ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF THE PROPOSED KIRI HYDRO-ELECTRIC POWER PROJECT

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A DISSERTATION SUBMITTED TO THE DEPARTMENT OF WATER RESOURCES AND ENVIRONMENTAL ENGINEERING AHMADU BELLO UNIVERSITY, ZARIA-NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN WATER RESOURCES AND ENVIRONMENTAL ENGINEERING

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OCTOBER 2015

DECLARATION

I declare that the work in this thesis entitled **"ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF THE PROPOSED KIRI HYDRO-ELECTRIC POWER PROJECT''** had been performed by me in the Department of Water Resources and Environmental Engineering under the supervision of **DR. E. M. SHAIBU-IMODAGBE**and **PROF C. A. OKUOFU.** It has not, either in part or whole, been submitted by me or anybody for this or any other degree or qualification at this or any University.

The information derived from the literature has been duly acknowledged in the text and a list of references provided.

Taitiya Kenneth YUGUDA _____ _____

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CERTIFICATION

This thesis entitled **"ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF THE PROPOSED KIRI HYDRO-ELECTRIC POWER PROJECT''**By Taitiya Kenneth YUGUDA meets the regulations governing the award of the degree of Master of Sciences (M.Sc) of Ahmadu Bello University, Zaria, and approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to the **Almighty God** and to the family of **Prof.** and **Mrs YUGUDA**, the two most influential figures in my academic and social life.

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TABLE OF CONTENTS

Title page i

Declaration ii

Certification iii

Dedication iv

Acknowledgment v

Table of contents vi

List of Tables xi

List of Figures xiii

List of Plates xiv

List of Appendices xv

List of Abbreviation and Acronyms xvi

Abstract xix

CHAPTER ONE: INTRODUCTION

1.1 Preamble 1

1.2 Background of the study 3

1.3 Statement of the Problem 6

1.4 Justification 7

1.5 Aims and Objectives of the Investigation 7

1.6 Scope and Limitation 8

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction 9

2.2 The History of Hydropower 13

2.3 Modern Hydropower 13

2.3.1 Modern Dams Role in Development 13

2.3.2 Modern Hydropower and Hydroelectric Development 14

2.4 Impacts of dams and Reservoirs 15
2.4.1 Abiotic Impact of Dams 15
2.4.2 Impacts on Flow Regime 15
2.4.3 Impacts on Thermal Regime 16
2.4.4 Impacts on Water Chemistry 17
2.4.5 Impacts on Sedimentation 17
2.4.6 Impacts on Organisms and Biodiversity 18
2.4.7 Impacts on Primary Production 18
2.4.8 Impacts on Health 20
2.5 Schistosomiasis in Dams 20
2.6 Methods of Environmental Impact Assessment 22
2.6.1 Ad Hoc Method 22
2.6.2 Methods of Organizing and Presenting Information 23
2.6.2.1 Checklists 23
2.6.2.2 Scales and Weights 25
2.6.2.3 Matrices 26
2.6.2.4 Leopold Matrices 27
2.6.3 Networks 28
2.6.4 Spatially Based Method 29
2.6.4.1 Overlays 29
2.6.4.2 Geographic Information Systems 31

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 The Research Design 34
3.2 Methods of Impact Identification 35
3.3 Sources of Data 36
3.4 Selection of the Respondents 36
3.5 Data Collection 36

3.5.1 Questionnaire and Interview 36
3.5.2 Focus Group Discussion 38
3.5.3. GIS and Remote Sensing Software 39
3.5.3.1 Image Classification 39
3.5.3.2 Change Detection Techniques 40
3.5.3.3 Change Detection by Area Calculation 40
3.5.4 Secondary Data Sources 41
3.6 Data Analysis 42
3.7 Environmental Baseline 42
3.7.1 Bio-physical Environment 42
3.7.1.1 Location and Extent 42
3.7.1.2 Geology 45
3.7.1.3 Relief and Drainage 45
3.7.1.4 Climate 45
3.7.1.5 Soil and Vegetation 46
3.7.1.6 Surface Water Use 47
3.7.1.7 Terrestrial Habitats 47
3.8 Project Description 47
3.8.1 Description of Existing Project 47
CHAPTER FOUR: ANALYSIS OF DATA AND DISCUSSION OF RESULTS
4.1 Introduction 50
4.2 Hydrology Assessment of the Project 50
4.3 Kiri HPP Power Potential and Options 56
4.3.1 Generating Potential 56
4.4 Options for Installation 59
4.4.1 Scour Gates 59
4.4.1.1 Advantages of the Scour Gates 61

4.4.1.2 Disadvantages of the Scour Gates 61
4.4.2 Tainter Gates 61
4.4.2.1 Advantages of the Tainter Gates Option 62
4.4.2.2 Disadvantages of the Tainter Gates Option 62
4.4.3 New Intake; Penstocks through Embankment 63
4.4.3.1 Advantages of the New Intake Option 63
4.4.3.2 Disadvantages of the New Intake Option 64
4.5 Description of the Proposed Project Installation 64
4.5.1 Kiri Dam Hydro-Power Project 64
4.5.2 Plan, Features and Construction 64
4.5.3 Power Evacuation 68
4.5.4 Construction Cost Estimate 70
4.5.5 Operation Cost Estimate 73
4.5.6 Energy and Production 75
4.5.7 Summary 76
4.6 Land-Use and Land Cover Changes in the KIRI Lake Basin (1976 - 2014) 78
4.6.1 Extent of the Changes of Each Land-Use/ land Cover 83
4.7 Projection of Future Changes within the Basin 84
4.8 Socio-Demographic Survey 86
4.8.1 Socio-Demographic Background 87
4.9 Reported Adverse Impacts of the Dam 89
4.10 Environmental Impacts Identified 91
4.11 Environmental Health Impacts Identified 92
4.12 Economic Impact 96
4.12.1 Benefits of the Dam 96
4.13 Perception of the Local People on the KIRI HPP 97
4.14 Consulted Local Stakeholders 100

4.14.1 Outcome of Stakeholders Consultations 101

4.15 Potential Environmental and Socio-Economic Impacts of KIRI Hydropower Project 102

4.15.1 General Impacts 102

4.16 Impact Criterion and Classification 103

4.17 Nature of Impacts 103

4.17.1 Positive/Beneficial Impacts of the Proposed KIRI Hydropower Project 104

4.17.1.1 Construction Stage 104

4.17.1.2 Operation Stage 105

4.17.2 Negative/Adverse Impacts of the proposed KIRI Hydropower Project 110

4.17.2.1 Construction Stage 110

4.17.2.1 Operation Stage 116

4.18 Environmental Monitoring and Management Plan 127

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Summary 134

5.2 Conclusion 134

5.2 Recommendations 135

REFERENCES 138

APPENDICES 148

LIST OF TABLES

Table 3.1: Data Type and Sources 39

Table 3.2: Land-Use and Land Cover Classification Scheme 40

Table 3.3: Agro- Meteorological Data (Station: Tallum) 46

Table 3.4: Facilities and Features of Kiri Dam 49

Table 4.1: Monthly Spillway Release Volume- Historical 52

Table 4.2: Monthly Mean Flow Release 53

Table 4.3: Kiri Dam Estimated Flow Duration Curve for Generation with DadinKowa Hydro-power (Unadjusted) 54

Table 4.4: Post- Hydropower Installation at DadinKowa Release Balance 55

Table 4.5: Annual Energy Production Estimate 58

Table 4.6: Cost Estimate, Kiri Dam Construction (Year 2014) 71

Table 4.7: Annual Cost Estimate, Kiri Dam Operations (Year 2014) 74

Table 4.8: Salient Features of the Proposed Kiri HPP 77

Table 4.9: The Trends of Land-Use /Land Cover of the River Basin (1976-2014) 81

Table 4.10: The Magnitudes, Percentage and Annual Rate of Change of the Lake Basin (1976-1986) 81

Table 4.11: The Magnitudes, Percentage and Annual Rate of Change of the Lake Basin (1986-1991) 81

Table 4.12: The Magnitudes, Percentage and Annual Rate of Change of the Lake Basin (1991-2014) 82

Table 4.13: The Extent of Changes of the Lake Reservoir, Flood Plains and Agriculture/Human Settlement (1976-2014) 83

Table 4.14a: List of Key Social Issues 99

Table 4.14b: List of Environmental Issues 100

Table 4.15: Types of Probable Impacts Identified During the Study 103

Table 4.16: Evaluation of Potential Environmental Impacts for Kiri dam HPP: - Construction Stage 120

Table 4.17: Evaluation of Potential Environmental Impacts for Kiri dam HPP: - Operational Stage 124

Table 4.18: Summary of Mitigation and Enhancement Measures for Kiri HPP 126

Table 4.19: Environmental Management/Monitoring plan for Kiri Hydroelectric Power Project 129

LIST OF FIGURES

Figure 3.1: Kiri Dam 43

Figure 3.2: Map Showing Connection of Kiri Dam and DadinKowa Dam 44

Figure 4.1: Classified Landsat Image of Kiri Lake Basin in 1976, 1986, 1991, 2014 79

Figure 4.2: Classified Kiri Lake Basin Immediately Before and After the Dam Construction 80

Figure 4.3: Potential Basin Characteristics after Kiri HPP Installation 85

Figure 4.4: Respondents Level of Education in Selected Towns 86

Figure 4.5: Educational Background of the Respondents According to Sex 87

Figure 4.6: Occupation of Respondents in the Selected Towns 89

Figure 4.7: Reported Causes of Environmental Degradation 90

Figure 4.8: The Common Environmental Problems in Surveyed Villages 92

Figure 4.9: The Most Common Diseases in the Surveyed Villages 96

Figure 4.10: Various Uses of Kiri Dam 97

LIST OF PLATE

Plate 1: Photograph of the Existing Structure 48

LIST OF APPENDICES

Appendix A

Table A1: Respondents Level of Education in Selected Towns 148

Table A2: Educational Background of the Respondents According to Sex 148

Appendix B

Table B: Occupation of Respondents in the Selected Towns 149

Appendix C

Table C: Causes of Environmental Degradation 149

Appendix D

Table D: The Common Environmental Problems in Surveyed Villages 150

Appendix E

Table E: The Most Common Diseases in the Surveyed Villages 151

Appendix F

Table F: Various Uses of Kiri Dam 152

Appendix G

Environmental Impact Assessment Report for the Proposed Kiri Hydro-electric Power Project 153

