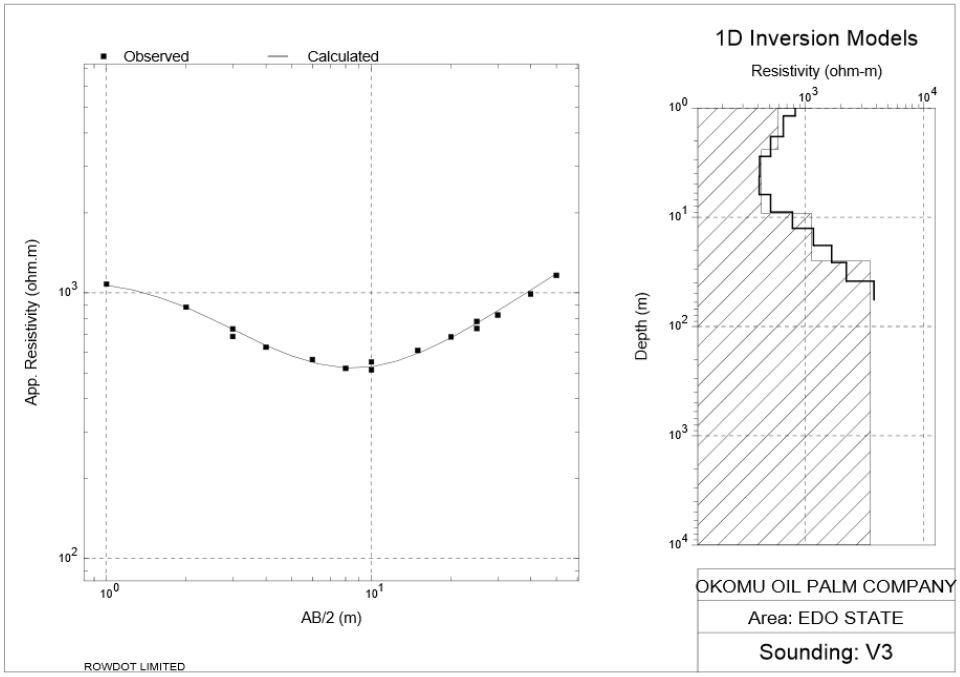
SCHLUMBERGER ARRAY ELECTRICAL RESISTIVITY DATA SHEET

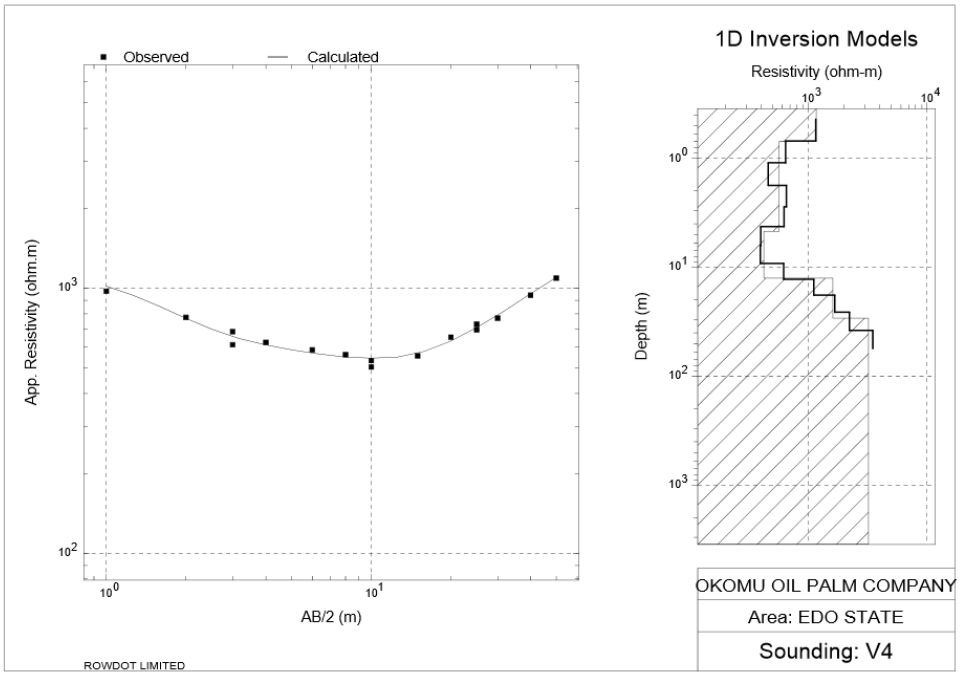
Field Data:

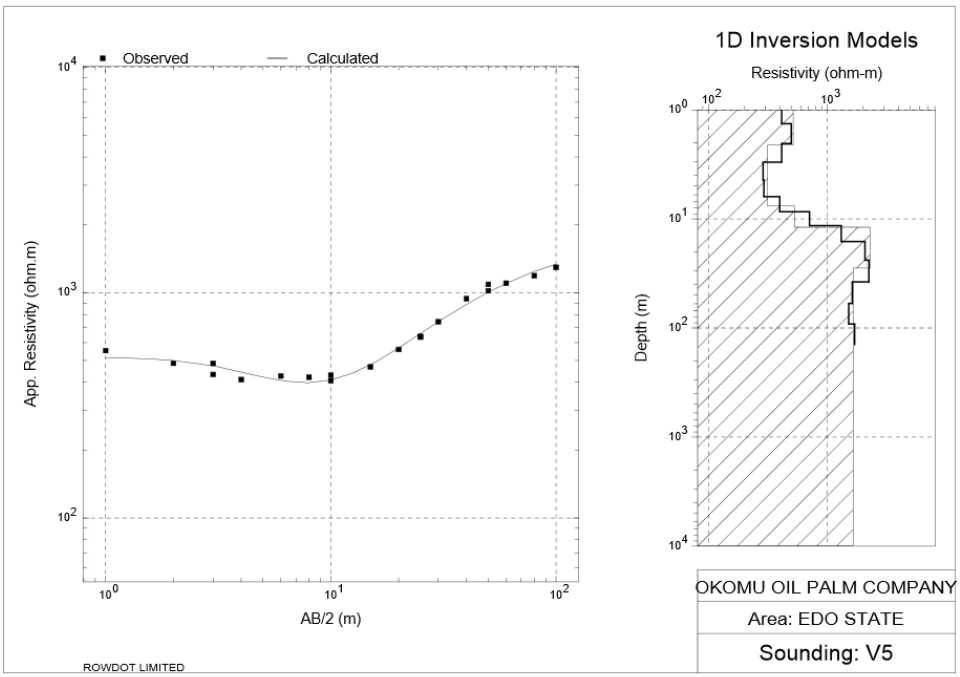
AB/2	VES 1	VES 2	VES 3	VES 4	VES 5	VES 6	VES 7	VES 8
	GEOGRAPHIC COORDINATES							
	6.39988 5.20920	6.40075 5.20910	6.39984 5.21198	6.40091 5.21206	6.40066 5.21453	6.40155 5.21611	6.39971 5.21386	6.40049 5.21625
	APPARENT RESISTIVITY (Ωm)							
1	959	907	1081	973	552	802	528	710
2	722	719	884	775	485	740	467	576
3	640	661	732	612	486	570	345	479
3	651	679	685	685	434	572	462	514
4	597	624	559	624	411	554	391	495
6	854	606	562	584	427	483	359	427
8	521	541	521	561	421	461	361	421
10	501	533	470	532	407	439	376	439
10	550	535	550	505	430	385	392	370
15	677	608	608	556	468	451	469	434
20	902	715	684	653	560	529	560	529
25	1073	829	780	732	634	683	683	634
25	641	698	735	698	640	566	622	584
30	742	770	825	770	742	660	742	687
40	891	940	990	940	940	742	891	841
50	1089	1089	1166	1089	1089	731	1166	1011
50	980	-----	-----	-----	1018	-----	-----	-----
60	1045	-----	-----	-----	1100	-----	-----	-----
80	1485	-----	-----	-----	1188	-----	-----	-----
100	1417	-----	-----	-----	1292	-----	-----	-----

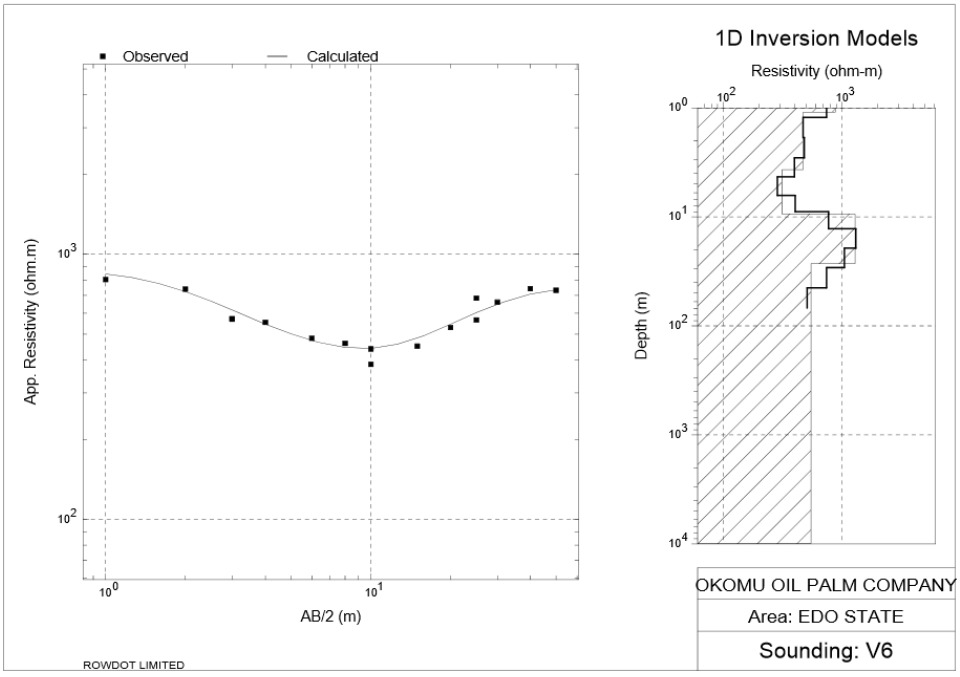

Observed
Calculated
App. Resistivity (ohm.m)
AB/2 (m)
1D Inversion Models
Resistivity (ohm-m)
Depth (m)
OKOMU OIL PALM COMPANY
Area: EDO STATE
Sounding: V1
ROWDOT LIMITED

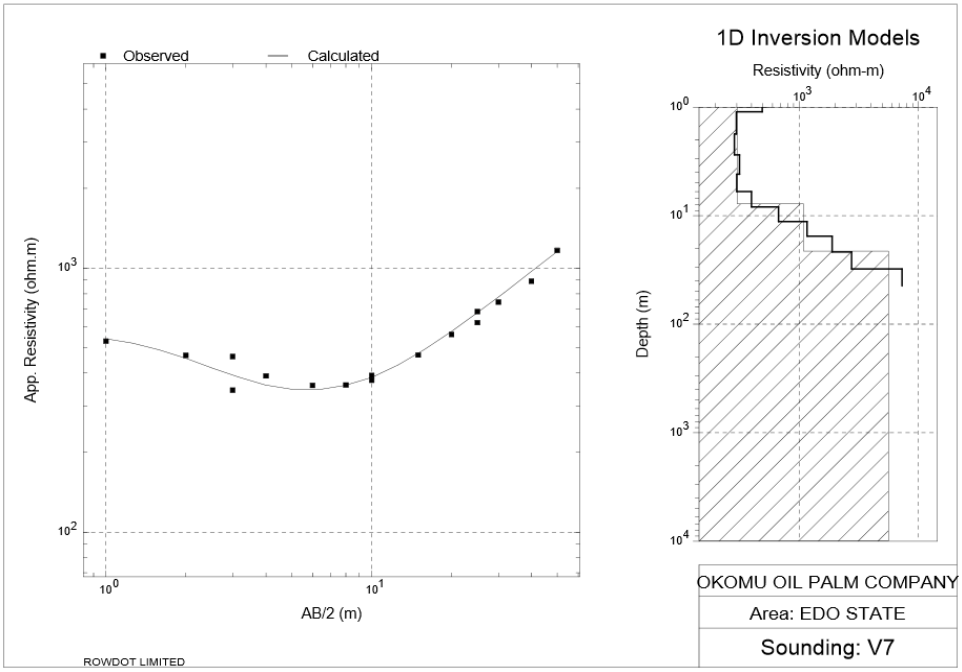

Observed
Calculated
App. Resistivity (ohm.m)
AB/2 (m)
1D Inversion Models
Resistivity (ohm-m)
Depth (m)
OKOMU OIL PALM COMPANY
Area: EDO STATE
Sounding: V2
ROWDOT LIMITED