Appendix H

Questionnaire for Host Communities 191

Appendix I

Questionnaire for URBDA/GOBADEC 194

LIST OF ABBREVIATIONS AND ACRONYMS

AIDS	Acquired Immune Deficiency Syndrome
CBN	Central Bank of Nigeria
CIIA	Certified International Investment Analyst
DPR	Department Of Petroleum Resources
DO	Dissolved Oxygen
EA	Environmental Assessment
ECP	Emergency Conservation Program
EMP	Environmental Management Plan
EMO	Environmental Management Office
ESIA	Environmental and Social Impact Assessment
EPA	` Environmental Protection Agency
ECN	Energy Commission of Nigeria
EIA	Environmental Impact Assessment
FGD	Focus Group Discussion
FEPA	Federal Environmental Protection Agency
GOBADEC	Gongola Basin Development Energy Commission
GHG	Greenhouse Gases
GDP	Gross Domestic Product
GIS	Geographical Information Systems
HIV	Human Immunodeficiency Virus
HPP	Hydro Power Project
HEP	Hydroelectric Power
IPAC	Industrial Pollution and Abatement Committee

IMM	Impact Mitigation Monitoring
ICOLD	International Commission on Large Dams
IEA	International Energy Agency
IEC	International Electrochemical Commission
IHA	Integrated Association Healthcare
KEPA	Kaduna Environmental Protection Agency
LNG	Liquefied Natural Gas
MAN	Manufacturers Association of Nigeria
MDGs	Millennium Development Goals
MoENV	Ministry of Environment
NEPA	National Electrical Power Authority
NLNG	Nigeria Liquefied Natural Gas
NNPC	Nigeria National Petroleum Corporation
NECCO	Nigerian Engineering and Construction Corporation
NGOs	Non-Governmental Organisations
OPGW	Optical Ground Wire
PHCN	Power Holding Company of Nigeria
PA	Peasant Association
PRA	Participatory Rural Appraisal
PC	Planning Commission
PCR	Public Consultation Report
RAP	Resettlement Action Plan
SCF/D	Standard Cubic Feet per Day
SACD	South Africa Development Community

SCADA	System Control and Data Acquisition
SRMP	Sustainable Resource Management Plan
STIs	Sexually Transmitted Infections
UNCED	United Nations Conference on Environment and Development
UBRBDA	Upper Benue River Basin Development Authority
UNIDO	United Nation's Industrial Development Organisation
WHO	World Health Organisation
WCD	World Commission on Dams
WCED	World Commission on Environment and Development

ABSTRACT

This thesis assesses the potential environmental as well as the social impacts that are associated with the conversion of Kiri dam to a hydro-electric power dam. As case studies, five villages namely; Mabonde, Gelode, WuroJauro, Kiri and New Talum in the Guyuk District of the Adamawa State region respectively, were selected for questionnaire survey and scheduled focus group discussion. A total of 150 questionnaires were administered in the villages and 8 persons from each village were involved in the scheduled focus group discussions. Consultations were made to the institutional stakeholders of the project planning including GOBADEC, UBRBDA, State Ministry of Environment Yola, and State Ministry of Works Yola to ascertain their understanding of the project impacts on the environment. Site visit was also undertaken to ascertain the formation and modification of the of the proposed project environment since the inception of the dam. Geographic Information Systems and remote sensing was applied to study the changes in land-use and vegetation cover since the impoundment of the river in 1982 and it was found that 27.77 km^2 of land was lost to the lake reservoir, 20.96 km^2 of land was lost to flood plains and 6.82 km^2 of land lost to agriculture/settlement, totalling 55.55 km^2 of land lost in the last two decades. The result of the study has revealed that the potential adverse impacts of the proposed project such as flooding, pollution and threat to public health to mention a few, are mostly limited to the construction stage of the project. However, numerous benefits such as boost to economic growth, skill transfer to locals and increase in local economic activities are to be enjoyed during both the construction and operational stages of the hydropower project. To avert the potential adverse environmental and social problems in the area, the study recommends equal partnership between the project owners, responsible authority (UBRBDA) with the local people to combat environmental degradation. Furthermore, the use of computer based technologies like Remote Sensing and Geographical Information System (GIS) should be implemented to play a major role in assisting and combating the problems within the lake and dam catchment areas.

CHAPTER ONE
INTRODUCTION

1.1 Preamble

In the technologically advanced world of the 21st century, the development imperative of renewable energy resources and hydroelectric power in particular, in developing countries is attributed to the role it plays in economic advancement and in everyday activities including production, consumption, health and education. Although electric energy is one of the major propellers of economic growth, one of the biggest challenges facing both developed and developing countries currently is the guarantee of a sufficient supply of environmentally friendly energy (El Bassam, 2004).

Renewable energy resources in general and hydropower in particular have been characterized as benign sources of electrical energy that can have a positive contribution for climate change mitigation (Integrated Healthcare Association; (IHA), 2003). Research on replenishing electrical energy resources has established an empirical ground to argue why renewable resources should constitute an essential part of the electrical energy system. Major reason include that it is a clean alternative to greenhouse gas producing fossil fuels and they can supply the demand from a rapid population increase in the developing countries. The rise in the price of fossil fuels, and its reserves depletion makes renewable fuel possible options for developing economies (El Bassam 2004; Sternberg 2008). These key justifications may provide decision makers in developing countries a ground to consider renewable energy resources as an alternative source of energy or at least as part of the energy mix.A large number of developing countries, of which Nigeria is not an exception, have framed an alternative policy that could facilitate the exploitation of locally available renewable electric energy sources such as hydropower resources. Thus, the

question why many developing countries and particularly Nigeria focus on exploiting locally available renewable sources of energy such as hydropower can be a linked to empirically established rationale and frequently debated challenges in major development and political discourses.

Hydropower has a recorded history of electric production, providing substantial energy services in many parts of the world such as the U.S.A., China, Canada, and Norway (Gilpin, 1995). Different national policy documents on hydropower development project, justifying the development of this sector. Hydro power is a renewable, economic, non-polluting and environmentally benign source of energy. Hydropower stations help in improving the reliability of the power system. In addition some hydroelectric projects have long life spans extending over 50 years and help in conserving scarce fossil fuels (Integrated Healthcare Association; (IHA), 2003).

However, rarely mentioned in these policy documents arethe social and environmental costs of hydropower development projects. These dimensions have not been addressed sufficiently as parts ofhydropower project development processes and it is argued that these two dimensions are the major sources of controversies of hydropower development projects in developing countries (Briscoe, 1999) and all developing projects in general.

The perception of large dams as a developing imperative is challenged by a paradigmatic shift in water resources development from a supply-based and control-based approach to increased concern for environmental and ecological impacts as well as economic and social costs of the construction of a large dam (Alhassan, 2009). Consequently the negative

impacts of large dams on both society and nature have generated the perception of larger dams as failed development technologies (Alhassan, 2009).

The critics of large dams is based on the concerns about how they dismember rivers, dislocate entire communities, fracture social cohesion, and damage the dignity and mental psyche of those affected , leading to untold and irreparable hardships, yet without any corresponding benefits' (Alhassan 2009). As a result some of the populace who resettled due to the construction of dams feel short-changed. And if they at all are compensated or relocated, the relocated are left usually without post-compensation management.

The disapproval of large dams as a failed technology due to the social and environmental costs has coincided with a surge in non-governmental activism. The strong opposition against large-scale hydropower dams in contemporary Africa has then hinged the support of such large infrastructure developments in the continent, leading to a significant decline in the development of large dams in the late 1980s (Bergeret*et al.*, 2003, in Alhassan 2009).

1.2Background of the Study

Recently, demand of the growing population for food, electric power supply and economic growth has led to the initiation of large scale river development projects. Hence the construction of manmade lakes and dams are examples of commonest forms of river developments aimed at providing water for hydroelectric power, irrigation of floodplains, fishing industry and domestic needs among others. Some of these multipurpose dams provide integrated series of benefits like reservoir fisheries, transportation, domestic and industrial water supply, and recreational facilities needed by man.

Of course, it is in connection with the purposes stated above that the River Gongola was dammed at Kiri under the sponsorship of the Upper Benue River Basin Development Authority on behalf of the Federal Republic of Nigeria. Kiri dam was originally conceived by Savannah Sugar Company but was completed by and it's now under the control of the Upper Benue River Basin Authority (UBRBDA). Savannah Sugar Company is however, still the greatest user of the dam, where the water is used for irrigating its sugarcane plantation. The dam was constructed in 1982, on River Gongola at Kiri some 25kilometres up stream of its confluence with river Benue. The dam covers the land area of about 134 Square Kilometres. It has been reported that the construction of the dam displaced over 20,000 people who were resettled in new areas (Salau, 1986). The main aim of constructing Kiri dam is to provide water for irrigation, fisher and transportation among others.

The development of well-planned water infrastructure is widely recognized as a critical component of economic growth (World Bank, 2004). This is particularly true in sub-Saharan Africa, which experiences more climatic variability than other regions of the World. Dams are constructed for a variety of reasons.They are built for flow regulation and many more reasons including provision of both domestic and agricultural water supplies at times when water is naturally scarce, to provide power and, to reduce the devastating effects of floods. Consequently are provided opportunities for improve rent of livelihood, increased incomes and reduced vulnerability.

Currently, only 1,039 of the 45,000 large dams on the World Register of Dams (International Commission on Large Dams (ICOLD), 1998) are located in sub-Saharan Africa and half of these are located in South Africa. The majority are for irrigation (World Commission on Dams (WCD), 2000). Water storage capacity per person is often used as an

indicator of water security and a measure of water infrastructural development. Per capita storage in many sub-Saharan countries is the lowest in the world. For example, although Australia and Ethiopia have similar climatic variability, the two countries' per capita storage capacity is 4,729m^3 and 43m^3 respectively (World Bank, 2004). Kenya has levels of storage similar to Ethiopia and it has been estimated that seasonal and inter-annual variability in runoff costs theEthiopia, through production losses and flood damage, the equivalent of 2.4% of GDP per annum (Stockholm International Water Institute, 2005).

The need for construction of more dams in Africa therefore seems clear. However, the recent review undertaken by the World Commission on Dams concluded that while large dams have made a significant contribution to human development, in the past they have often failed to live up to expectations and in many cases the environmental and social impacts have been unnecessary and, by current standards, unacceptable (WCD, 2000). It is now widely agreed that there is a need to improve the environmental management of dam impacts in order to achieve sustainable development. As a result, considerable effort has been invested in developing approaches to lessen the most damaging effects of dams. However, experience indicates that the success of these measures is extremely variable and far from the assured (Bergkamp*et al.*, 2000).

The present study is formulated in an effort to evaluate the environmental impact of Kiri Dam with respect to the proposed hydroelectric power project. This is because little or no comprehensive research has been undertaken so far to appraise the environmental and socio-economic problems associated with the hydropower development.

1.3 Statementof the Problem

Over the past decade or so, hydropower projects around the world have attracted muchattention concerning the environmental and social impacts that have arisen from suchdevelopments. Construction and operation of dams have always been associated withchanges in the physical and biological environment. Adverse effects have more often than not, outnumbered the positive effect. Some of the negative impacts ofhydropower include loss of vegetations, changes in river-rine flow patterns and regimes,involuntary resettlement, health problems, loss of cultural values, marginalization of local people, inundating of valuable agricultural land, and severe reductionof flow downstream. Most hydropower projects in the past have been given muchattention regarding the technical design and economic issues of the project rather thantheir environmental and social impacts. The Kiri dam wasconstructed to purposely supply irrigation water for savannah Sugar Company. At thetime of the construction, Environmental Impact Assessment (EIA) was not a planning and management tool available in Nigeria. In view of this, there are several issues ofenvironmental impacts, which have not been considered under mitigation measures asshould have been done in a proper environmental impact assessment (EIA). However,today, the hydropower industry is in quest for improved project performance. In order to make hydropower a sound and sustainable energy alternative, increased attentionneed be paid to the environmental and social issues when dams are to be built or retrofitted.

In this particular thesis, the author examines/assesses the environmental and socialimpacts that are likely to arise from the development of Kiri dam to generate hydropower inNigeria.

1.4Justification The research study was conceived for the purpose of regional planning. This is because it will reveal thepotential adverse impacts from the implementation of the project, despite itspotential benefits to be derived. However, the result of this research would also assist government and other concerned bodies/agencies to work out possible strategies to combat these ill effects of the hydropower project upon the people of Guyuk and make reasonable environmental consideration in the development of future hydropower projects.

1.5 Aim and Objectives of the Study

The general aim of the research is to assess the potential environmental and socio-economic impacts of the proposedKirihydroelectric power project.

The specific objectives designed to address the research objective are as follows:

1. To examine the hydrology, power potential and most feasible installation option of the Kiri hydropower project.
2. To assess the actual land areas which have been lost or gained by the principal features in the lake basin, that is, the lake reservoir, flood plains and the agriculture/settlement within the study period of 1976-2014.
3. To identify the potential physical, ecological, socio-cultural, economic impacts of the conversion ofthe Kiri dam to a hydroelectric dam in its construction and operation phases of the project.
4. Produce an Environmental Impact Assessment Report of the project.

1.6Scope and Limitation The scope of this study covers the entire community of Kiri and its neighbouring environment, and the hydropower project will be assessed. The main limitation of the study will be the time at the disposal of the researcher and the fact that only the hydropower project will be assessed, excluding the dam structure(s). In addition, it was very difficult to obtain the relevant data from government, as well as other agencies due to their prevalent bureaucratic procedure.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Large dams are known to have both negative and positive impacts on their immediate and adjoining environment and capable of altering the harmonious inter-relationship between the environment and human activities. The concept of living in harmony with nature dated back to antiquity. As a follow-up on this, in the 1960s to early 1970s, the concept of sustainable development came into limelight, with the view that any development that meets the needs of today, must not compromise the ability of the future generation to meet their own needs (World Commission on Environmental and Development (WCED), 1987). The emphasis of sustainable development is on the interplay between 3 dimensions of sustainability namely: social, economy and the environment. Two schools ofthought exist in this discussion, these are: the 'weak' and the 'strong' sustainability schools (Berkermman, 1995, Niemeyer, 2003).

The strong school of thought believes that pursuit of development must not lead to disastrous consequences on the environment, and that resources thatwill deteriorate the environment andare better left unharnessed. The 'weak' school on the other hand is premised on collaboration and on sensible compromise; with the effect that poverty eradication for example, cannot be realized without modification to the ecosystems. Therefore trade-off should be expected in resource development and deployment to a limit that permits coexistence between the social, economic and the environment without unwarranted damage to lives and properties (WCD, 2000)

It has been estimated that there are about 45,000 large dams in the world (Okafor and Joe-Uzuegbu, 2010). Hydropower accounts for 16% of the world total energy production and 80% of Nigeria energy production (Okafor and Joe-Uzuegbu, 2010). The inception of hydropower in Nigeria dates to back to 1898. Criticism of the hydropower projects has increased since the 90s, but the hydropower industry too has risen to these challenges, by taking various types of measures. The hydropower technology in itself does not impede the ability of future generations in meeting their needs. This explains why it is recommended by the Millennium Development Goals (MDGs) as a medium of eradicating poverty. Sustainable development and the way hydropower has sometimes been developed have not always been in harmony. The problem of hydropower development has recently been complicated with the climate change issues since year 2000(WCD, 2000)

Meanwhile, irrespective of the perspective it is viewed, Hydro Electric Power will have negative and positive consequences. Some of the expected consequences may include the provision of low operating and maintenance costs, possession of long life span (50-100 years), water storage and release flexibility, provision of reliable service and proven technology. It also instigates and fosters regional development, makes water available for other uses, provides highest energy efficiency rate (pay back ratio and conversion process), instigation of revenue generation for other water uses such as tourism, irrigated agriculture, leisure and sports amongst others. It creates employment opportunities particularly during the construction phase, provides energy independence by exploiting natural resources, and optimizes power supply of other generating options (thermal and variable renewable). It also has positive social cost such as creating opportunities for capacity building by local/indigenous governments, companies and individuals, often provides flood protection,

may enhance navigation conditions, enhances recreational facilities, enhances accessibility of the territory and its resources (access roads, ramps and bridges), provides opportunities for construction and operation with high percentage of local manpower, may improve living conditions through sustained livelihoods (freshwater, food supply). The positive environmental implications may also include: production of no atmospheric pollutants and only very few Green House Gases (GHGs) emissions, enhancement of air quality, absence of water, and provision of an alternative to non renewable fuel resources (coal, gas and oil). Finally, it neither consumes nor pollutes the water it uses for electricity generation purposes (International Energy Agency (IEA),2000).

On the other hand the negative implication of HEP can be seen in the following respects: high upfront investment, in-situ water use or dependency reduction in the storage capacity of reservoirs due to silting requirement for long term planning and agreement for the implementation. Also, it often requires foreign contractors and funding and, conflicting water users can occur.

Its social negative implications include: resettlement of natives, modification of local land use pattern, checking water borne diseases vectors proliferation, proper management of competing water uses, andnegative implicationon local people's livelihood patterns. Furthermore, construction phase can be followed by unemployment, disruption of local relationships with land and water.The negative environmental consequences may include: inundation of terrestrial habitats, modification of hydrological regimes and modification of aquatic habitats (IHA,2003).

The impacts of hydro-electric dams have been widely studied across the world. For example, in Costa Rica hydropower dams have led to the transformation of free flowing rivers of Sarapiqui into altered system physically and biologically, it has devastated 10% of stream length in the watershed upstream, and 31 kilometre of stream have been devastated, it has increased competition and conflicts over freshwater resources and it has also promoted river conservation. In the same vein, emissions of greenhouse gases due to hydro electric dam construction have also been documented (Louis, *et. al.* 2003, Fearnside, 2005; Mickinen and Khan, 2010).

Baskaya, *et al.*, (2011) also documented the impacts of hydro dams on habitat deterioration in Turkey to include impacts on birds, waste generation, illegal hunting, inadequate rehabilitation and restoration. The impacts of hydropower dams on culture have been widely documented in different parts of Africa. For example, Inskeep (2000) documented the impact of Pikirayi dam on ancestral landscape and the concomitant psychological trauma resulting in mental health problem in Zambia. Kinahan (2000) in Angola also studied the impacts of hydro dams on the Himba pastoralist and the over 4,000 year's archival history. Hassan (2000) examined the impacts of Aswan high dam on Nubian monuments and cultural heritage in Egypt and Sudan. Brandt (2000) also reported a negative dam impact in two World Bank sponsored dams in Somalia and Ethiopia respectively. About 600 archaeologicalsites were destroyed in Somalia, while several pre historic stones and pottery materials were recovered from dam sites in Ethiopia. Studies in America confirmed that America has about 75,000 dams, which arealready having various impacts. Hence, such a scenario has made America a good study site on the effects of dams as all the positive and negative impacts are now presently feasible (Graf, 1999).