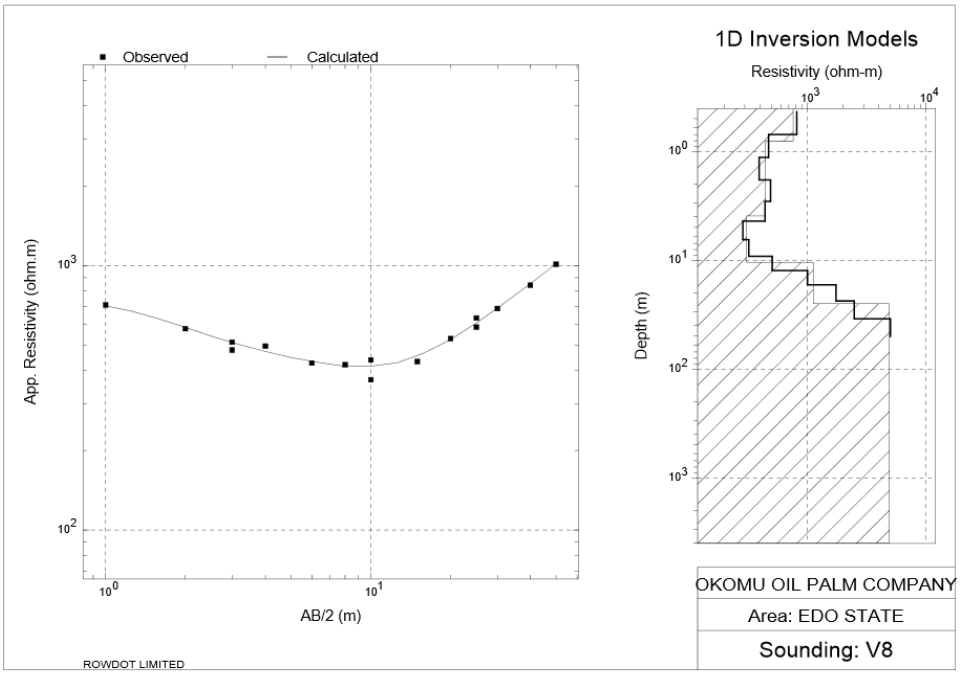

Observed
Calculated
App. Resistivity (ohm.m)
AB/2 (m)
ROWDOT LIMITED
1D Inversion Models
Resistivity (ohm-m)
Depth (m)
OKOMU OIL PALM COMPANY
Area: EDO STATE
Sounding: V3


Observed
Calculated
App. Resistivity (ohm.m)
AB/2 (m)
ROWDOT LIMITED
1D Inversion Models
Resistivity (ohm-m)
Depth (m)
OKOMU OIL PALM COMPANY
Area: EDO STATE
Sounding: V4


Observed
Calculated
App. Resistivity (ohm.m)
AB/2 (m)
1D Inversion Models
Resistivity (ohm-m)
Depth (m)
OKOMU OIL PALM COMPANY
Area: EDO STATE
Sounding: V5
ROWDOT LIMITED


Observed
Calculated
App. Resistivity (ohm.m)
AB/2 (m)
1D Inversion Models
Resistivity (ohm-m)
Depth (m)
OKOMU OIL PALM COMPANY
Area: EDO STATE
Sounding: V6
ROWDOT LIMITED


Observed
Calculated
App. Resistivity (ohm.m)
AB/2 (m)
ROWDOT LIMITED
1D Inversion Models
Resistivity (ohm-m)
Depth (m)
OKOMU OIL PALM COMPANY
Area: EDO STATE
Sounding: V7


Observed
Calculated
App. Resistivity (ohm.m)
AB/2 (m)
ROWDOT LIMITED
1D Inversion Models
Resistivity (ohm-m)
Depth (m)
OKOMU OIL PALM COMPANY
Area: EDO STATE
Sounding: V8

4.8.4.6 Discussion of Results

A relatively uniform sequence was delineated beneath the sounding stations with the curves being essentially of the QH type tending towards QHK type. This curve type; QH, is an indication of a low resistive medium underlying the topsoil and in turn being underlain by a high resistive medium. Considering the geology of the study area, low resistive horizons are expected to be constituted of clayey deposits, while high resistive horizons are expected to be composed of sandy materials. Thus, regions with thickest low resistive horizon is considered most favourable for the intended purpose.

An attempt at quantitative interpretation of the data set was carried out. This yielded essentially five major geo-electric layers from ground surface to a depth of between 21m and 38m with the low resistive horizons being delineated at varying depths; albeit not exceeding 13m. A summary of the quantitative interpretation results with corresponding inferred lithology is given in the table below.

Summary of Results

VES 1				
Layer	**Resistivity (Ωm)**	**Thickness (m)**	**Depth to layer base (m)**	**Lithology**
1	1095	0.6	0.6	Topsoil
2	592	3.1	3.7	Sandy Clay
3	372	8.5	12.2	Clay
4	2160	25.8	38.0	Sand
5	1550	-----	-----	Clayey Sand
VES 2				
Layer	**Resistivity (Ωm)**	**Thickness (m)**	**Depth to layer base (m)**	**Lithology**
1	1035	0.6	0.6	Topsoil
2	622	3.0	3.6	Sandy Clay
3	411	6.5	10.1	Clay
4	1430	15.4	25.5	Sand
5	4300	-----	-----	

VES 3				
Layer	**Resistivity (Ωm)**	**Thickness (m)**	**Depth to layer base (m)**	**Lithology**
1	1130	1.0	1.0	Topsoil
2	590	1.4	2.4	Sandy Clay
3	430	6.9	9.3	Clay
4	1140	15.8	25.1	Sand
5	3540	-----	-----	
VES 4				
Layer	**Resistivity (Ωm)**	**Thickness (m)**	**Depth to layer base (m)**	**Lithology**
1	1165	0.7	0.7	Topsoil
2	570	4.0	4.7	Sandy Clay
3	423	7.9	12.6	Clay
4	1605	16.7	29.3	Sand
5	3189	-----	-----	
VES 5				
Layer	**Resistivity (Ωm)**	**Thickness (m)**	**Depth to layer base (m)**	**Lithology**
1	517	2.1	2.1	Topsoil
2	316	5.5	7.6	Clay
3	530	4.3	11.9	Sandy Clay
4	2300	16.3	28.2	Sand
5	1650	-----	-----	Clayey Sand
VES 6				
Layer	**Resistivity (Ωm)**	**Thickness (m)**	**Depth to layer base (m)**	**Lithology**
1	880	1.1	1.1	Topsoil
2	473	2.6	3.7	Sandy Clay
3	315	5.7	9.4	Clay
4	1287	17.4	26.8	Sand
5	550	-----	-----	Sandy Clay
VES 7				
Layer	**Resistivity (Ωm)**	**Thickness (m)**	**Depth to layer base (m)**	**Lithology**
1	570	1.0	1.0	Topsoil
2	303	6.8	7.8	Clay
3	1093	13.5	21.3	Sand
4	5620	-----	-----	
VES 8				
Layer	**Resistivity (Ωm)**	**Thickness (m)**	**Depth to layer base (m)**	**Lithology**
1	760	0.8	0.8	Topsoil
2	447	3.1	3.9	Sandy Clay
3	308	6.5	10.4	Clay
4	1130	14.8	25.2	Sand
5	4870	-----	-----	

A profile line was taken through the site to include all the sounding stations. This was to enable a comparison of the delineated subsurface sequence beneath the sounding stations. Consequently, revealing sections with thicker low resistive materials being encountered at shallower horizons. Resistivity values from respective sounding stations were contoured thus creating a basis for the comparison and yielding a pseudo- 2D cross section (Figure 4-7) of the subsurface using the WingLink Software.

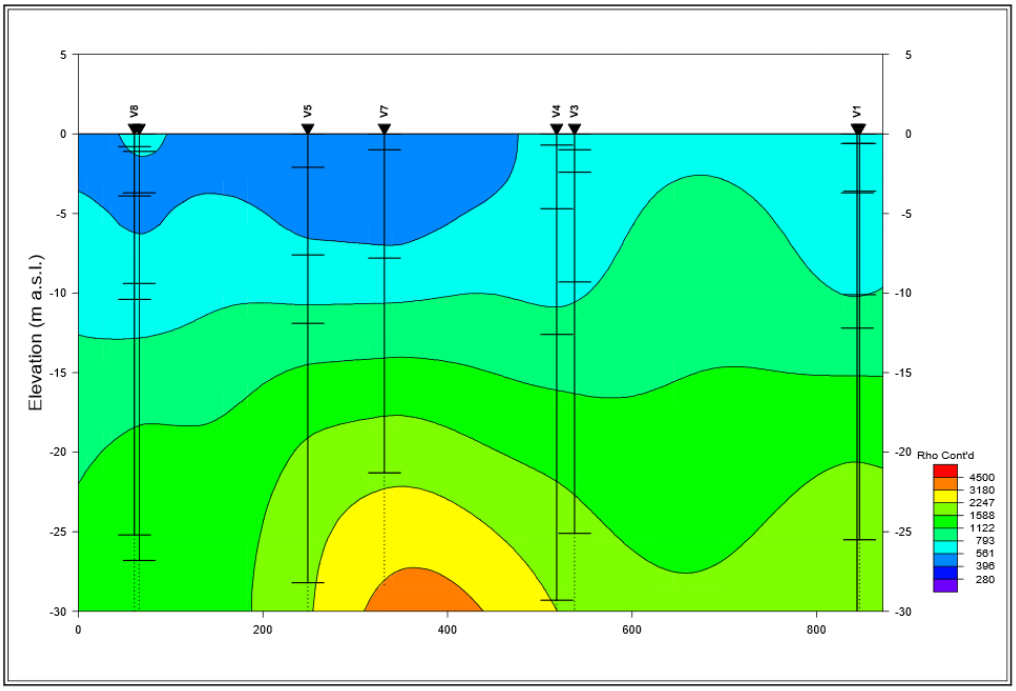


Figure 4-7: Resistivity Cross Section beneath the sounding stations

The figure shows relatively horizontal layering beneath the subsurface and indicates that the lowest resistivity values close to ground surface obtain around VES 5 to 8 although concentrated around VES 5 and 7, with the low resistive regions extending to depth of about 6m below the ground surface.

4.8.4.7 Conclusion

Consequent on the need to determine regions with thickest near surface clayey horizons, the electrical resistivity method of geophysical prospecting was employed for site investigation at Okomu Oil Palm Company in Edo State. Eight Vertical Electrical Soundings were conducted while varying electrode spread between 2m and 200m in order to achieve sufficient probe of the subsurface.

Following from the field exercise, five major geo-electric layers were delineated from ground surface to depth of about 38m composed of sandy and clayey materials.

A pseudo- 2-D resistivity cross section beneath the site was generated from East to West. The cross section reveals lower resistivity values and therefore more clayey materials on the Eastern flank of the site around VES 5, 6, 7 and 8.

Thus, in lieu of our considerations and observations, the Eastern (the south-eastern in particular) flank of the site is best suited for the intended purpose.

4.9 Soil Microbiology

Dry Season March 2015

The results gives the variety and distribution of soil micro-organisms in the swamps around the proposed mill expansion area in dry season March 2015. Soil samples taken for microbial analysis were at exactly same locations as those taken in dry season March 2015 for wet season September 2015.

Wet Season, 2015

The results shows the dominant species of soil micro-organisms at swamps around the proposed mill expansion at Okomu Oil Palm Company Plc. The predominant heterotrophic and hydrocarbon utilizing bacterial species present in the soils were: *Bacillus sp., Corynebacterium sp., Micrococcus sp.* These microbial groups have been associated with organic transformation and re-cycling in soils. Some *Fusarium* species cause oil palm diseases such as vascular wilt.

Population levels of hydrocarbon utilizers in soil, sediment and water reflects the historical exposure of these habitats to hydrocarbons. Sizeable increase in the population of hydrocarbon utilizing micro-organisms occurs when a particular environment is exposed to hydrocarbons such as petroleum and vegetable oils. The population levels within the microbial community are used as indication of or index of sensitivity to environmental exposure to hydrocarbons. In unpolluted ecosystem, hydrocarbon utilizers constitute less than 0.1% of the total microbial community. While in oil polluted ecosystem, they constitute more than 1.0% and up to 100.0%. But in the case of the proposed study area, the hydrocarbon utilizers constitute less than 0.1% of the total microbial community.

Current Status

Most of the Okomu Oil Palm Company Plc land concessions have been planted with oil palms and rubber trees of different ages leaving mainly ecological sensitive areas (wetland, watersheds etc). The entire banks of the flowing rivers inside the company are populated by riparian forests stretching across the six rivers within the estate. The biodiversity plot covers about 638.9 ha of the total concession area.

Plates 4-1: Riparian Forest along the six Surface Rivers within the Estate

Table 4-10: Composition and Classification of the Plant Forms in the Freshwater Swamp Forest in the Study Area

S/N	SPECIES	FAMILY	COMMON NAME
1.	*Aframomum melegueta*	Zingiberaceae	Alligator pepper
2.	*Anthocleista vogelli*	Loganiaceae	Cabbage tree
3.	*Baphia nitida*	Sapindaceae	Camwood
4.	*Calamus rotang*	Palmae	Cane palm
5.	*Carapa procera*	Meliaceae	Crabwood tree
6.	*Costus afer*	Zingiberaceae	Ginger tree
7.	*Elaeis guineensis*	Palmae	Oil palm
8.	*Havea brasiliensis*	Euphorbiaceae	Para rubber
9.	*Raphia vinfera*	Palmae	Wine palm
10.	*Raphia hookeri*	Palmae	Wine palm

4.10 Terrestrial Invertebrate

A total of 20 major invertebrate taxa consisting of 1 earthworm, 2 myriapod, 15 insects and 2 gastropod mollusc families/major taxa were recorded in all sampling stations combined.

Ants were found everywhere particularly the black ants *Monomorium destructor* and soldier ants *Oecophylla,* and so were beetles, flies, earthworms.

Table 4-11: Terrestrial and Soil Invertebrate Fauna Present in the Fresh Water Swamp Forest around the Proposed Oil Mill Expansion Site

S/N	MAJOR TAXA	SPECIES	COMMON NAME
I.	Annelida: Oligochaeta Eudrillidae:	*Eudrilus sp.* *Hyperiodrilus africanus* *Libyodrilus violaceus*	Swamp forest earthworms
II.	Insecta		
	Acraeidae	*Acraea sp.; Precis, Papilio; Graphium; Danus; Appias; Colotis; Tereas; Euphaedra.*	Butterflies and Moths and Catterpillars
	Acrididae	*Zonocerus variegates; catantops; Orthocanthacris*	Grasshoppers
	Carabidae	*Anthia sp.*	Ground beetle
	Chrysomelidae	*Chrysochus; Cassida; Monolepta*	Leaf beetle
	Cicadellidae	*Comelus*	Leaf hoppers
	Formicidae	*Formica, Monomorium Oecophylla, Solenopsis*	Ants
	Glossinidae	*Glossina*	Tse-tse fly
	Gryllidae	*Gryllus*	Cricket
	Mantidae	*Sphedromantis lineola*	Praying mantis
	Muscidae	*Musa domestica*	House fly
III.	Mollusca; Gastropoda Achantinidae	*Archachatina marginata*	Giant land snail
		Limicolaria flamea	Garden snail
		Limicolaria aurora	Garden snail

Wildlife

The banks of the river and the swamp forest on either side of it contain evergreen vegetation. This vegetation harbours most of the wildlife. The wildlife consists of the African giant land snail, reptiles and birds.

IUCN Red List of Threatened Species

Endemic Species

These are taxa that are unique to a specific geographical area and are not found anywhere else in the ecological zones of a given country or region. None of the listed wildlife species is endemic to ecosystem.

Extinct Species

These are taxa that no longer exist but which were previously in existence some 50 or more years ago in the locality. None of these are found on the proposed site. However, most of these species may probably be found at Okomu National Park which is about 40km from the proposed project site.

Endangered Species

These are taxa in danger of extinction either because their numbers have been reduced to a critical level or the habitat have been so drastically reduced that they (taxa) are in immediate danger of extinction. There are no endangered species on the local ecosystem.

CITES: (Convention on International Trade in Endangered Wild Species of Fauna and Flora):

Based on Decree 11 of 1985 for the control of International Trade and Traffic in endangered wild species, the following wildlife taxa in the forests are for international trade, and thus are prohibited.

a. Tree pangolin - *Manis tricuspis*
b. Civet - *Civettictis civetta*
c. Genet - *Genetta maculatta*
d. Short-nosed crocodile - *Osteolaemus tetraspis*
e. Royal python - *Python regius*
f. Black kite - *Milvus migrans.*
g. Eagles:
    - West African River Eagle : *Falco vocifer*
    - Vulturine Fish Eagle : *Gypohierax angolensis*
    - Shikra : *Accipiter badius*
h. All monkeys

Vulnerable Species
These are taxa likely to move into the endangered category in the near future if the causal factors continue operating. No taxa in the IUCN Red List that are vulnerable are present at Okomu Oil Palm Company Plc ecosystem. Also, no wildlife falls in the IUCN categories of Rare and Indeterminate Species.

Commercially Threatened
Taxa not currently threatened with extinction but most or all of whose population are threatened as a sustainable commercial resource, or will become so, unless their exploitation is regulated. This category applies only to taxa whose populations are assumed to be relatively large. This category has only been used for marine species of commercial importance that are being over-fished. The African giant snail *Atchachatina marginata* belongs to this category.

Snail, frogs and toads, were particularly abundant in the wet season. So also were kingfishers, hornbills, coucals, doves, mona monkeys, giant rats, ground squirrels mice and mongoose, herons, plantain eaters and grey parrot were not observed throughout the period of this study.

4.11 Consultation with and Participation by Stakeholders

4.11.1 Introduction
In the EIA, process consultation with and participation by stakeholders is a very important activity. It is a continuous activity in the EIA process, taking place in early stages prior to the decision on the action to be taken on the project. The decision may be made by the proponent, jointly by the proponent and the decision-making and environmental regulators (screening and scoping decision) and the public on whether or not to allow the project or proposal to proceed (Wood, 1996). The stakeholders include the adjoining communities to the proposed project location, environmental regulatory agencies, government ministries and parastatals, local governments, non-governmental organizations (NGO) and persons having interest and concerns on the conservation of the areas where the mill expansion would be built (Figure 4-8).

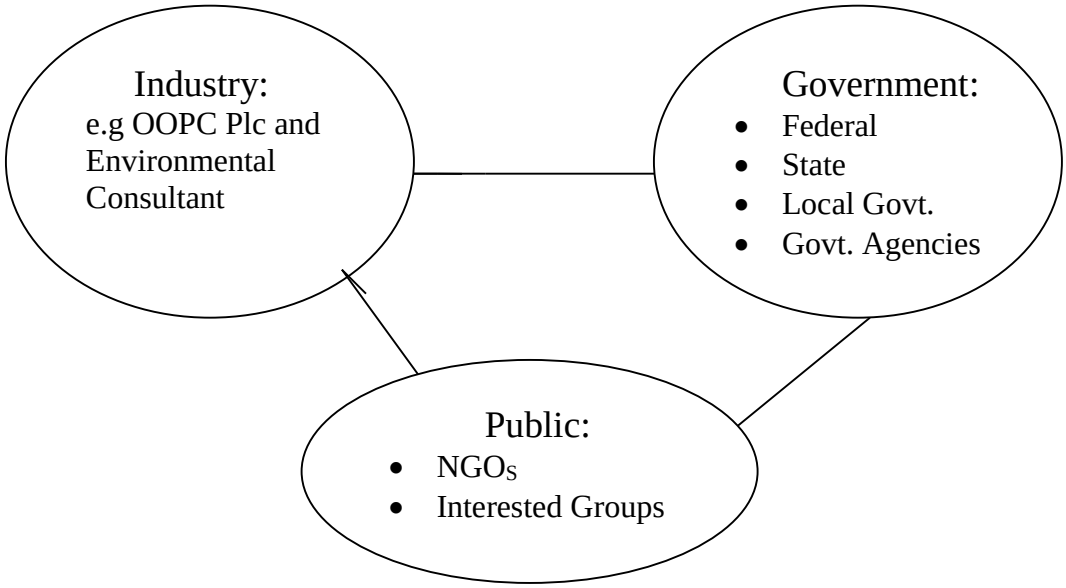


Figure 4-8: Stakeholders interrelationship in the activities for an E.I.A Study

4.11.2 Objectives

The specific objectives of the consultation and participation process are to:

- Inform and educate stakeholders about the project
- Obtain stakeholders views on the project as it may affect the existing conditions of the environment of the area
- Assist in scoping of activities to be included in the study outlined in the scope of work.
- Resolve conflicts relating to the project
- Identify problems, concerns and needs of adjoining communities
- Establish a coordinal link between the proponent and the communities.

4.11.3 Consultations with Stakeholders

4.11.3.1 Institutions

a. Federal Ministry of Environment

The Federal Ministry of Environment at Abuja was consulted in screening process or initial environmental examination (IEE) in order to categorize the project. Also, at application stage for an EIA study by the proponent in 2012, the Terms of Reference (TOR) and scope of study to be carried out by the proponent were submitted to the FMEnv for approval. The FMEnv visited the proposed project site and carried out the verification of the EIA study proposal submitted by Okomu Oil Palm Company Plc, after which the TOR was approved. There were regular contacts with the FMEnv at Abuja and the Edo State Zonal Controller of the FMEnv, at Ekenwa Road, Benin City.

b. Edo State Ministries of Environment & Public Utilities and Agriculture at Benin City.
c. Ovia-Southwest Local Government Area, Igbobazuwa.

The involvement of various interagency/Non-governmental Organisations in the consultation is summarized in *Section 4.11.4.*

4.11.3.2 Communities

There are no recognised and structured communities around the periphery of Okomu Oil Palm Company Plc. The Udo community which is the nearest structured community is more than 24 kilometres from the proposed project area and Utesi settlement which is about 13.25 kilometres also southeast of the estate - these are outside the area of influence of the proposed mill expansion project. In line with the company's Corporate Social Responsibility, it holds regular meetings with the Udo community to discuss the company's community support and development programmes and projects. At many of such meetings, the proposed mill expansion was discussed, especially as additional investment by the company and source of increased economic benefits to the community.

The relationship between the company and the Udo community has been very cordial and harmonious. Against this background, the community has been quite receptive of the proposed mill expansion project.

4.11.4 Interagency/Non-Governmental Organisations/Public Consultation

Non-Governmental Organisations

Consultations with the Nigerian Environmental Society (NES) and Nigerian Conservation Foundation (NCF) indicated that there are no registered or known non-governmental organisations (NGOs) in the surrounding communities.

Interagency Consultations

This project will not materialize without the involvement of the following agencies:

- The Federal Ministry of Environment, which must grant planning and environmental permission for the project.
- The Edo State Waste Management Board must grant permission for dumpsite or landfill to be established for solid waste disposal.
- The State Fire Service will need to approve the fire prevention arrangements for the proposed mill expansion.
- The Factories Inspectorate Unit of the Federal Ministry of Labour will need to approve the design of the proposed mill expansion for effectiveness in relation to workplace health and safety.

CHAPTER FIVE

5.0 ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACT OF THE PROPOSED PROJECT

5.1 Introduction

The primary intention of this Environmental Impact Assessment (EIA) is to identify the associated and potential impacts of the proposed mill expansion project and to develop options for mitigating the negative impacts that have been so identified.

The primary objectives of the impact assessment process are to:

- Establish the significance of identified potential impacts that may occur as a result of a project activity being undertaken.
- Differentiate between those impacts that are insignificant (i.e. can be sustained by natural systems) and those that are significant (i.e. cannot be sustained by natural systems).

  Unacceptable negative impacts will require additional mitigation measures to complement those incorporated in the project design. Potential cumulative impacts are also considered. The significance of an impact is determined by:

  - Determining the environmental consequence of the activity;
  - Determining the likelihood of occurrence of the activity and
  - Subsequently calculating the product of these two parameters.

This chapter basically identified the potential environmental impacts by considering the anticipated effects of the proposed mill expansion project on the existing physical, chemical, biological conditions of the environment.

At an earlier stage in this study, an environmental screening and scoping exercise was carried out, the process employed was a combination of desk study, site visitation, and consultations with stakeholders. From this, an overview of the potential impacts, the choice of the appropriate field analysis and likely mitigation measures and the monitoring programme were examined.

This chapter presents an overview of the impact assessment methodology as well as results of impact screening followed by detailed qualitative and quantitative impact assessments. Their inclusion does not mean they would necessarily occur or cannot be successfully mitigated.

The boundaries (temporal and spatial) of this EIA study were determined through the scoping process involving consultations with stakeholders, social, economic

and health studies. The project activities that would impact on the environment were identified as:

- Pre-construction activities
- Construction
- Operation and maintenance
- Decommissioning

5.1.1 Social and Environmental Impacts

Social Impacts

The palm oil industry has had both positive and negative impacts on workers, indigenous peoples and residents of palm oil-producing communities. Palm oil production provides employment opportunities, and has been shown to improve infrastructure, social services and reduce poverty. However, in some cases, oil palm plantations have developed lands without consultation or compensation of the indigenous people occupying the land, resulting in social conflict. The use of illegal immigrants in Malaysia has also raised concerns about working conditions within the palm oil industry.