2.2 The History of Hydropower

Most communities, from a village to a city, are located adjacent to a body of water. Communities depended on rivers for basic needs until fossil fuels became the next most efficient source of available power for industrial development, pulling people away from navigable waters, and sprawling communities across the landscape (Modern Hydropower, 2007). As global energy production shifts away from fossil fuels, and domestic production of energy is increasingly desired. Decision-makers are revisiting hydroelectric dams as a means to increase energy security and support economic growth and development (Modern Hydropower, 2007). Since hydropower is the original "fuel" of global development, looking back to the industrial revolution, it is no surprise that developing nations are increasingly turning to dams with the goal of increasing domestic electricity production and distribution (Modern Hydropower, 2007).

2.3Modern Hydropower

2.3.1Modern Dams' Role in Development

Dams can control flood patterns, divert rivers, store water for drinking and irrigation, and generate power (Workman, 2009). In terms of modern hydropower, dams are the primary way to manipulate a river for human benefit. Also, by controlling flood patterns, dams have allowed many civilizations to develop in extreme proximity to rivers, where volatile flood plains would otherwise not allow it (Modern Hydropower, 2007). Dams are so to speak, a way to "budget" a river. They can ensure a reliable river flow year round and bring water to otherwise arid landscapes (Modern Hydropower, 2007). However, dams intervene with the world's natural hydrology in the same way deforestation fragments ecosystems, and the sustainability of this intervention is up for debate.

The presence of dams has increased globally due to the amazing ability humans possess to manipulate natural processes for their benefit. International Rivers State, that the end of the twentieth century, the dam industry had choked more than half of the earth's major rivers with more than 50,000 large dams.In the United Statesalone, the exact number of dams is unknown. It is estimated that there are more than 2.5 million small dams, 78,747 dam structures requiring federal hazard safety oversight, and additionally there are 99,000 state regulated dams (Workman, 2009). Modern dam development is driven by politics, economics, and energy demand. North America's largest dams were developed for a variety of purposes: navigation and recreation (24 percent), flood control (13 percent), irrigation (11 percent), hydropower (11 percent), water supply (10 percent), and for multiple purposes (30 percent) (Workman, 2009). Dams come in a broad range, built for various purposes, with various materials, and in various environments. On the contrary, modern decision-making and design for dam projects is quite generic, where the design of the dam may not fit the hydrology of the host river. Additionally, time and funding limits pre-construction cost benefit analysis for economic, environmental, and social factors. The cost benefit analysis of dams must be re-evaluated to maximize potential benefits and minimize costs.

2.3.2 Modern Hydropower and Hydroelectric Development

Historically, hydropower captures the energy of water movement to perform work. In a modern context, hydropower uses turbines to capture the energy of water movement to generate electricity (Modern Hydropower, 2007). Hydroelectric generation accounts for 16 percent of worldwide electricity generation (Evans*et al.,* 2009). Typically, hydroelectric facilities consist of a hydroelectric power plant stationed within a dam. Modern trends in hydropower development suggest, as the current energy crisis worsens, developers will

increasingly resort to hydropower for electric production of the world (Modern Hydropower, 2007). To quantify the cost and benefit of hydroelectric dams is a complex task, having an important role in energy security, yet producing sizable impacts on the local economy, environment and communities.

2.4 Impacts of Dams and Reservoirs

2.4.1Abiotic Impacts of Dams

Rivers exist as a continuum of linked surface and groundwater flow paths and are important natural corridors for the flows of energy, matter and species. The spatial and temporal heterogeneity of river systems is responsible for a diverse array of dynamic aquatic habitats and hence biological diversity, all of which are maintained by the constantly changing flow regimes. Inundation of floodplains increases organic matter decomposition and nutrient cycling and has led to the evolution of adaptive strategies that are tightly coupled to the flood regime (Bergkamp*et al.*, 2000).

Dams constitute obstacles for longitudinal exchanges along fluvial systems and so result in "discontinuities" in the river continuum Post impoundment phenomena directly and indirectly influence a myriad of factors that affect natural processes and so ultimately alter the ecological structure of ecosystems(Ward and Stanford, 1995).

2.4.2Impacts on Flow Regime

The most obvious impact of storage reservoirs is the upstream inundation of terrestrial ecosystems and, in the river channel, the conversion of lotic to lentic systems. Dams also alter the downstream flow regime. The effect of a dam and its reservoir on flow regimes depends on both the storage capacity of the reservoir relative to the volume of river flow and the way the dam is operated. The most common attribute of flow regulation is a decrease in the magnitude of flood peaks and an increase in low flows. A consequence of

reduced flood peaks is reduction in the frequency and extent of overbank flooding. For example, in the Hadejia-Nguru wetlands in Nigeria, annual flooding of about 3,000 km^2 prior to the building of dams was reduced to less than 1000 km^2 after construction (Hollis *et al*., 1993).

In some circumstances, operational procedures can result in rapid flow fluctuations that occur at non-natural rates. Hydroelectric power and irrigation demands are the most usual causes, but short-duration and high discharges are also utilized for navigational purposes and for recreation. For many purposes, so called "pulse releases" are made regularly. For example, daily releases through power turbines often reflect diurnal variation in power demand (Matthew *et al*., 2004).

2.4.3Impacts on thermal Regime

Water temperature influences many important ecological processes. Temperature is an important factor affecting growth in freshwater fish, both directly and indirectly, through feeding behaviour, food assimilation, and the production of food organisms. Under natural conditions the relatively small volume of water in a river section and turbulent mixing ensure that river water responds rapidly to changes in the prevailing meteorological conditions. In contrast, the relatively large mass of still water in reservoirs allows heat storage and produces a characteristic seasonal pattern of thermal behaviour(Bergkamp*et al.*, 2000).Depending on geographical location, water retained in deep reservoirs may become stratified. This is less common in Africa than in temperate regions, but even without thermal stratification, water released from reservoirs is often thermally out of phase with the natural regime of the river (IEA, 2000).

2.4.4Impacts on Water Chemistry Water storage in reservoirs induces physical, chemical and biological changes, all of which affect water chemistry. Consequently the water discharged often has a very different composition to that of inflowing rivers. Nutrients, particularly phosphorous, are released biologically and leached from flooded vegetation and soil. Oxygen demand and nutrient levels generally decrease as the organic matter decays (Bergkamp*et al*, 2000).

Some reservoirs require many years for the development of stable water-quality regimes. After maturation, reservoirs, like natural lakes, can act as nutrient sinks. Eutrophication of reservoirs may occur as a consequence of large influxes of organic material and nutrients, often arising as a consequence of anthropogenic activity in the catchment hence catchment management has a key role to play in sustaining reservoir water quality (Bergkamp*et al.*, 2000).

The quality of water released from a reservoir is determined by the elevation of the outflow structure(s). Water released from near the surface is generally well-oxygenated, warm and nutrient-depleted. In contrast, water released from near the bottom is often cold, oxygen-depleted, nutrient-rich water that may be high in hydrogen sulphide, iron and manganese. In the period immediately following impoundment, water abstracted from the Volta Reservoir, Ghana for example, had to be treated with potassium permanganate to remove 'high' concentrations of iron and manganese, neither of which was present prior to dam construction (Kumi, 1973).

2.4.5Impacts on Sedimentation

Reservoirs reduce flow velocity and so enhance sedimentation. The rate at which sedimentation occurs within a reservoir depends on the physiographic features and land-use practices of the catchment, as well as the way the dam is operated. Large magnitude and

frequent fluctuation in water levels in reservoirs can cause erosion of the shores and add to deposition. It is estimated that between 0.5 and 1% of the storage volume of the world's reservoirs is lost annually due to sediment deposition (Mahmood, 1987).

Downstream of a dam, reduction in sediment load in rivers can result in increased erosion of river-banks and beds, loss of floodplains (through erosion and decreased over-bank accretion) and degradation of coastal deltas. Removal of fine material may leave coarser sediments that 'armor' the riverbed, protecting it from further scour. In some circumstances, material entrained from tributaries cannot be moved through the channel system by regulated flows, resulting in aggradations. Reservoir flushing (i.e. the selective release of highly turbid waters) is a technique sometimes used to reduce reservoir sedimentation. Consequently, reservoir operations may periodically result in unnaturally high concentrations of sediment in downstream systems (Bergkamp*et al.*, 2000).

2.4.6Impacts on Organisms and Biodiversity

Dams, through disruption of physiochemical and biological processes, modify the conditions to which ecosystems have adapted. The impacts of dams vary substantially from one geographical location to another and are dependent on the exact design and the way a dam is operated. Every dam has unique characteristics and, consequently, the scale and nature of environmental changes are highly site-specific. However, impacts invariably affect biota and can impact biodiversity (Staissny, 1996).

2.4.7Impacts on Primary Production

The introduction of a dam into a river system affects primary production. In freshwater ecosystems, phytoplankton, periphyton and macrophytes form the base of the food web. Upstream of a dam, the slow-moving water of the reservoir is often an ideal habitat for phytoplankton, but, depending on depth, temperature, light penetration and the nature of the

substratum may be less suited for periphyton and rooted macrophytes(Goes, 2002). Downstream of a dam, primary production is affected by the changes to flow, water chemistry and thermal regimes, as well as current velocities and turbidity. In Nigeria, dam construction has resulted in the growth of aquatic macrophytes (mainly *Typhadomingensis*) and associated silt deposition in the Old Hadejia River. This has blocked the channel and significantly reduced flows to the Yobe River (Goes, 2002).

Modification of primary production may alter the aquatic environment directly. For example, blooms of phytoplankton and floating plants reduce light penetration, impede oxygen diffusion from the atmosphere and deplete oxygen when they decompose, and so have an adverse impact on other species. The infestation of reservoirs by invasive aquatic weeds, for example, water hyacinth *(Eichorniacrassipes)*, is a major constraint on water resource management in many African countries. Change in flow regimes, brought about by the construction of dams along the Niger River has resulted in the rapid spread of water hyacinth. It is estimated that in the Niger Delta some 5 million people are adversely affected by the weed, through its negative impact on fishing, navigation, irrigation, fish ponds and, human health because it provides a habitat for mosquitoes, (Joffe and Cooke, 1997).