Some social initiatives use palm oil cultivation as part of poverty alleviation strategies. Examples include the UN Food and Agriculture Organization's hybrid oil palm project in Western Kenya, which improves incomes and diets of local populations, and Malaysia's Federal Land Development Authority and Federal Land Consolidation and Rehabilitation Authority, which both support rural development.

The use of palm oil in the production of biodiesel has led to concerns that the need for fuel is being placed ahead of the need for food, leading to malnourishment in developing nations. This is known as the food versus fuel debate. According to a 2008 report published in the *Renewable and Sustainable Energy Reviews*, palm oil was determined to be a sustainable source of both food and biofuel. The production of palm oil biodiesel does not pose a threat to edible palm oil supplies. According to a 2009 study published in the *Environmental Science and Policy* journal, palm oil biodiesel might increase the demand for palm oil in the future, resulting in the expansion of palm oil production, and therefore an increased supply of food.

Environmental Impacts

Oil palm cultivation has been criticized for impacts on the natural environment, including deforestation, loss of natural habitats, which has threatened critically endangered species such as the orangutan and Sumatran

tiger, and increased greenhouse gas emissions. Many oil palm plantations are built on top of existing peat bogs, and clearing the land for palm oil cultivation may contribute to greenhouse gas emissions.

Efforts to portray palm oil cultivation as sustainable have been made by organizations including the Roundtable on Sustainable Palm Oil, an industry group, and the Malaysian government, which has committed to preserve 50 percent of its total land area as forest. According to research conducted by the Tropical Peat Research Laboratory, a group studying palm oil cultivation in support of the industry, oil palms plantations act as carbon sinks, converting carbon dioxide into oxygen and, according to Malaysia's Second National Communication to the United Nations Framework Convention on Climate Change, the plantations contribute to Malaysia's status as a net carbon sink.

Environmental groups such as Greenpeace and Friends of the Earth oppose the use of palm oil biofuels, claiming that the deforestation caused by oil palm plantations is more damaging for the climate than the benefits gained by switching to biofuel and utilizing the palms as carbon sinks.

5.2. Methodology of impact assessment

5.2.1 Overall methodology

The overall methodology comprises five steps as follows:

Step 1

- Identification and description of project phase.
- Associated activities and their possible interactions with environmental, social and health components.

Step 2

Preliminary identification of potential impacts on environmental, social and health components

Step 3

- Screening for impact significance
- Elimination of activity of environmental interactions producing no effect;
- Selection of focus impacts for further assessments

Step 4

Detailed assessment of selected focus impacts in terms of:

- Nature- positive or negative, direct or indirect
- Magnitude-qualitative and quantitative

- Areal extent-qualitative and quantitative
- Frequency
- Receptor sensitivity
- Duration including reversibility
- Cumulative effects

Step 5

- Final assessment and assignment of overall impact significance levels based on step 4 results and application of objective impact severity criteria and likelihood;
- Identification of impacts requiring mitigation.

The analysis of impacts covers the aspects of the project activities described in Chapter Three.

For each activity, potentially affected environmental media are identified and the nature of the effects are qualified and quantified.

5.2.2 Preliminary Identification and Screening

In accordance with recommended impact assessment approaches (FMEHUD, 1995; UNEP, 1996; Canter, 1996; Lohani et al 1997) the first level of impact assessment involves the preliminary identification and screening of potential environmental impacts by anticipating activity – environment interactions. This requires a thorough understanding of the project activities (project description), the project setting (the environmental description), and the interaction with environmental components. A modified Leopold matrix (Leopold, 1971) was used for the identification and screening. The matrix shows project activities against environmental (biophysical, social and health) components, and supports a methodical, comprehensive, and objective identification of the impacts each project activity may have on each biophysical, social, and health component.

Impact identification is based on Wathern (1988), who defines an impact as "having both spatial and temporal components and can be described as the change in an environmental parameter over a specified period within a defined area, resulting from a particular activity compared with the situation which would have occurred had the activity not been initiated".

To further guide the identification and screening of impacts using the matrix, established environmental impact indicators or indices are developed for each of the environmental interaction categories. Impact indicators are the observable or measurable parameters of each environmental component that can be directly or indirectly linked to changes in environmental conditions.

The integrated impact assessment is conducted with consideration of environmental, social and health elements, some procedures specific to each element were used in the process as relevant to the study.

5.3 Checklist of Environmental Indicators

(a) Biophysical (Natural and Physical)

The major indicators are:

- Climate and meteorology
- Air quality
- Noise travel
- Ground water
- Surface River
- Geology and geomorphology
- Soil
- Drainage pattern/flooding
- Unique physical features/aesthetics
- Vegetation, forestry and economic crops/plants
- Terrestrial fauna and wildlife
- Fisheries

(b) Socio-Economic

- Land use
- Community population and ethnicity
- Employment and income
- Culture and religion
- Infrastructure provision
- Health
- Education
- Traditional administration
- Community

Each of the environmental indicators above was also evaluated to ascertain the present situation and extent of damage and/or degradation as presented in Chapter Four.

5.4 Project and Associated Activities of Proposed Mill Expansion Project

The major activities at the proposed mill expansion site will be:

a. Pre-construction stage

- Contract Award
- Mobilization

b. Construction Stage - The activities include:

- Heavy machinery use
- Installation of equipment
- Generator use
- Civil, Electrical and Mechanical works
- Solid waste disposal

c. Operation Phase

- Transportation of FFB to the mill
- Palm oil processing/production
- Noise and gaseous emission
- Solid waste disposal
- Palm Oil Mill Effluent disposal

d. Decommissioning and Abandonment

- Laying off workers
- Lack of care of plantation
- Abandonment of equipment and vehicles

5.5 Screening Project – Environmental Interactions Criteria

The criteria used in categorizing the various impacts are shown in Table 5-1.

Table 5-1: Impact Type

Type	Positive/Beneficial or Negative/Adverse
Severity	Minor/very low/insignificant, moderate, high/major/very significant
Prevalence	Likely extent of the impact
Duration	Long term (>12 months), short term (<12 months or intermittent)
Importance	Economic, social and cultural values attached to the undisturbed project

Severity is classified as shown in Table 5-2.

Table 5-2: Criteria for Rating Magnitude, Duration and Severity of Environmental Impacts

Severity of Impact	Description/Quantification
1. Impact on Sensitive Habitats e.g. wetlands; forest reserve	
Very High, 5 points	Very severe long term adverse effects; more than 20% of the habitat area will be destroyed or damaged.
High, 4 points	Major long term adverse effects: 1 – 2% of the habitat area will be destroyed or damaged
Moderate, 3 points	Moderate adverse effects: 0.25 – 1% of the habitat area will be destroyed or damaged
Low, 2 points	Minor adverse effects: 0.02 – 0.025% of the habitat area will be destroyed or damaged
Very Low, 1 point	Negligible to minor adverse effects: 0.02% of the habitat area will be destroyed or damaged
2. Impacts on Water Quality (Rivers and Streams)	
Very High	Water quality parameters change significantly by several orders of magnitude: toxic trace metals or hydrocarbons exceed FMEnv's safe levels; changes persists for months or longer.
High	Water quality parameters change significantly by one or two orders of magnitude: toxic trace metals or hydrocarbons exceed FMEnv's safe levels; changes persist for months or longer.
Moderate	Statistically significant changes in water quality parameters which persists for several weeks.
Low	Some measures of water quality deviate significantly from ambient measures but are quickly (within 1-2 days) restored to normal.
Very Low	Normal measures of water quality such as dissolved oxygen content, salinity, temperature, trace metal concentrations and hydrocarbon levels show no statistically significant changes from ambient conditions.
3. Impacts on Air Quality and Noise	
Very High	Significant increase in levels of criteria pollutants. Significant effects on public health and welfare are expected.
High	Increase in levels of criteria pollutants likely to pose hazards to public health and welfare.
Moderate	Increase in levels of criteria pollutants moderate and unlikely to pose hazards to public health and welfare.
Low	Increase in levels of criteria pollutants unlikely to pose hazards to public health and welfare.
Very Low	Increase in levels of criteria pollutants does not pose hazards to public health and welfare.
4. Impacts on Cultural/Archaeological Resources	
Very high	An interaction between a cultural resource/archaeological site and an

	impact producing factor occurs and results in the loss of unique cultural/archaeological information.
Moderate	The interaction occurs and results in the loss of cultural/archaeological data that are not significant.
Low	The results are temporary and reversible.
Very Low	Little damaging interaction between an impact producing factor and cultural resource/archaeological site occurs.
5. Impacts on Local Employment, Income, and Population	
Very High	10% or greater annual growth in employment, payroll, population.
High	7-9% annual growth in employment, payroll, population.
Moderate	4-6% annual growth in employment, payroll, population.
Low	2-3% annual growth in employment, payroll, population.
Very Low	1% or less annual growth in employment, payroll, population.
6. Impacts on Community Infrastructure	
Very High	Potentially major long-term effects on community services and facilities indicated by a 10% or more increase in the infrastructure.
High	The effect is indicated by a 3-9.9% increase/decrease
Moderate	The effect is indicated by a 1.5-2.9% increase/decrease
Low	Minor effects on community services and facilities: indicated by a 0.5-1.4% increase/decrease
Very Low	Negligible to minor effects on community services and facilities: indicated by a less than 0.5% increase/decrease,
7. Impacts on Wildlife/Forestry	
Very High	A specie, population, community or assemblage of wildlife will be harmed, as a result of habitat area destroyed or disturbed, to the extent that recovery of that particular entity may not occur.
High	A significant interference with ecological relationships. This usually involves the mortality or alteration of a noticeable segment of the population, community or assemblage.
Moderate	A short-term interference with ecological relationships. Although some species may sustain substantial losses, other species will sustain low losses, and the ecological mix will not be altered.
Low	A few species may sustain low losses, but any interference with ecological relationships will not be evident.
Very Low	Loss of a few individuals but no interference with ecological relationships.

5.6 Leopold Matrix Screening

The modified Leopold impact matrix consists of a horizontal list of biophysical, social and health environmental components that could be affected by the proposed project activities versus a vertical list of project activities, which represent environmental aspects, or "sources of impact", associated with each project phase. Environmental aspects are elements of an activity that can or will interact with the biophysical, social and health conditions within the area of influence.

Entries in the matrix cells represent the nature and preliminary ranking of the severity of the impact. Ranking of the severity is based on the following scale and symbols:

- Major: 2
- Minor: 1
- Negligible or no effect: - (a dash)
- Positive: +

Table 5-3 gives the criteria for rating an impact and the scores awarded to each criterion/severity category and Table 5-4 gives the matrix obtained.

Table 5-3: Scores awarded to magnitude, duration and each severity category

EFFECTS	SCORES
A major long term effect (Very high)	points (in a square)
A major short term effect (High)	4 points
A moderate long term effect (Moderate)	3 points
A moderate short term effect (Low)	2 points
A minor effect in magnitude and duration (Very Low)	1 point (in a square)
No impact/interaction	0 point/Blank square
Positive impact	+ added in front of a number
Negative impact	- added in front of a number

For this preliminary impact assessment stage, the impacts are defined as follows:
A Major impact is one that would affect a large (higher than 40%) amount of a resource/receptor and or have a relatively large footprint and persist for a long time or is irreversible;

A Minor impact is one that could either affect a large (as defined above) or moderate (less than 40%) amount of an affected resource/receptor, has a mid to long term effect (1 to 10 years) but is most likely reversible.

A Negligible impact is one that may occur but based on experience, available scientific information and expert knowledge will have no measurable effect on the environmental component;

A Positive impact is one that adds a measurable benefit to the immediate and larger project environment including its social, cultural and health dimensions.

All number entries denote negative impacts. Cells with both positive sign (+) and numbers indicate that the specific activity and environmental interaction will potentially result in both positive and negative impact. All potential impacts, whether likely or unlikely are also considered at this stage. The likelihood of an impact is further assessed in the detailed impact evaluation. The identification of and screening of an impact relies on the following:

- Available knowledge of product activity
- Documented impacts of similar projects in similar environment
- Consultation with experts
- Professional judgment
- Result of earlier environmental studies carried out in the Lagos lagoon area.

Spatial boundaries of interaction were decided based on specialist knowledge and documented experience of the specific activity on environmental interaction.