Dams can also affect riverside and floodplain vegetation, the characteristics of which are often controlled by the dynamic interaction of flooding and sedimentation. By changing the magnitude and extent of floodplain inundation and land-water interaction, dams can disrupt plant reproduction and allow the encroachment of upland plants previously prevented by frequent flooding. Studies on the floodplain of the lower Zambezi have shown encroachment of woody savannah and thicket species (e.g. *Hyphanaecorciacea*and *Acacia robusta*) and displacement of flood tolerant grass species (e.g. *Setaria spp*.)by drought

tolerant grass species (e.g. *Hyparrheniarufa*). These changes are attributed to reduced frequency of flooding, which affect not just soil moisture conditions, but also result in changes in herbivore grazing patterns (Beilfuss*et al*, 2001).

2.4.8Impact on Health

The environmental changes and social disruption resulting from dams and associated infrastructure such as irrigation schemes have significant adverse health outcomes for local populations and downstream communities. Among the resettled, access to drinking water and to health services and ability to cope with new social and physical environments determine health conditions. In tropical areas, numerous vector-borne diseases are associated with the reservoirs of dams. The most common of these diseases is schistosomiasis, a parasitic disease causing untold misery in 75 countries (World Health Organization (WHO), 1985), affecting over 200 million people worldwide with 500-600 million more exposed to the infection (Webbe, 1981).

Schistosomiasis is associated with water resource development projects such as dams and irrigation schemes, where the snail is the intermediate host of the parasite breeds. The snail intermediate host breeds in slow-flowing or stagnant water. Hence, the main courses of large rivers are not usually a major source of schistosomiasis, but waters sustained by them through seasonal flooding, impoundment and withdrawal canals for irrigation are important transmission sites (Ogbeide and Uyigue, 2004). The disease is essentially an infection of rural and agricultural communities where the way of life of people promotes the contamination of inland water with human excreta.

2.5Schistosomiasis in Dams

In terms of schistosomiasisendemicity, Nigeria has been divided into three zones: hyperendemic zone, moderate zone and zone with low or no endemicity. About 192 (59%)

of these dams are located in the 10 hyperendemic states, 50 (16%) are located in moderately endemic states and 81 (25%) are located in low/no endemic states and the Federal Capital Territory, indicating a greater tendency to build dams in hyperendemic zone than in other Zones (Cowper, 1973).

A total of 47 (15%) of the 323 dams have been surveyed for the presence of snail intermediate host species of schistosomiasis, putting into consideration its distribution and ecology. The survey revealed that 45 out the 47 dams are located in the hyperendemic zone while the remaining two are located in the moderately endemic zone. Results show that 20 (43%) of the total surveyed harboured *Bulinusglobosus*and/or *Biomphalariapfeifferi*, the local intermediate host of the *Schistosoma*parasite. Eighteen of these are located in the hyperendemic zone while the other two are in the moderately endemic zone. Fifteen of them are in the northern part of the country while the remaining five are in the Southwest (Ofoezie, 2002).

Since the snail intermediate host of schistosomiasis breeds in slow-flowing/stagnant water, reservoirs of dams have provided favourable conditions for year-round transmission of the disease even in areas where snail distribution used to be seasonal (Betterton *et al.*, 1988). Imevbore*et al.* (1986) reported that within the reservoirs, distribution is focal and is confined to the human contact sites, especially along their shallow vegetative shore, not more than few meters from the shores or deep into the water. The reports of Okwosa and Ukoli (1980) and Smith (1982) revealed that in Nigeria, snail density is not significantly affected by water turbidity, temperature, alkalinity, acidity and the presence of major ions, but is significantly limited by conductivity, dissolved oxygen, biochemical oxygen demand and the presence of aquatic vegetation(Matthew *et al., 2004)*

2.6 Methods for Environmental Impact Assessment

Changes in the practice of Environmental Impact Assessment (EIA) and advances in information technology have greatly expanded the range of tools available to the EIA practitioner. For example, map overlay methods, originally pioneered by McHarg (1971), have evolved into sophisticated Geographic Information Systems (GIS). Expert systems, a branch of artificial intelligence, have been developed to help in screening, scoping, developing terms of reference (TOR), and conducting preliminary assessments. These systems use comprehensive checklists, matrices, and networks in combination with hundreds of impact rules developed by EIA experts. The global embrace of sustainable development has made the analysis of costs and benefits an integral part of EIA. This has forced the expansion of factors to be considered in traditional cost benefit analysis. The following chapters describe some of these more specialized approaches and methods that have evolved to meet the changing needs of EIA: 1) predictive methods (Chapter 4); 2) environmental risk assessment (Chapter 5); 3) economic analysis (Chapter 6); and expert systems (Chapter 8).

This chapter describes some of the simplest techniques and methods for EIA, and gives information to help choose the most appropriate method for a given situation.

2.6.1 Ad Hoc Method

Ad hoc methods are not really methods as they do not structure the problem so it is more amenable to systematic analysis. A good example of an ad hoc method is a team of experts assembled for a short time to conduct an EIA. Each expert's conclusions are based on a unique combination of experience, training and intuition. These conclusions are assembled into a report. Sometimes this is the only required or possible approach. In other instances, when more scientific methods are available, it is not sufficient to rely on ad hoc methods.

2.6.2 Methods for Organizing and Presenting Information

Checklists and matrices are commonly used to organize and present information. Many of the more sophisticated methods and techniques often use checklists and matrices as a starting point for analysis. All checklists and matrices have boxes or cells that must be filled with information about the nature of the impact. Depending on the method, this information can be descriptive or evaluative. The simplest methods merely determine the possibility or potential existence of an impact, while others, like weighting-scaling checklists, make judgments about the magnitude and importance of the impact.

2.6.2.1 Checklists

Checklists are standard lists of the types of impacts associated with a particular type of project. Checklists methods are primarily for organizing information or ensuring that no potential impact is overlooked. They are a more formalized version of ad hoc approaches in that specific areas of impact are listed and instructions are supplied for impact identification and evaluation. Sophisticated checklists include: 1) scaling checklists in which the listed impacts are ranked in order of magnitude or severity, and 2) weighting-scaling checklists, in which numerous environmental parameters are weighted (using expert judgment), and an index is then calculated to serve as a measure for comparing project alternatives.

There are four general types of checklists:

i. ***Simple Checklist:*** a list of environmental parameters with no guidelines on how they are to be measured and interpreted.

ii. ***Descriptive Checklist:*** includes an identification of environmental parameters and guidelines on how to measure data on particular parameters.

iii. ***Scaling Checklist:*** similar to a descriptive checklist, but with additional information on subjective scaling of the parameters.

iv. ***Scaling Weighting Checklist:*** similar to a scaling checklist, with additional information for the subjective evaluation of each parameter with respect to all the other parameters.

Varying levels of information and expertise are required to prepare checklists. Simple checklists may require only a generalized knowledge of the environmental parameters likely to be affected, and access to an information base. Alternatively, simple checklist methods can be used to summarize the results of an EIA. Scaling weighted checklists are likely to require more expertise to prepare. There are several major reasons for using checklists:

i.They are useful in summarizing information to make it accessible to specialists from other fields, or to decision makers who may have a limited amount of technical knowledge;

ii. Scaling checklists provide a preliminary level of analysis; and

iii. Weighting is a mechanism for incorporating information about ecosystem functions. Westman (1985) listed some of the problems with checklists when used as an impact assessment method:

i. They are too general or incomplete;

ii. They do not illustrate interactions between effects;

iii. The number of categories to be reviewed can be immense, thus distracting from the most significantimpacts; and

iv. The identification of effects is qualitative and subjective.

2.6.2.2 Scales and Weights

Descriptive checklists are excellent for describing comprehensive lists of impacts; however, they are not able to rank alternatives. Various methods have been developed for the evaluation of alternatives. Before discussing the simplest of these methods (that is, checklists), it is necessary to define the basic steps of methods for evaluating alternatives:

i. Determine an appropriate set of environmental factors to be considered (for example, wildlife habitat);

ii. Determine the environmental impact index for each factor;

a) Define the units of measurement for each environmental factor (e.g., hectares preserved),

b) Collect the data on the environmental factor (e.g., 10000 hectares preserved),

c) Decide on a common interval scale for each environmental factor index (e.g., 0 to 1),

d) Convert the data for the environmental factor to environmental factor index (this is usually doneby normalizing all values over a maximum or minimum value);

iii. Determine a weight for each environmental factor; and

iv. Decide on the method of aggregation across all factors (usually additive).

Many applications of EIA methods are flawed because practitioners often construct quantitative representations of ordinal data. They then wrongly assume that they can aggregate ordinal data into a grand index. For example, instead of asking an expert to assign the magnitude of impact as low, medium, or high, the practitioner might ask for magnitude on a scale from 1 to 10 where 1 is low, medium is 5 and 10 is high. While this is now numerical data, it is still represented on an ordinal scale and should not be aggregated. To construct an interval scale special care must be taken. In the context of constructing environmental quality indices,Dee *et al.*,and (1972) suggested the following procedure:

i. Collect information on the relationship between the factor and the quality of the environment.

ii. Order the environmental factor scales (normally the x-axis) so that the lowest (or worst) value for the environmental factor corresponds to zero in the environmental quality scale (normally the y-axis).

iii. Divide the environmental quality scale into equal intervals ranging between 0 and 1, and determine the appropriate value of the factor for each interval. Continue this process until a reasonable curve may be drawn.

iv. Steps 1 to 3 should be repeated independently by various experts. The average values should produce the group curve. If factors are based on value judgements alone, a representative cross-section should be used.

v. If there are large variations among the different experts, a review may be performed.

vi. Steps 1 through 5 should be repeated by various groups of experts to test reproducibility.

2.6.2.3 Matrices

Matrix methods identify interactions between various project actions and environmental parameters and components. They incorporate a list of project activities with a checklist of environmental components that might be affected by these activities. A matrix of potential interactions is produced by combining these two lists (placing one on the vertical axis and the other on the horizontal axis). One of the earliest matrix methods was developed by Leopold *et al.,* (1971). In a Leopold matrix and its variants, the columns of the matrix correspond to project actions (for example, flow alteration) while the rows represent environmental conditions (for example, water temperature). The impact associated with the action columns and the environmental condition row is described in terms of its magnitude and significance.Most matrices were built for specific applications, although the Leopold Matrix itself is quite general.