5.7 Detailed Assessment of Impact

The preliminary identification and screening of environmental impact resulted in a group of focus impacts (impacts ranked 1 and 2) which were further assessed in terms of severity and significance. Impact severity and significance criteria used at this next stage relied on a number of resources and tools including the following:

- FMEnv Environmental Assessment guidelines;
- Overlaying project component on maps of existing conditions to identify potential impact areas and issues
- Environmental baseline studies
- Results of earlier studies carried out in the area; experience from similar projects in Nigeria and elsewhere.
- Published and unpublished documents (such as the World Bank environmental assessment source book; relevant IFC performance standards, and other authoritative texts on performing environmental impact assessment) providing guidance on performing impact analysis for industrial development activities;

5.8 Impact Severity and Significance Evaluation

The overall methodology for assessing impacts of activities associated with the proposed mill expansion involves establishing impact indicators, and evaluating the potential effects of project activities on each project specific impact indicator. Impacts may be positive (beneficial) or adverse (detrimental). Impact indicators are easily identifiable environmental or socio-economic components that would readily indicate changes in environmental or socio-economic conditions. For the purpose of this project, the impact indicators selected are shown in Table 5-4.

In order to facilitate the process of impact assessment, a tabular checklist was developed from information provided by the client, to highlight the major activities and the key concerns in the project location.

5.9 Impact Severity Evaluation Criteria

To objectively review those issues warranting consideration as potential impacts (previously identified as focus areas) and to determine the likely significance of those impacts when compared to baseline conditions, certain significance criteria were developed. This EIA uses the significance criteria to evaluate impacts, which enables systematic identification and focus on those resources and receptors most likely to be impacted by the proposed project. These significance criteria were applied to all potential impacts initially identified during the screening process to determine whether they would likely be Positive, Negligible, Minor, Moderate, or Major. Those issues determined to be inconsequential or not applicable based on the significance criteria were eliminated or "screened out" from further consideration. This impact severity assessment takes into account three main areas of significance criteria: temporal factors, areal extent, and magnitude of the impact. The components of each of these primary criteria are described below, i.e., temporal factors include duration, frequency, and reversibility. In addition to the three main significance criteria, supplementary factors were considered as part of the overall impacts severity assessment, sensitivity of the receptor, indirect or secondary influences, and Cumulative effects.

Eligible is used in some instances and a negligible rating should be considered in deriving the overall impact severity. The term is omitted from the impact assessment matrix table that follows this section, but the criteria are described in the preceding text. The following describes the severity rating criteria.

5.10 Magnitude

Magnitude is defined as the quantitative intensity of the impact, and can be measured as the percentage of a resource or a population within the area of influence that may be affected by an impact. The definitions of "high", "medium",

and "low" with respect to magnitude may vary depending upon the specific receptor. The magnitude of an impact is characterized as follows:

- High – large amount of the resources or population is affected; easily observable and measurable effect;
- Medium – moderate amount of the resource or population is affected; generally measurable and observable effect;
- Low – small amount of the resource or population is affected; low magnitude impact may be within the range of normal variation of background conditions:
- Negligible – amount of resource or population affected is unnoticeable or immeasurably small.

Magnitude may also be defined with respect to quantitative or semi – quantitative criteria, if available and applicable, (e.g., level of noise as decibels). The magnitude of an impact is characterized as follows:

- High –greater than the quantitative or semi – quantitative criteria
- Medium – at the quantitative or semi – quantitative criteria
- Low – less than the quantitative or semi – quantitative criteria
- Negligible – impact not detected or at background levels.

5.11 Duration

Duration is defined as the time that is estimated for a population or resource to return to pre – impact/baseline conditions. The duration is calculated from the time the impact begins, which may coincide with the start of the activity that caused the impact.

The duration of an impact is characterized as follows:

- High – long –term impact (recovery would not occur within ten years)
- Medium – moderate –term impact (recovery time between one year and ten years)
- Low – short –term impact (recovery time within less than one year)
- Negligible – impact or recovery time is very short or immediate characterization of the duration of an impact as low, medium, or high includes consideration of the degree of reversibility of the impact. Impacts for which the duration is classified as high, as defined above, are considered irreversible impacts

5.12 Frequency

Frequency is defined as the number of times an impact is expected to occur over the life of the project, the frequency of an impact is characterized as follows:

- High-impact will occur continuously throughout the life of the project (e.g, continuous transportation of FFB to the mill)
- Medium-impact will occur intermittently over the life of the project (e.g, operations and maintenance)
- Low-impact will occur rarely or a very limited number of times (e.g. construction impacts – civil work during mill construction

There is no "negligible" category for frequency because impacts with no frequency would not occur, and were screened out.

5.13 Extent

Areal Extent refers to the potential geographic range of an impact and quantified in units of area affected (e.g. hectares). The areal extent is classified as follows:
High-impact has influence well beyond the project environment to the regional or even global environment.

Medium-impact limited to the general vicinity of the project site/study area.

Low-impact limited to the immediate area of the activity of occurrence.

Negligible-impact limited to a very small part of the activity area.

5.14 Sensitivity

Sensitivity refers to economic, social, and/or environmental/ecological relevance of the receptor, including the intrinsic sensitivity of the resource, reliance on the receptor by people for sustenance, livelihood, cultural significance or economic activity, and to the importance of direct impacts to persons associated with the resource.

The sensitivity criterion also refers to potential impacts to Environmentally Sensitive Areas (ESAs) and impacts on species, with effects including loss of endangered species introduction of invasive species, and similar environmental/ecological impacts. The intrinsic sensitivities of a receptor species and actions that after then function of the receptor are also considered. Sensitivity is characterized as follows:

High – receptor is of high economic, social, and/or environmental relevance and or has an intrinsic sensitivity (including vulnerability and exposure) to the specific impact (e.g. water resources).

Medium- receptor is of moderate economic, social, and/or environmental relevance and is not particularly vulnerable and/or exposed to the impact.
Negligible –receptor is not of economic, social and/or environmental relevance or is not sensitive to impact.

5.15 Impact Significance

The following section describes the method by which the overall impact severity rating and associated impact significance is derived.

Impact Severity Rating
To reach an overall impact severity rating for each impact assessed, the five impact severity criteria above are aggregated using impact severity matrices. Aggregation is at three levels.

First, magnitude and areal extent are combined to arrive at a rating for the Impact Quantum while duration and frequency are aggregated to give the overall temporal effects.

Impact Quantum and Temporal Effects are then combined and their resulting aggregate assessed in terms of sensitivity to arrive at the overall impact severity.

Impact Likelihood
To further assess the significance of the severity associated with each potential negative impact identified in the previous section, a likelihood criterion is applied to each negative impact. The likelihood criteria are used to determine whether negative impacts can be prevented or mitigated or if they are unavoidable.

It should be noted that the likelihood criteria are applied to the likelihood of the impact occurring and not of the activity occurring. Thus the overall severity rating (significance) of a negative environmental impact is a function of its severity as earlier defined and the likelihood of occurrence as defined in the table.

Overall Impact Significance
The overall impact significance is indicated by the position on the impact significance matrix. Impacts with a high likelihood of occurrence and consequence have a high significance rating. These high-significance impacts become high priority for further evaluation or management action (e.g. design, change or mitigation). Impacts that are moderate are of medium priority; There are also activities with low impacts. Other impacts are positive or beneficial impacts. The criteria and severity matrix set forth in this section are applicable to all the types of events and impacts identified.

Table 5-4: Matrix for Identification of Significant Activity Impacts of Mill Expansion Project on the Environment at OOPC Main Estate

ENVIRONMENTAL COMPONENTS	Project Activity Phases												
	Pre-Construction		Construction				Operation and Maintenance				Decommission and Abandonment		
	Contracts Award	Mobilisation	Heavy Machinery Use	Generator Use	Civil, Electric and Mechanical works	Solid Waste Disposal	Trucks Carrying FFB	Generators and Machine: Noise and Gaseous Emission	Palm Oil Mill Effluent (POME) Disposal	Solis Waste Disposal	Laying off Staff	Mill Abandonment	Equipment and Chemicals Abandonment
Air Quality			-2	-2	-2			-3	-3				
Noise level		-2	-2	-2	-2			-3					
Vegetation								-2	-2				
Terrestrial Inverts.								-2	-2				
Wildlife								-2					
Groundwater					-2				-3				
Surface River					-2	-2			-4	-2			-1
Soil/Land Pollution		-1			-2	-2	-2		-4	-2			
Landuse/Landscape						-1			-3	-1			
Drainage													
Demography					-1								
Employment/Income	+3	+3			+3				+2				
Culture/Religion									-3				
Health/Accidents		-1	-2		-2		-2	-3	-3	-2			
Infrastructure													
Community Relations	+3										-3	-2	
Economic loss											-3	-2	
Corporate Image									-2	-2	-3	-2	-3

KEY: + Positive impact
- Negative impact

No impact = Blank Square
Minor effect, (very low) = 1 point in square
Moderate short term effect (Low) = 2 points
Moderate long term effect (Moderate) = 3 points
Major short term effect (High) = 4 points
Major long term effect (Very high) = 5 points

5.16 Description of Impacts

5.16.1 Significant Impacts

The mill expansion project by OOPC Plc offers a number of potential beneficial impacts to the people of the project site and area beyond. These effects shall be enhanced throughout the duration of the project. Improved and more secured palm oil mill would benefit a broad range of individuals and businesses throughout Nigeria. The project will substantially improve agricultural development by improving palm oil production that will continuously provide job opportunities for teeming youths in Nigeria.

In addition, the project will contribute to achieving some of the objectives of the Federal Ministries of Agriculture & Rural Development and Trade & Investment, which include securing the social and economic benefits of an efficient Agricultural and Investment sector; considerably increasing Palm oil production to meet its annual requirement in the country.

Moreover, the mill expansion will provide employment opportunities for qualified Nigerians (skilled, semi –skilled and unskilled) from the immediate project area and beyond. The employment opportunity will lead to acquisition of new skills and introduction of all manners of income generating spill over effects.

Other potential benefits of the project include:

- Increase the life span of the palm oil mill
- Provide direct employment
- Create additional jobs
- Contribute to the socio-economic development of the neighbouring communities

5.16.2 Significant Negative Impacts

In this section, only activity-receptor relationships resulting in impact significance above ‘low’ are presented and discussed to understand how additional mitigation measures beyond those incorporated in the project design could help bring down the residual impacts to ‘low’ in the least. In the analysis, the environmental receptors are considered singly or collectively along with the corresponding project activities.

5.16.2.1 Evaluation of Potential Impacts of Project Activities

5.16.2.1.1 Adverse Impact Loss of vegetation

There will be complete loss of vegetation in the main land area that is going to contain the discharged POME especially mature oil palm. Considering the large volume of POME that is going to be discharged especially during optimal capacity production level of the palm oil mill, large land area would be lost to POME treatment ponds.

5.16.2.1.2 Palm Oil Mill Effluent (POME) disposal

The discharge of the raw and untreated POME to the open land area although undesirable, has beneficial impact on the adjoining soils.

Soil nutrient enrichment: the recent study has revealed that the levels of both essential macro and micronutrient elements needed for plant growth and development were increased following the open discharge of the POME in the soil. Specifically, there were notable increases in the levels of exchangeable cations of potassium and magnesium, and corresponding elevation in the values of available phosphorus, organic carbon and total nitrogen content of the soils containing POME. Also, the amount of iron, zinc, manganese and copper increased in these soils. Proper and effective management of the soils could lead to increase in crop yield and productivity.

Hydrocarbon and Oil/Grease Contaminants: The increase in the amount of these contaminants in the soil could have adverse effect in the functionality and productivity capacity of the soils. Relatively high levels of THC and Oil/Grease in the soil receiving POME can reduce the microbial activity of the soil thereby making potentially available nutrients unavailable for plant uptake.

Heavy Metals Enrichment: Enrichment of the POME soil with heavy metals such as lead, cadmium, chromium, nickel and vanadium as determined in the present study would have adverse effects or impacts on soil quality. This is because, under favourable soil conditions of pH, texture and moisture regimes, these metals could be made available for plant uptake, especially when the soil is used for the cultivation of vegetables and shallow rooting crops.

5.16.2.1.3 Transportation of Fresh Fruit Bunches

During harvesting, fronds are pruned. This helps to give easy access to the ripe fruit bunches as well as keep the oil palm stem clean of hanging dead and decaying leaves. The fronds are left on the ground to add organic

matter to the soil. The pruning of fronds, harvesting and collection of fruit bunches are activities which provide employment for more workers.

5.16.2.1.4 Decommissioning and Abandonment

- Permanent and casual workers will be laid off resulting in loss of employment and income. This can itself give rise to strained relations between workers/community and the company.
- The palm oil mill will no longer be regularly and properly serviced and maintained. There will be great economic loss to company, shareholders and the nation. There will be no facility to process FFB harvested from the plantation thereby making the fruits to get rotten.
- Equipment and Materials Abandonment, Abandoned trucks and other mill machinery will blight the workshop and mill premises. This is also an economic loss to the Company and its shareholders.

5.16.3 Significant Impact Producing Activities

Based on a score of 3 points and above as shown in Table 5-4, the significant impact producing activities (IPA_S) are as follow:

- Palm Oil Mill Effluent (POME) may contaminate and/or pollute groundwater thereby causing health problem to the public.
- Transportation of Fresh Fruit Bunches (FFB) from other plantations to the Palm Oil Mill for processing
- Laying off workers/Severance Payment
- Palm Oil Mill Abandonment
- Decommissioning and abandonment have three main activities, which will produce adverse impacts as listed in section *5.16.2.1.4*.

5.16.4 Cumulative Impacts

Cumulative impacts are changes to the environment that are caused by an activity in combination with other past, present and future human activities (GSI, 2003). The concept of cumulative effects is an important one. It holds that, while impacts may be small individually, the overall impact of all environmental changes affecting the receptors taken together can be significant. When a resource is nearing its tolerance threshold, a small change can push it over. The objective of the cumulative impact assessment is to identify those environmental and/or socio-economic aspects that may not on their own constitute a significant impact but when combined with impacts from past, present or reasonably foreseeable future activities associated with this and/or other projects, result in a larger and more significant impact[s].

5.16.4.1 Project Specific Cumulative Effects' Assessment

This section evaluates the cumulative effects of the individual impacts evaluated in the preceding sections.

5.16.4.1.1 Land Based Traffic

It is envisioned that land based traffic will also increase as a result of the mill expansion project. Land based traffic is expected to increase mainly during the operation phase to allow the FFB collected in the field to be processed at the mill. Activities at the project site during construction will however be varied and limited to the construction phase. The mill expansion project will result in a negligible impact on traffic, circulation and parking at the project site and its vicinity. It would be unlikely that the rate of motor vehicle accidents would increase due to the project. No additional cumulative transportation impacts would result from the proposed action. Therefore, it is anticipated that no long-term environmental impact will be forthwith in considering the land-based traffic.

5.16.4.1.2 Public Services

There would be no impact to public services under the mill expansion project. The project will not introduce any additional long-term population or employment into the area, and thus, would not result in any additional demand for police or fire services or the need for new or altered facilities. No damage to roadways is expected beyond that which would be considered normal wear and tear. Therefore, the proposed project would result in negligible impact on public utilities.

5.16.4.1.3 Employment Opportunities

There will be some beneficial impacts that are cumulative that are in the employment sector. During the operational phase of the project, the company will employ workers – all Nigerian. Positive cumulative social benefits include gainful employment and tax being paid to government coffers.

5.16.4.1.4 Abandonment/Laying off staff

There will be serious negative impacts that are cumulative that are also in the employment sector. During the abandonment/decommissioning phase of the project, the company will lay off workers. Negative cumulative social impacts include loss of employment and thereby adding to the unemployment status of the region in particular and the nation in general.

5.17 Health Impact Assessment (HIA) of the mill expansion project

The health impact assessment of the mill expansion project is a rapid appraisal of the likely health impacts the project might have on the totality of the environment. The assessment will consist simply of a summary table and a conclusion. The summary table shall list the intermediate factors and their likely impacts with minimal qualification.

5.17.1 Identifying Intermediate Factors that Impact on Health

Many proposals that are not intended to affect health directly have indirect effects on health and well-being, often these indirect effects have not been recognized. Proposals may affect things such as employment, income, air quality or housing which in turn affect health. These factors which are not health indicators but do influence health are referred to as intermediate factors. (They may also be called determinants of health).

Some of the identified intermediate factors of the proposed project are:

- Air Quality
- Water Quality and Hydrology
- Noise and Vibration
- Health and Safety
- Traffic and transport
- Waste Management
- Workers' Welfare
- Social cohesion
- Corporate Image

Table 5-5: Summary of Health Impacts of the proposed mill expansion project at OOPC Plc.			
Intermediate Factor	**Affected Group**	**Health Impact**	**Action to be Taken**
Air quality Dust and gaseous emissions from land preparation and palm oil mill and vehicular emission leading to high suspended particulates in the atmosphere.	All	- Allergy - Eye irritation Nose irritation - Respiratory Tract Infections	**OOPC** shall ensure the following: - Low-emission/high efficiency engines shall be used. - Regular maintenance of vehicles to ensure optimal performance. - Movement of men and materials shall be properly coordinated to optimize vehicle use and resultant emissions. - Dust and particulate barriers shall be used during operation. - Avoid burning in the oil mill (i.e. zero burning).
Noise and vibration Noise emissions generated by heavy duty vehicles and palm oil mill	All	- Hearing impairment, hypertension, annoyance, sleep disturbance of site workers. - Hand-Arm Vibration Syndrome (HAVS)	**OOPC** shall ensure the following: - Noise attenuation measures such as installation of acoustic mufflers on large engines and equipment; - Hearing protection shall be provided and usage enforced for workers on site.
Water Quality and Hydrology Increased receiving water body turbidity from runoff. Improper storage and handling of, hydrocarbons, fuel and other chemicals	All	- Illnesses including Typhoid, Cholera, Dysentery, Polio, Hepatitis	**OOPC** shall ensure the following: - Stack demolition materials properly to reduce turbidity effect on surface runoffs; **OOPC** shall ensure the following: - Put in place adequate contingency measures to curtail accidental spills and ensure spill containment equipment shall be available at the construction site

would inevitably result in spillage during construction activities.			- In order to reduce ground contamination, an impervious sump or container shall be placed under the spigots of fuel drums to collect drippings. - Re-fuelling and maintenance of heavy construction vehicles at the site, shall be done at specified areas or makeshift "depots" where measures are in place to deal with spillages and temporary storage of oily waste. Preferably these depots shall be located in an area that would ultimately be permanently paved (e.g. parking lots) thereby covering any contaminated soil. - A thick layer of sawdust or absorbent would be used to absorb any spillages. Subsequently, this layer shall be removed for proper disposal. In the event of a large spill, the latter will be cleaned up immediately by excavating the contaminated soil and removing it in a secure vehicle to an approved disposal site.
Solid Waste - Solid waste constituting aesthetic nuisance - Sewage nuisance	All	- Improper solid waste handling can lead to the following: - - Creating conditions favourable to the survival and growth of microbial pathogens - - Causing infectious and	**OOPC** shall ensure the following: - Waste is contained and removed regularly through its own waste management system already in place.

		chronic diseases especially the waste workers.	
Hostility Industrial disputes	Workers and communities	- Youth restiveness - Persistence conflicts between community and company - Hostages	**OOPC** shall ensure the following: - Grievance and conflict resolution mechanism is instituted. - Employ as much local labour as possible. - Adequate stakeholders forum and information shall be given to stakeholders. - Adequate compensation shall be paid to permanent workers in case of any eventualities.
Health and Safety - Accidents, Vehicular, slips, falls, trips etc - Hearing impairment due to exposure to noise of heavy machineries - Improper storage and handling of hazardous materials (e.g, lubricants, fuels, etc), are potential health hazards workers Carcinogenic/Toxic/Chemical hazards: corrosive substances - Poor chemical handling - Asphyxiating atmosphere - Road Traffic Accident	All	Health hazards that can arise from poor health and safety include: - Occupational health problems such as terminal diseases and/or prolonged ill health - Permanent Loss Injury - Temporary Loss Injury -	**OOPC** shall ensure the following: - Wearing of ear protection. - Safe storage areas shall be identified and retaining structures constructed prior to the arrival of material. - Hazardous materials (e.g. fuels) shall be properly stored in appropriate containers and shall be safely locked away. - Conspicuous warning signs (e.g. 'No Smoking') shall be posted around hazardous waste storage and handling facilities. **OOPC** shall ensure the following: - Guideline on safe handling of chemicals (SHOC) and appropriate PPE are provided. - Guideline on traffic control to ensure best traffic safety practices on the road.

- Wrong use of PPE - Inadequate PPE - Inadequate equipment/surface guard on equipment - Low awareness			**OOPC** shall ensure: - Awareness training - Sufficient PPE are provided **OOPC** shall ensure: - Equipment specifications are made available. - Provision of adequate training to workers. - Provision of warning signs to workers and commuters.
Waste Management - Wastes constitute aesthetic and pollution issues for the project area - Accumulated waste could lead to contamination of soil/groundwater and breeding grounds for vectors and rodents	All	Health hazards associated with poor waste management include: - Skin and blood infections resulting from direct contact with waste. - Different diseases such as intestinal infections that result from poor waste management. Reduction in aquatic food supply - Disruption of food chain	**OOPC** shall ensure the following: - A site waste management plan although already in place shall be prepared prior to project commencement. This shall include designation of appropriate waste storage areas, collection and removal schedule, identification of approved disposal sites, and system for supervision and monitoring. - Preparation and implementation of the plan shall be the responsibility of **OOPC** with the system being monitored independently. - Waste shall be properly contained to avoid contamination of groundwater.
Sewage - Faecal aesthetic issues for the project area. - Spillage of septic liquor	Workers	- Cholera - Dysentery - Infectious and chronic diseases	**OOPC** shall ensure the following: - Onsite toilets shall be made available for use.
	All		**OOPC** shall ensure the following:

Socio-economics - Promiscuity - Sexual harassment - Youth Militancy - Unemployment - grievances		- Sexually transmitted diseases (STDs) - HIV/AIDS - Population explosion	- Public enlightenment about potential health risks (STDs). - Facilitate education/enlightenment about the project and its nature. - Appropriate policies.
Workers' Welfare Especially when workers leave the organization and/or layoff.	Workers	- Depression - Hypertension - Workers' restiveness	**OOPC** shall ensure that: - Workers receive their full benefits when leaving the organization.
Corporate Image The negative corporate image arising from day-to-day activities of the organization,	Company/All	- Annoyance - Depression	**OOPC** shall always ensure that its day-to-day activities and operations do not portend bad image about the organization to the general public and therefore operate according to the best industry standards and practice.

***Note: "All" in the Affected Group column means, "Totality of the Environment" including flora and fauna and humans.**

Table 5-6: Checklist for Health Impact Assessment of the Project

	Effect on Health		
	Good	**None**	**Bad**
Employment	✓		
Income	✓		
Workplace	✓		
Housing	✓		
Transport	✓		
Built Environment		✓	
Air Pollutants			✓
Water pollutants			✓
Noise			✓
Amenity		✓	
Lifestyle	✓		
Social Cohesion		✓	
Parenting		✓	
Education	✓		
Use of health services	✓		
Other cause of public concern		✓	

5.18 Conclusion

The main negative impacts are health and safety. However, mitigation measures will be put in place for health and safety through the provision of adequate and appropriate PPE.

As a result of the above provisions and measures, the net health impact of the proposed project is positive.

CHAPTER SIX

6.0 MITIGATION MEASURES

6.1 Introduction

The rationale for impact quantification and significance has earlier been discussed in the previous chapter. The results have indicated, that various components would be impacted positively or negatively. In order to preserve the present integrity of the environment, certain steps have been recommended to mitigate or control the major negative impacts identified in this study. The control/mitigation measures have been based on the baseline conditions with regards to the biophysical environment, socio-economic and health status of the supposed host communities. Also considered were the project activities and their envisaged impacts and concerns of stakeholders during consultation meetings and socio-economic/health status of the host communities. However, mitigation measures are defined for the identified significant present impacts and associated and/or potential impacts based on the following criteria:

- **Prevention –** design and management measures for ensuring that significant potential impacts and risks do not occur.
- **Reduction –** operational and management measures for ensuring that the effects or consequences of those significant associated and potential impacts that cannot be prevented are reduced to a level as low as reasonably practical (ALARP).
- **Control -** Operational and management measures for ensuring that residual associated impacts are reduced to a level as low as reasonably practical (ALARP).
- **Corrective/Precaution –** Operational and management measures for correcting the identified impacts emanating from previous operations and also taking appropriate precautions to preventing reoccurrence

Most of the significant environmental impacts that can likely arise from the construction and operation of the mill expansion project can be mitigated once appropriate precautions are in place.

The following tables define the identified and potential environmental and social impacts, their sources and the recommended mitigation measures.