Matrices can be tailor-made to suit the needs of any project that is to be evaluated. They should preferably cover both the construction and the operation phases of the project, because sometimes, the former causes greater impacts than the latter. Simple matrices are useful: 1) early in EIA processes for scoping the assessment; 2) for identifying areas that require further research; and 3) for identifying interactions between project activities and specific environmental components. However, matrices also have their disadvantages: they tend to overly simplify impact pathways, they do not explicitly represent spatial or temporal considerations, and they do not adequately address synergistic impacts.

Matrices require information about both the environmental components and project activities. The cells of the matrix are filled in using subjective (expert) judgement, or by using extensive data bases. There are two general types of matrices: 1) simple interaction matrices; and 2) significance or importance-rated matrices. Simple matrix methods simply identify the potential for interaction. Significance or importance-rated methods require either more extensive data bases or more experience to prepare. Values assigned to each cell in the matrix are based on scores or assigned ratings, not on measurement and experimentation. For example, the significance or importance of impact may be categorized (no impact, insignificant impact, significant impact, or uncertain). Alternatively, it may be assigned a numerical score (for example, 0 is no impact, 10 is maximum impact).

2.6.2.3.1 Leopold Matrix

Leopold *et al.*, (1971) designed a matrix with a hundred specified actions and 88 environmental components. Each action and its potential for impacting each environmental item is considered. The magnitude of the interaction (extensiveness or scale) is described by assigning a value ranging from 1 (for small magnitudes) to 10 (for large magnitudes). The assignment of numerical values is based on an evaluation of available facts and data.

Similarly, the scale of importance also ranges from 1 (very low interaction) to 10 (very important interaction). Assignment of numerical values for importance is based on the subjective judgement of the interdisciplinary team working on the EIA study.

The matrix approach is reasonably flexible. The total number of specified actions and environmental items may increase or decrease depending on the nature and scope of the study and the specific TOR for which the environmental impact study is undertaken. This is one of the attractive features of the Leopold Matrix.

Technically, the Leopold Matrix approach is a gross screening technique to identify impacts. It is a valuable tool for explaining impacts by presenting a visual display of the impacted items and their causes. Summing the rows and columns that are designated as having interactions can provide deeper insight and aid further interpretation of the impacts. The matrix can also be employed to identify impacts during the various parts of the entire project cycle — construction, operation, and even dismantling phases.

2.6.3 Networks

Development of the conceptual models that represent potential impact pathways as causal chains is at theessence of the application of the SSA. As illustrated by the examples presented in the previous section, network diagrams are one of the best ways of representing these causal chains. Network diagrams provide a means for displaying first, secondary, tertiary, and higher order impacts. To develop a network, a series of questions related to each project activity (such as what are the primary impact areas, the primary impacts within these areas, the secondary impact areas, the secondary impacts within these areas, and so on) must be answered. In developing a network diagram, the first step is to identify the first order changes in environmental components. The secondary changes in other environmental components that will result from the first order changes are then

identified. In turn, third order charges resulting from secondary changes are identified. This process is continued until the network diagram is completed to the practitioner's satisfaction. The network helps in exploring and understanding the underlying relationships between environmental components that produce higher order changes that are often overlooked by simpler approaches.

2.6.4 Spatially Based Methods

2.6.4.1 Overlays

Shopley and Fuggle (1984) credited McHarg (1969) with the development of map overlays. An overlay isbased on a set of transparent maps, each of which represents the spatial distribution of an environmental characteristic (for example, susceptibility to erosion). Information for an array of variables is collected forstandard geographical units within the study area, and recorded on a series of maps, typically one for eachvariable. These maps are overlaid to produce a composite. The resulting composite mapscharacterize the area's physical, social, ecological, land use and other relevant characteristics, relative to thelocation of the proposed development. To investigate the degree of associated impacts, any number of projectalternatives can be located on the final map. The validity of the analysis is related to the type and number ofparameters chosen. For a readable composite map, the number of parameters in a transparency overlay is limited to about ten. These methods are used in at least two ways in impact assessment. One way is to use before and after maps to assess visually the changes to the landscape. The other way is to combine mapping with an analysis of sensitive areas or ecological carrying capacity. When used in this latter way, constraints on the level of development are set on the basis of limits determined by the location of sensitive areas and by assessments of carrying capacity. These methods are spatially oriented and are capable of clearly communicating the spatial

aspects of cumulative impacts. Their limitations relate to: 1) lack of causal explanation of impact pathways; and 2) lack of predictive capability with respect to population effects. However, some sophisticated versions can make predictions about potential habitat loss. Essentially, the overlay method divides the study area into convenient geographical units based on uniformly spaced grid points, topographic features, or differing land uses. Field surveys, topographical land inventory maps, aerial photography, etc., are used to assemble information related to environmental and human factors within the geographical units. Factors are composed by assembling concerns that have a common basis, and regional maps are drawn for each factor. Through the use of overlays, landuse possibilities and engineeringfeasibility are visually determined (McHarg, 1968). The scale of the maps can vary from large-scale (for regional planning purposes) to small-scale identification of site specific features. Overlays also are used in route selection for linear projects such as roads and transmission lines. Their use facilitates screening of alternative routes at an early stage, reducing the amount of detailed analysis required by eliminating some routes early on. For optimal results data for various characteristics must be of comparable quality; if the data base for one characteristic is weaker than for the others it will be under-represented through this method.McHarg (1968) demonstrated this technique with specific orientation towards highways. His methodconsisted of transparencies of environmental characteristics overlaid on a regional base map. Eleven to sixteenenvironmental and land use characteristics were mapped. The maps represented three levels of environmental and land use characteristics based upon "compatibility with the highway." The approach seems most useful forscreening alternative project sites or routes before a detailed impact analysis is completed. The method has alsobeen used for evaluating development options in coastal areas and for routing pipelines and transmission lines.

2.6.4.2 Geographic Information Systems

Traditionally, the overlays have been produced by hand. As a result of recent developments, GeographicalInformation Systems (GIS) are becoming popular in situations where the computer technology and trainedpersonnel are available. Computers also are used routinely to do cluster analyses of complex overlays.A significant application of GIS is the construction of real world models based on digital data. Modelingcan analyze trends, identify factors that are causing those, reveal alternative paths to solving the given problem,and indicate the implications or consequences of decisions. For example, GIS can show how a natural resourcewill be affected by a decision. Based on satellite data, areas that suffer most from deforestation may be identified and analyzed on the basis of overlaying data on soil types, the species required, the likely growth and yield, and the impact of regulatory measures applicable to the area (Asian Development Bank, 1991). The timing, types, and scale of timber management practices needed may then be indicated, specifying the consequences. In agriculture, the potential loss of natural vegetation to expanded rice cultivation can be quantified, based on economic evaluation. Where conventional change detection techniques do not yield satisfactory results, a GIS approach can indicate the change in quantitative terms (for example, in new area development). The impact of development plans on the environment can be assessed by integrating data on land use with topographic and geologic information. Similarly, satellite imagery can periodically be used to update maps of irrigated land. The spectral features of irrigated and non-irrigated fields can be combined with other data on the fields to derive estimates of demand for irrigation water and devise land management plans. GIS can be used to assess the risk of drought in choosing areas for rainfed crops. In fisheries, based on past trends of population dynamics in a given area, long-term consequences of restocking programs on

the environment may be indicated. GIS is also used in determining optimal routes for communications, irrigation, and road maintenance. Network modeling to connect various data bases can also be done.

Another important application of GIS is in statistical analysis of features (for example, the area of forestwater body or the length of rivers, canals, and roads). An area can be statistically described, for example, by soil type. The length of a road can be classified in terms of its condition. It is also common to delineate what is known as "buffer zones" around points, lines, or polygons to indicate selected areas for special attention. For example, the land surrounding a reserve forest can be studied for determining the most appropriate land use. The "buffer zone" could be overlayed with an ideal land capability layer to choose the best possible use.

A "ranking method" can be used to evaluate lands suitable for cultivation of particular crops. The methodinvolves the use of several thematic maps from satellite data as well as non-image data. For example, landresources can be evaluated for paddy field development. Data on land conditions, land productivity, and soilmoisture conditions need to be collected and evaluated so that suitable areas for paddy cultivation can be identified. GIS is a powerful management tool for resource managers and planners. Its applications are limited only by the quality, quantity, and coverage of data that are fed into the system. Some of the standard GIS applications are integrating maps made at different scales; overlaying different types of maps which show different attributes; and identifying required areas within a given distance from roads or rivers. For instance, by overlaying maps of vegetation and soils, a new map on land suitability can be generated and the impact of proposed projects can be studied. The farm-to-market transport economics can be considered in

determining the planting of specific areas on a commercial scale. Similarly, the most favorable zones for the development of shrimp farming outside mangroves can be located.

RESEARCH METHODOLOGY

3.1The Research Design The research design entails the ‘ logical sequence that connects the empirical data to the study’s initial research questions and ultimately, to its conclusions (yin, 2009).

This research focuses mainly on actors’ involvement in the planning process of the proposed Kiri hydropower development project, the local environmental and social problems that will be caused by the project and the perceptions of the local people regarding the installation of hydropower component to the existing Kiri dam in their local environment. The research was designed to collect the required data for the study and to analyse it using the research techniques within the domain of qualitative methodology. According to Yin (2009), the research design can be dictated by the nature of the problem to be suited and the research questions a researcher is intrested in. The main function of the research design is to set out the logic of inquiry and explain how the researcher will find answers to the research questions (Kumar,1999). Accordingly, for this study, in-depth interviews and focus group discussions were the major techniques employed. Interview guides were produced to exploit various views and perceptions on policy issues, local social and environmental issues, public participation and local peoples’ perceptions of the hydropower project in general. Overall, the research design and the method employed are dictated by the question of how to find sufficient data in order to conduct rigorous explanations for the research questions under investigation (Corbin and Strauss, 2008;Yin 2009).

3.2 Methods of Impact Identification The following EIA methods were employed in impact identification and classification as reviewed in

chapter 2 **a) Maps (GIS);** this is based on the use of GIS and remotely sensed data to capture, study and classify land-cover and land-use changes over the area of concern. **b) Questionnaire Checklist;** these were based on a set of questions to be answered. Some of the questions may concern indirect impacts and possible mitigation measures. They may also provide a scale for classifying estimated impacts from highly adverse to highly beneficial. **c) Magnitude matrices;** these go beyond the mere identification of impacts according to their magnitude, importance and or time frame (e.g. short, medium or long term).

3.3Sources of Data

The data obtained for this work were from two sources. These are through primary and secondary sources. Primary source involvedthe use of interview, questionnaires,scheduled focus group discussions and field observations using GIS and remote sensing.

The datacollected from secondary sources include;Climatic data, which were obtained from the Upper Benue River Basin and Rural Development Authority. Socio-cultural data were obtained from Focus Group discussions with selected communities with the Kiri area including Kiri village. Health implication records were obtained for community hospitals and clinics, Samples of biological species were collected for full identification with values established for their degree of dominance with assistance of a qualified taxonomist. In addition to Focus Group Discussion(FGD), Rapid Participatory Appraisal Technique (RPPT)was used to obtain valuable information from the local stakeholders to the project, including officials of PHCN, in Yola or nearby districts to the project.

Other data on the project such as the type, size, operation and EIA reports were obtained from Upper Benue River Basin Development Authority (URBDA) YolaandGongola Basin Development Energy Commission (GOBADEC), literature studies (review) of published materials selected reports, other relevant journal articles and internet sources.

3.4Selection ofthe Respondents Selection of respondents was carried out purposively after studying the nature of the project especially of accessibility to the different Peasant Associations (PAs) along the riverbank and conducting a meeting with experts of the Environmental Monitoring Unit at the project site. This helped clarify how I should proceed with interview selection taking into consideration. Transportation facilities to reach the peasant associations (PAs), and the proximity of the PAs to the dam site. Finally, five PAs of the Shelleng zone in the proximity of the dam site were selected. From the five PAs, a total of 150 people were randomly sampled for questionaires administration and survey, while 8 people from each of the PAs were selected for the focused group discussions.

3.5Data Collection

3.5.1 Questionnaire and interview The questionnaires were structured in accordance with the objective of the study. The questions are both open and close end. This allowed flexibility in the responses, and also helped to solicit views, which would otherwise not be captured in the questions.

A random sampling technique was applied in picking up the individual respondents.This was done after the prospective respondents had been identified and grouped according to their occupations. Five villages were selected for this particular study Area. A total of 150 people were randomly sampled for questionnaires administration and survey.

Prior to conducting interviews, an interview guide was made for different interviewees, including the Environmental Protection Authority (EPA), the project office (GOBADEC), and the project affected peasants. These questions were in part posed interviewer. In this sense the question guides are used as reminders of the information that need to be collected and why (Yin, 2009). These questions may serve 'as prompts in asking questions during the interview but the main purpose of these questionnaires guide was to keep the researcher on track as data collection proceed (Yin, 2009). The next step consisted of contacting the interviewes according to schedule.

Before travelling to the project site, a discussion was conduted with two experts from the Environmental Protection Unit of the Ministry of Environment AdamawaState, as well as theEngineer at the project site. An informal discussion with the project administrator at the project site was also conducted. The discussion was more concerned with the practical problems to be experienced during the hydropower construction, complaints by the local people, how these issues would be handled and many other relevant issues around the project development. The discussion gave more insight into the practical problems being experienced during the phase of the Kiri hydropower project.

3.5.2 Focus Group Discussion

A group discussion was contacted with 8 members each of the of the five PAs. These members of the PAs were purposefully selected from a list of farmers and fishermen obtained from the project site. These people were part of the project affected communities. Some of them were claimants who lost their farms during the dam construction while some

were affected by the road realignment project that crosses the Kiri River directly above the dam . Two respondents were affected by both of these. Thus the focus group discussion aimed to generate information about the impacts of the dam construction on local people. The mix of respondents proved fruitful, generating substantial information on the dam's impacts on local lives. Some respondents were understandably emotional while explaining their views, reflecting the depth of the problem for them and their families and the implications for wellbeing in the future.

The discussion provided information to crosscheck additional information from the interviews conducted at the individual level. The focus group responses helped obtain more information from the participants including views on the project development in the Kiri reservoir, expectations from the proposed project.

In both cases a tape recorder was used after getting permission from the respondents. Later, the information was translated from Hausa into English for further organisation and analysis. The main problem experienced while conducting interview was that initially, people considered the interview as a government representative there to solve problems rather than just to conduct a research. This misconception was settled after introduction and explanation of intentions. Very descriptive discussions followed where the participants explained personal views and feelings about various project socio-economic issues relating to the hydropower project.

3.5.3 GIS and Remote Sensing Software Geographic information systems (GIS) and remote sensing softwares were used to study and classify the landcover and land-use changes that have resulted in the Kiri lake basin since its inception in 1982.

Landsat images were classified using ArcGIS 10.2.2 software package as presented in Table 3.1.

Table 3.1: Date Type and Sources

S/No	Data Type	Resolution	Date	Sources
1	Landsat MSS (Multi-Spectral Scanner)	79m	12-06-1979	Global Land Cover Facility.
2	Landsat TM (Thematic Mapper)	30m	02-07-1986	Global Land Cover Facility.
3	Landsat ETM+ (Enhanced Thematic Mapper Plus)	30m	14-08-1991	Global Land Cover Facility.
4	Landsat ETM+ (Enhanced Thematic Mapper Plus)	30m	04-09-2014	Global Land Cover Facility.

Source: Global Land Cover Facility, 2014

3.5.3.1 Image Classification

In classifying the images into various themes, the supervised approach to classification was adopted using Arc GIS 10.1 software. The images were classified into three major classes: water body; agricultural, built-up and other land-uses and; floodplain and water weed seen on Table 3.2. Maximum likelihood classification method was adopted.

Table 3.2: Land-Use and Land Cover Classification Scheme

1	Water Body	Dam reservoir water
2	Agricultural, Built-up and Other land	Agricultural lands, areas containing buildings etc.

3	Floodplain and water Weed	Floodplain and water Weedwithin the river bed.

Source: Adapted and modified from Anderson, Hardy, Roach and Witmer (1976).

Three features of major concern were selected for this purpose: the lake or reservoir, the flood plains and the agriculture/settlement areas. The result was to produce the following:

1. Areas that were not Lake or Reservoir in 1976 but have changed to Lake or Reservoir in 2014 so as to know whether the lake is expanding or not as has been the fear of Nigerians.

2. Areas that were flood plains in 1976 but have changed to other land-use types in 2014. This was done to determine the land areas of the flood plains that have been lost within the study periods to other land use types.

3. Areas that were not intensive agriculture/settlement in 1976 but have changed to intensive agriculture in 2014 so as to assess the rate of land captured by intensive agriculture/settlement within the study periods.

3.5.3.2Change detection techniques Threechange detection methods which have been previously applied by several researchers (Adeniyi and Omojala, 1999; Ikusemoran, 2009a) were employed in this assessment.

3.5.3.3Change Detection by Area Calculation 1. The first step is the calculation of the magnitude of change, which is derived by subtracting observed change of each period of years from the previous period of years.

2. The second step is the calculation of the trends, that is, the percentage change of each of the land-use, by subtracting the percentage of the previous land-use from the recent land-use divided by the total land-use and multiplied by

$$100\left(\frac{B-A}{T\times 100}\right)(1.0)$$

3. The last is the calculation of the annual rate of change by dividing the percentage change by 100 and multiplied by the number of the study years, that is 38 years (1976-2014)

3.5.4 Secondary Data Sources In most research, pre-existing researches and information serve as inportant sources of relevant data which can be readily collected and studied by other researchers, without the need of going to the field. This information can be used as sources to extract the required information for the of the study (Kumar, 1999).

The present study utilized secondary data obtained from different sources. Various publications related to environment, hydropower project management plans, and the Environmental and Social Impact Assessment (ESIA) of the proposed Kiriproject, were used. The data also involved articles, journals, internet materials and reports about the project. These sources were collected mainly from the UBRBDA, EPA, GOBADEC project office and the Kiri dam project site, Modibbo AdamaUniversity of Technology Yola, and also from NGOs websites.

While using the data obtained from secondary sources, it is important to be aware that the use of information from secondary sources can suffer from personal and institutional bias as these documents may exhibit less rigorousness and objectivity (Kumar, 1999, Punch, 2005). Be that as it may, the secondary sources have been part of the data used to examine the issues associated with the proposed Kiri hydropower project.

3.6 Data Analysis The information obtained from the study wereanalyzed using statement explanationsStatistical techniques

were used to analyze the data generated from the study. Some of the software utilized was Statistical Package for Social Sciences (SPSS) and Microsoft Excel. The results were presented in the form of charts,bars, and tables. To enable a detailed write up of the Environmental Impact Assessment (EIA) report of the hydroelectric power project.