Table 6-1: Summary of Impact and Mitigation Measures (Construction Phase)

Activity phase	Environmental Aspects	Type of Impact	Mitigation measures	Impact Rating
Construction phase	**Air quality**	Dust and gaseous emissions from mill construction and vehicular emission leading to high suspended particulates in the atmosphere.	**OOPC** shall ensure the following: - Low-emission/high efficiency engines shall be used. - Regular maintenance of vehicles to ensure optimal performance - Movement of men and materials shall be properly coordinated to optimize vehicle use and resultant emissions. - Dust and particulate barriers shall be used during operation. - Avoid burning in the oil mill (i.e. zero burning).	Low
	Noise and vibration	Noise emissions generated by heavy duty vehicles and workers activities and resultant hearing impairment on site workers.	**OOPC** shall ensure the following: - Noise attenuation measures such as installation of acoustic mufflers on large engines and equipment; - Hearing protection shall be provided and usage enforced for workers on site.	Low
	Water Quality and Hydrology	Increased receiving water body turbidity from runoff from the mill.	**OOPC** shall ensure the following: - Stack demolition materials properly to reduce turbidity effect on surface runoffs;	Low

Table 6-1: Summary of Impact and Mitigation Measures (Construction Phase) Cont'd

Activity phase	Environmental Aspects	Type of Impact	Mitigation measures	Impact Rating
Construction phase	**Solid Waste**	- Solid waste constituting aesthetic nuisance - Sewage nuisance	**OOPC** shall ensure the following: - Waste is contained and removed regularly through its own waste management system already in place.	Low
	Hostility	Conflicts between the communities and the company. Payment of severance to permanent workers	**OOPC** shall ensure the following: - Conflict resolution mechanism is instituted. - Employ as much local labour as possible. - Adequate stakeholders' forum and information shall be given to stakeholders. - Adequate compensation shall be paid to permanent workers in case of any eventualities.	High

Table 6-2: Summary of Impact and Mitigation Measures (Operation Phase)

Activity phase	Environmental Aspects	Type of Impact	Mitigation measures	Impact Rating
Operation Phase	**Air quality**	- Stack emission - Fugitive emissions from tanks used to store petroleum and other hydrocarbon products. - Combustion emissions from exhausts of machines e.g. pumps power generating sets	**OOPC** shall ensure the following: - All flanges and vents shall be properly tightened to reduce fugitive emissions. - All systems shall be properly checked to ensure there are no leakages or losses. - All machinery and vehicles for the project shall have high efficiency burner to reduce emission of noxious gases. - Avoid all forms of burning (zero burning).	Low
	Solid waste and sewage and POME	- Waste runoff flowing into the surface waters. - Solid waste constituting aesthetic nuisance. - Sewage nuisance. - GHG emission - Weeds and long grass - Blue-green algae - Algae blooms	**OOPC** shall ensure the following: - Waste is contained and removed regularly through its own waste management system already in place. - Efficient POME treatment system. - Lagoon banks would be mowed and weeded regularly. - Unlike green algae, this algae is stringy and can clump, block sunlight, and cause short-circuiting. It can dominate lagoons when conditions are poor, when pH is low, or when protozoa eat all of the green algae. Blue-green algae can be physically removed like duckweed. - After periods of cloudy weather or abrupt temperature changes, algae can multiply quickly and then die-off. Matted algae on the surface can block sunlight and cause foul odors. These shall be broken up (with a boat or rake) and dispersed.	Low

		- Odors - Erosion - Sludge accumulation	- There would be proper operation and maintenance- to help prevent odors. - There would be regular control of burrowing animals around the lagoon by appropriately constructing bund walls around. This shall help prevent erosion of banks and dikes. Installing a stone or rock surface (called riprap) along banks and dikes can help in some cases. - Sludge in the bottom of lagoons shall be measured at least once per year and removed as needed.	

Table 6-2: Summary of Impact and Mitigation Measures (Operation Phase) Cont'd

Activity phase	Environmental Aspects	Type of Impact	Mitigation measures	Impact Rating
Operation Phase	**Health and Safety**	- Carcinogenic/Toxic - Chemical hazards: corrosive substances - Poor chemical handling - Asphyxiating atmosphere - Road Traffic Accident - Lagoons can attract children, pets and unsuspecting adults, who may think they look like good places to play and even swim	**OOPC** shall ensure the following: - Guideline on safe handling of chemicals (SHOC) and appropriate PPE are provided. - Guideline on traffic control to ensure best traffic safety practices on the road. - Lagoon to be surrounded by bund walls and have warning signs clearly posted. - All OOPC occupational safety practices and standards by anyone working near a body of water would be observed.	High
		- Wrong use of PPE - Inadequate PPE	**OOPC** shall ensure: - Awareness training - Sufficient PPE are provided	High
		- Inadequate equipment/surface guard on equipment - Low awareness	**OOPC** shall ensure: - Equipment specifications are made available. - Provision of adequate training to workers. - Provision of warning signs to workers and commuters.	High

Table 6-2: Summary of Impact and Mitigation Measures (Operation Phase) Cont'd

Activity phase	Environmental Aspects	Type of Impact	Mitigation measures	Impact Rating
Operation Phase	***Oil/Fuel Spills*** Oil spills can occur within and outside the powerhouse, and the fuel and lubricant storage area.	- Oil/fuel can enter the drainage system and contaminate the land and water. - Effluent pipe leakages	- The fuel storage tanks will be surrounded by a bund wall to contain up to 1.5 times the total storage capacity in case of a spill. - All wash down from inside the powerhouse will be directed to a sump equipped with an oil/water separator to trap and filter oil from wastewater before it is discharged to the drains. - Arrangements for the proper disposal of the waste oil collected in the oil/water separator will be made. - An emergency response plan will be developed with detailed procedures for preventing and handling spills. - There are two independent lines, which would be switched in case of leakage. - OOPC shall carry out daily inspection on these pipe lines.	Low
	Water Quality and Hydrology	Increased receiving water body turbidity from runoff from the plantation.	**OOPC** shall ensure the following: - Stack demolition materials properly to reduce turbidity effect on surface runoffs; - Adequate contingency measures shall be put in place to contain accidental spills, ensure spill containment equipment shall be available on site. - Quarterly monitoring of Surface River to ensure that eutrophication in case of wastewater discharge does not arise. - Quarterly inspections, testing, record keeping and maintenance as required by Local, State and Federal agencies, and are all necessary to ensure that lagoons continue to provide good treatment. - Test required for lagoons include those that measure the wastewaters temperature, pH, and amount of dissolved oxygen, solids, nitrogen, and disease causing organisms in the effluent. Regulatory agencies	Low

			use water quality measures as indicators of treatment system performance. Among the most important indicators are biochemical oxygen demand (BOD) and total suspended solids (TSS). - Samples would be sent out to a laboratory to be tested for above mentioned parameters.	

Table 6-2: Summary of Impact and Mitigation Measures (Operation Phase) Cont'd

Activity phase	Environmental Aspects	Type of Impact	Mitigation measures	Impact Rating
Operation Phase	**Workers' Welfare**	Especially when worker leaves the organization and/or layoff.	**OOPC** shall ensure that: - Workers receive their full benefits when leaving the organization.	High
	Socio-economics	- Sexual laxity disruption - Youth - Militancy/unemployment/grievances	**OOPC** shall ensure the following: - Public enlightenment about potential health risks (STDs). - Facilitate education/enlightenment about the project and its nature.	High
	Corporate Image	The negative corporate image arising from day-to-day activities of the organization.,	**OOPC** shall always - ensure that its day-to-day activities and operations do not portend bad image about the organization to the general public and therefore operate according to the best industry standards and practice.	High

In addition to the mitigation measures for environmental impacts and social issues above, the following management and mitigation measures are also proposed for adoption and implementation to address the significant potential social and environmental impacts in order to make the mill expansion operations environmentally and socially acceptable and beneficial:

- Develop and implement community engagement plan
- Prevention of pollution of water resources.
- Fire prevention programmes and zero or controlled burning.
- Corporate social services to communities.
- Provision of healthcare services and HIV prevention.
- Diligent implementation of social impact management plan

6.2 Cost Implications Associated with Mitigation Measures

6.2.1 Construction

The mitigation measures for mill expansion (construction phase) would be included as line items in the Bills of Quantities in the tender document so that the bidders are sure to cost these items and can be held accountable for them during construction. It is not possible to estimate these costs as they will vary depending on the contractor, the number of workers to be used.

6.2.2 Operation (FFB Processing)

The activities and equipment that will have costs associated with them are listed below in Table 6-3.

Table 6-3: Cost Implications associated with Mitigation Measures

Mitigation Measures	Cost Implications
Pollution abatement equipment.	This cost will be included in the cost of the project.
Construction of processing line, boiler and ponding system	Cost will be included as a line item in the Bills of Quantities for the project build-up.
All the necessary mill operation equipment	Not possible to estimate these costs.
Personal Protective Equipment (PPE) for the persons handling hazardous materials.	This cost will be part of the running cost of the mill expansion and cannot be determined at this point. All contracts relating to supply, handling and management of hazardous materials must have provisions for this, i.e. personnel being kitted with PPE.
Correction of all inherited impacts from previous activities and operation.	Costs will be decided and implemented by the management.

CHAPTER SEVEN

7.0 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLANS (ESMP)

Environmental monitoring will be required to monitor the effectiveness of the mitigation measures and to report to the regulatory agencies. Through sound environmental management, many avoidable adverse impacts from the construction and operation of the mill expansion project can be prevented.

7.1 Environmental Management and Monitoring – Construction

- All mitigation measures outlined in Tables 6-1 to 6-2 will be adhered to by the technical and production department of the company and contractors where applicable.
- The mill manager and project coordinator will be responsible for ensuring that the mitigation measures are implemented.

7.2 Environmental Management and Monitoring – Operation

The following environmental management and monitoring measures will be implemented during operation of the mill expansion project:

- All mitigation measures outlined in Table 6-1 to 6-2 will be adhered to by the Environment, Health and Safety department of the company.
- Emissions testing and reporting must be done in accordance with the regulatory requirements and record submitted to FMEnv.
- Fire prevention precautions must be in place as required by the State Fire Service.
- All fire fighting equipment will be inspected and maintained regularly.
- Regular inspections will be conducted to verify the integrity of the fuel tanks. Written procedures governing the operation of the fuel tanks and precautions to be taken will be developed.
- An organizational structure shall be developed to implement the EMP, and personnel including the HSE manager, lab technologist, production and maintenance engineer and the company's environmental consultants will be involved in the implementation of the EMP.
- The occupational health, safety and environmental policies shall be implemented.
- Capacity building programme for oil mill and mill workshop staff including awareness, in-plant training, seminars, workshops and short courses shall be undertaken regularly to enhance the implementation of the EMP.

7.3 Environmental Monitoring Programme

An environmental monitoring programme is required to set out the means to determine whether or not the project operates in line with the environmental quality standards established by the FMEnv. For the mill expansion project, the monitoring programme would cover a number of parameters including meteorology, ambient air quality, surface water quality, groundwater quality, health indices and noise levels. The monitoring programme is scheduled in Table 7-1.

Table 7-1: Schedule of Environmental Monitoring at OOPC Estate

Parameter	Variables	Period
Meteorology	Rainfall, temperatures, Wind Speed, Sunshine Hours	Daily
Groundwater quality	pH, BOD, COD, microbiology	Quarterly
Effluent/Wastewater Qualit	pH, BOD, COD, TSS, Oil and Grease, microbiology	Quarterly
Surface water	pH, TSS, TDS, Heavy metals, THC, microbiology	Quarterly
Vegetation (Biodiversity Plot)	Monitoring of Wildlife (Biodiversity)	3-5 Years
Ambient Air Quality	CO_2, CO, NO_x, SO_x, VOC, Particulates	Quarterly
Noise Levels	Noise generating Facilities	Monthly
Health	Occupational diseases and/or Medical statistics	6 Months

Table 7-2: Environmental Management Plan for the Proposed Mill Expansion Project at OOPC

Activity Phase	Potential Impact	Action that shall be taken	Responsibility for Mitigating Action	Monitoring of Mitigation/Impacts	
				Activity to be Monitored	Timing & Frequency
Construction and Operation Phase	Accidents from heavy machinery movement and assemblage	a) Operators must wear PPE b) Traffic control into/out of site.	Project Coordinator/Engineer	Influx of machine and material movement into the site	Daily; Duration of construction works and operation activities.
	Water/Land Pollution from POME.	Quarterly analysis of palm oil mill effluent.	HSE department	Wastewater/effluent discharge parameters	Quarterly analysis during operations
	Particulate emissions to the atmosphere from all point mill operation sources	Particulates emission from generators and chimneys shall be monitored quarterly	HSE department	Particulates in smoke	During operation quarterly
	Water quality and other aquatic impacts	Quarterly analysis of groundwater and surface river.	HSE department	Drinking water parameters	Quarterly analysis during operations
	Noise and Vibration	Site noise shall be minimized by implementing good working practices, installing acoustic mufflers in large machines. Equipment shall be maintained in good order	Project Coordinator/ Engineer/ HSE department	Excess of 90dBA levels at all work places and the powerhouse	Quarterly measurement and when desirable
	Occupational Health effects on workers	OOPC shall develop & implement its Occupational Health and Safety Policy to address hazards to workers	Managing Director/ HSE Committee/ HSE department	Non compliance and poor housekeeping practices	Daily
	Fire Hazards inside the palm oil mill	- Installation of smoke detector and fire alarms. - Constitution of fire surveillance and control team.	Oil Manager /HSE department	Fire alarm and routine Fire drills	Quarterly/monthly

Table 7-2: Environmental Management Plan for the Proposed Mill Expansion Project at OOPC Cont'd

Activity Phase	Potential Impact	Action that shall be taken	Responsibility for Mitigating Action	Monitoring of Mitigation/Impacts	
				Activity to be Monitored	Timing & Frequency
Decommissioning Phase	***Air Pollutants*** Generation of dust during mill components destruction and also residues retained on the inner surface of the machinery may pose a health risk to the persons dismantling the components and its ancillary facilities. This risk could spread to the residences if particulates and PM_{10} in the residues are allowed to become airborne through a failure to contain the contaminated parts. Pollutants of particular concern in the residues include PCBs, dioxins and heavy metals.	Decontamination will be done according to procedure that will be approved beforehand by FMEnv	Maintenance Engineer/Site Engineer	**C**ontamination and pollution of the soil	During decommissioning exercise
	Noise The dismantling and demolition of the mill components will generate minimal noise.	Decontamination will be done according to procedure that will be approved beforehand by FMEnv	Maintenance Engineer/Site Engineer	**C**ontamination and pollution of the soil	During decommissioning exercise
	Wastewater Though quantities of wastewater may be small, this needs to be appropriately contained to prevent release into any nearby waterways or leaching into soil.	Decontamination will be done according to procedure that will be approved beforehand by FMEnv	Maintenance Engineer/Site Engineer	**C**ontamination and pollution of the soil	During decommissioning exercise

Activity Phase	Potential Impact	Action that shall be taken	Responsibility for Mitigating Action	Monitoring of Mitigation/Impacts	
				Activity to be Monitored	Timing & Frequency
Decommissioning Phase	***Solid Waste*** Large quantities of steel, metal, wooden and concrete waste will be accumulated after demolition and dismantling of the machinery may be contaminated with residues of PCBs, dioxins and heavy metals.	Decontamination will be done according to procedure that will be approved beforehand by FMEnv	Maintenance Engineer/Site Engineer	**C**ontamination and pollution of the soil	During decommissioning exercise
	Air Pollutants Generation of dust during mill components destruction and also residues retained on the inner surface of the machinery may pose a health risk to the persons dismantling the components and its ancillary facilities. This risk could spread to the residences if particulates and PM_{10} in the residues are allowed to become airborne through a failure to contain the contaminated parts. Pollutants of particular concern in the residues include PCBs, dioxins and heavy metals.	Decontamination will be done according to procedure that will be approved beforehand by FMEnv	Maintenance Engineer/Site Engineer	**C**ontamination and pollution of the soil	During decommissioning exercise

7.4 Emergency Response Plan

An emergency is any unplanned occurrence caused by either natural or man-made events which can lead to deaths, significant injuries, cessation of operations, physical or environmental damage and economic losses. Numerous events can lead to emergencies. These include:

- Fires
- Floods
- Communications failure
- Chemical spills
- Oil Spills
- Structural failure
- Civil disturbance

Emergency management is therefore critical to planning, mitigating, responding and recovering from the potential impacts of these events. The emergency management process however is very site specific and varies according to type of operations, geographic location, proximity to neighbouring communities and the history of such occurrences. Therefore, one of the first stages in developing an Emergency Response Plan (ERP) would be the identification of the potential hazards or threats to the facility, organisation or operation based on the above mentioned factors.

The Emergency Response Plan must be documented and cover all the areas mentioned above. In addition;

- The plan must identify the person(s) responsible for Emergencies and Safety. This person will keep the documentation updated (at least annually) and ensure that it is disseminated to all relevant persons.
- The plan must speak to the preparatory actions that must be taken in case of emergencies with forewarning such as hurricanes and responsibilities must be assigned.
- The plan should include actions that must be taken when a spill, riot or fire occurs. A safe area (muster) must be designated for persons to congregate during an emergency.
- A system must be in place to account for all staff members in an emergency with the appropriate responsibilities assigned.
- Drills must be conducted on a specified frequency (for example 3 times in the year for fire).
- The plan must include for fire fighting equipment to be checked on a specified frequency by a competent entity.
- The plan must address clean up measures after the emergency.

The Emergency Response Plan must be developed in consultation with FMEnv to ensure that it meets their requirements. The Emergency Response Plan for the mill expansion will form a part of the overall Emergency Response Plan for the company.

7.5 Decommissioning

7.5.1 Decommissioning of a Palm Oil Mill

The approaches to the decommissioning of a palm oil mill would involve the combination of the following activities/options:

7.5.1.1 Asset Recovery

This would be achieved through a reputable decommissioning services company. The company would offer to purchase the complete asset units or sale of the entire palm oil mill. Assets recovery would be done such as to achieve maximum return for the assets within the specified time.

7.5.1.2 Dismantling

This is applicable to either the removal of installations or the 'un-building' of structures. Dismantling is generally achieved by a careful reversal of the construction process. Dismantling will be done to optimize asset recovery.

7.5.1.3 Demolition

Demolition usually applies to structures and plant which have reached the end of their working life, and must be carried out with a high degree of knowledge and expertise. The demolition techniques used include conventional, remote mechanical and the use of controlled explosive charges..

7.5.1.4 Decontamination

Contamination and pollution of the soil and buildings can often be a major problem for those decommissioning industrial premises. The contamination may be in various forms i.e. solid, liquid, vapour, gas or powder. This contamination can be present in the air or on surfaces such as plant items or building fabric. Decontamination will be done according to procedure that will be approved beforehand by FMEnv.

7.5.1.5 Remediation

Ground remediation, rehabilitation and regeneration package will form an integral part of the services to be performed by the company to be appointed for decommissioning.

7.6 Decommissioning Procedure

A decommissioning service company will be contracted to undertake the decommissioning. The company will prepare and submit a manual articulating the procedure and methodology of decommissioning, including approach, type of waste and disposal method. The procedure will be such as to minimize the adverse impacts associated with decommissioning and will be approved by FMEnv before commencement of decommissioning.

CHAPTER EIGHT

8.0 Conclusion

The project is an attestation to the sustainable growth of palm oil processing which will result in substantial economic benefits for Nigeria through employment opportunities generation in particular during the construction and operation phases.

This EIA also indicates that discharges including wastewater discharge, gaseous emissions and noise are expected from the operation of the palm oil mill. However, any such discharges, which can be considered as potential sources of adverse environmental effects, can be fully managed through preventive actions and mitigating measures. This means that no significant negative impact on the natural, health and social environmental sensitivities of the project area is expected to result from discharges, let alone the occurrence of a residual impact.

The assessment has gathered and analysed the present situation which shall form the basis for baseline data. The data seem adequate and have assisted to determine the present and socio-economic status of the project environment and the kinds of effects and responses that may result from the interaction of the mill operation. However, the mill expansion is not expected to have significant adverse effects on the natural, cultural, environmental and socioeconomic life in the project area.

The assessment further demonstrates that the mill expansion project will fully comply with legislative requirements in Nigeria and other relevant international regulations applicable to the planned operations much as in the case of the existing one in the same location.

The existing environmental management programme of OOPC Plc has put in place good solid waste management system, which will fully complement the waste management requirement of the proposed project.

An EMP involving environmental management and supervision organizations, and environmental monitoring has been established to ensure the environmental performance of the Project. To ensure successful implementation of these measures, the EMP covers major relevant aspects such as institutional arrangement for environmental management and supervision and environmental monitoring. With implementation of the mitigation measures defined in the EIA and EMP, all the likely adverse environmental impacts associated with the mill expansion will be prevented, eliminated, or minimized to environmentally and socially acceptable levels.

It is clear that the project is sustainable if all the identified and potential environmental and social impacts are adequately mitigated.

References

Adejuwon, J.O. 1971. The ecological status of fresh water swamp savannas in the forest zone of Nigeria. *Journal of the West African Science Association.* 16(2), pg 133-154

Agboola, S.A. 1979. *An Agricultural atlas of Nigeria*. Oxford University Press, Oxford. 248pp

Ahmed et al 2003

Ahn, M.P. 1970. *West African Soils*. Vol 1 Oxford University Press, London. 332pp

Allen J.R. 1965. *Late quaternary Niger Delta and adjacent areas: sedimentary environments and lithofaceies*. A.A.P.G. Bull. 49, 541-600.

Allison P.A. 1973. A historical sketch of the forests of Benin. *Bulletin of the Nigerian Forestry Departments* vol. 33 No. 1 1-30

Alloway, B.J. (ed) 1990. *Heavy metals in soils*. Blackie, Glasgow and London. 330pp.
APHA, 1985. *Standard methods for the examination of water and wastewaters 16th ed*. American Public Health Association, Washington D.C. 1268pp.

Bek Nelsen et al, 1999

Boorman, J. 1991. *West African insects*. Longman, Essex,. 98pp.

Borror, D.J. and White, R.E. 1970. *A field guide to insects of America North of Mexico*. Houghton Mullflim Company, Boston, 403pp.

Brown et al 1976

Canter, 1996

Davis, C.C. 1958. *The marine and freshwater plankton*. Michigan State University Press, Michigan. 562pp.

Federal Environmental Protection Agency (FEPA) 1991. *Guidelines and standards for Environmental Pollution Control in Nigeria*. Federal Republic of Nigeria.

Federal Environmental Protection Agency (FEPA) 1991. *National Effluent Limitations Regulations* S.I.8. Federal Republic of Nigeria.

Federal Environmental Protection Agency (FEPA) 1991. *Waste Management and hazardous waste regulations* S.I.15. Federal Republic of Nigeria.

Federal Government of Nigeria (FGN), 1985. *The endangered species Decree II* (Control of International Trade and Traffic), Federal Government of Nigeria.

Federal Military Government 1992. *Environmental Impact Assessment Decree No. 86* Federal Military Government of Nigeria.

FMEHUD, 1995

Glendhill, D. 11991. *West African Trees*. Longman, Essex. 67pp.

Hartley, 1988

Hill, F.W. 1952. *Economic Botany*. 2nd edn. MacGraw-Hill, NewYork.

Hendy, N.I. 1964. *An Introductory account of small algae of British coastal waters*. Fishery investigation. HMSO. London. Part iv. 317pp.

Holden, M. and Reed, W. 1991. *West African freshwater fish*. Longman, Essex. 68pp.

Hutchingson, J. and Daiziel, J.M. 1952-1974. *Flora of West Tropical Africa*. Crown Agents for Overseas Government and Administrations. London

International Union for the Conservation of Nature, IUCN 2014. *Red List of Threatened Species*. Gland, Switzerland.

Kinako, P.D.S. *Structure and function of some Nigerian wetland ecosystems in Nigeria Nigeria wetlands*. Akpata, T.V.I., Okali, D.U. (eds). Man and Biosphere, Lagos, pp48-54

Leopold, L.B., Clarke, F.E., Henshaw, B.B. and Balsley, J.T. 1971. *A procedure for evaluating environmental impacts*. Geological survey circular 645. Government Printing Office, Washington, D.C.

Lohani et al 1997

Madge, D.S. AND Sharma, G.D. 1969. *Soil Zoology*. Ibadan University Press, Ibadan.

Olaniyan, C.I.O. 2975. *An introduction to West African Animal Ecology*, 2nd ed., Heinemann Educational Books, Ltd, London. 170pp.

Raymond et al 1976

Slingsby, D. and Cook, C. 1989. *Practical ecology*. Macmillan Education, Bainstoke. 210pp.

Southwood, T.R.E. 1992. *Ecological Methods* 2nd ed., Chapman and Hall, London.

UNEP, 1996

Wathern, 1988

Wood, C. 1996. *Environmental impact assessment*. *A comparative review*. Longman, Harlow Essex, 337pp.

World Bank, 1991. Operational directive 4.01 Annex C. *Environmental Management Plan*. The World Bank Operational Manual.

World Bank 1995. Plantation and large scale agricultural development Annex E: *Defining an environmental development strategy for the Niger Delta*. Vol. 11, pp 17-21. Industry and Energy Operations Division. West Central Africa Department.

A history of wind mill Technology; Richard Leslie Hills, p.67, 172-178]