3.7 Environmental Baseline

3.7.1 Bio-physical Environment

3.7.1.1 Location and Extent

Kiri-dam is located on the flood plain of lower Gongola river basin, about 25 kilometre upstream of its confluence with river Benue at Numan, while Gongola valley is located within the upper Benue trough. It was formed as a rift phase due to the development of triple junction at a location close to the present Niger delta. The rift was due to lithospheric peak thinning which caused long narrow complex depressions, which develop in some places filled with variety of sedimentary environment (Whiteman, 1982, reported in Mubi, 2001). Specifically, Kiri-dam is located in Shelleng Local Government Area of Adamawa state and situated on latitude 09^0 39'00" N – 09^0 54'00"N and longitude 11^0 57' 00" E– 12^0 06' 00" E as shown in Fig. 3.1 below, the map linking DadinKawo and Kiri dam is also shown below in Figure 3.2

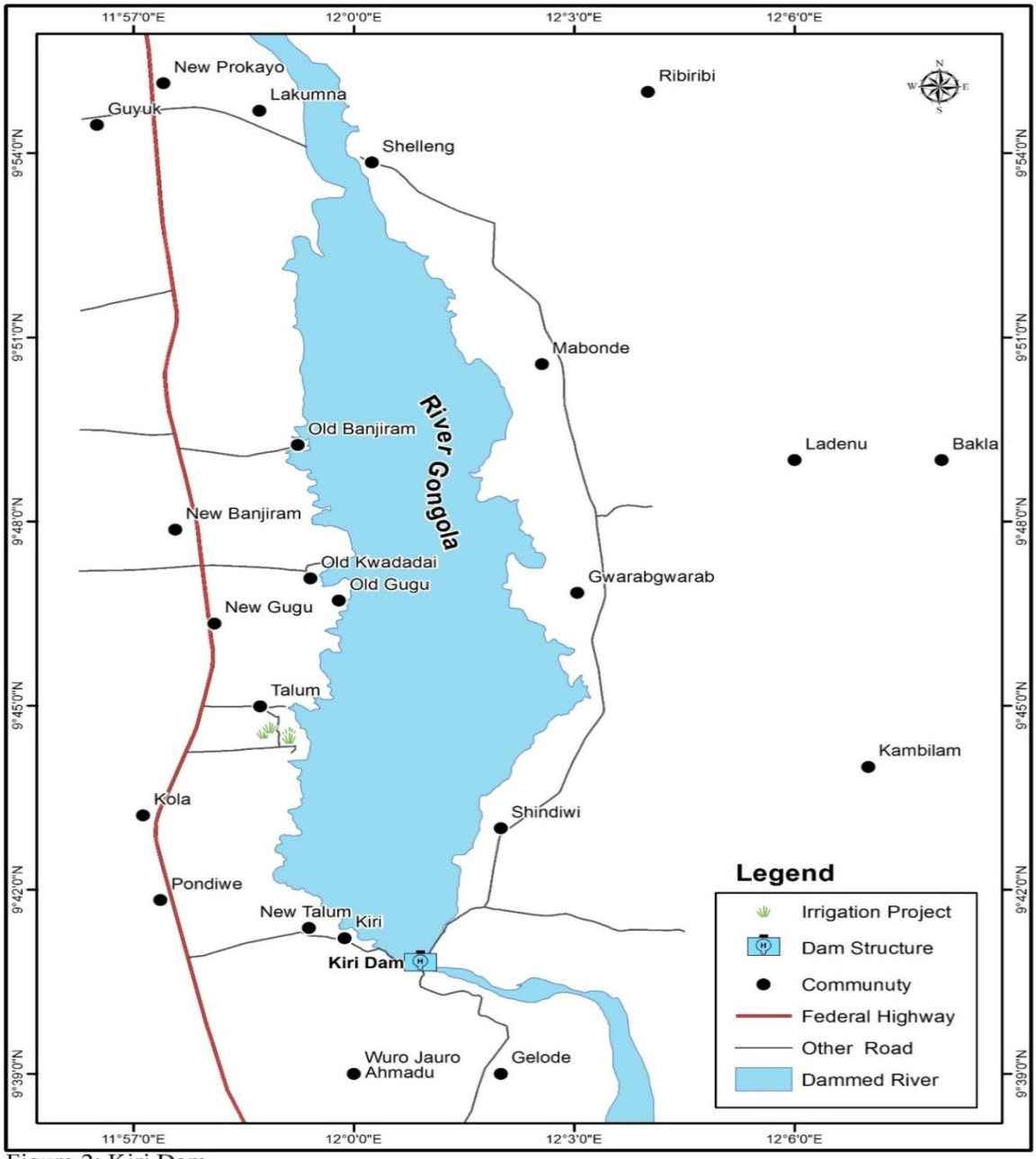


Figure 2: Kiri Dam
Source: Adapted and Modified from Google Maps, 2013

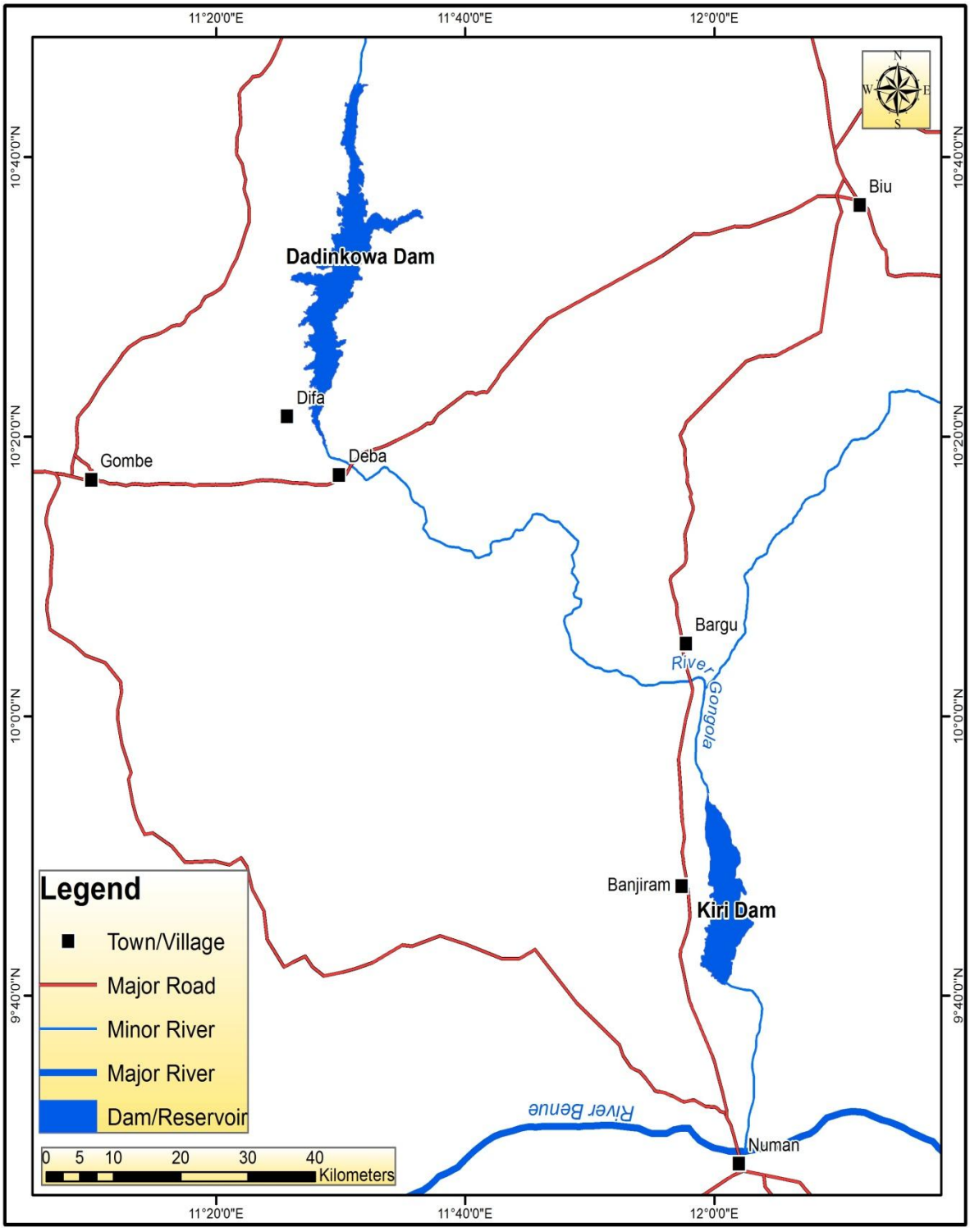


Figure 3.2: Map Showing Connection of Dadin Kowa Dam & Kiri Dam
Source: Modified from the Drainage Map of Nigeria

3.7.1.2 Geology This study area is situated on sedimentary rock made up of shale and thin bands of shale of limestone and lignite. It contains wide range of alluvial deposit along wide channels of river Benue and Gongola which overlies the cretaceous deposit (Olokor, 1995).

3.7.1.3 Relief and Drainage The study area is low land between 500-700 meters above sea level. The land forms are extensive flood plains and alluvial swamps. Most of the areas are liable to flooding, water logging or swamps along river catchments. The subsoil and shale formation allow underground flow of water, which raises water table during raining season and reduces it during dry season (Olokor, 1995).

3.7.1.4 Climate Kiri-dam is located in the lower Gongola valley. It has lower rainfall valley. The upper part of Gongola valley is the northern guinea with the high ground and higher rainfall. Geneally, Kiri is within one of the Gongola zones known as the Hawul catchment of the sudan zone.

The climate has two distinct single peaks and usually recorded, in the months of June and September. The rainfall regime in the area is tropical continental types of single peak toll usually in the month of August. The wet season ranges from April to September, with annual rainfall values between 510-1040 mm and dry season last for 7 months (Olokor, 1995).

Kiri area of the Gongola valley has warm temperature with a mean annual of 18^0 C in December (minimum) to a mean annual of 38^0 C in March (maximum). The evapotranspiration is very high throughout the year. Relative humidity varies greatly

throughout the year. It is high from May to October, which ranges from 60-78% but has lowest values during dry season, which ranges from 27-35% (Olokor, 1995). Table 3.3 shows mean monthly values of some climatic elements of the area.

Table 3.3: Agro - Meteorological Data (Station: Tallum)

Months	Rainfall (mm)	Temperature (℃)	R/ Humidity (%)	Evaporation	Wind Speed (Km/day)
Jan	0.00	35	28	310.50	189.50
Feb	0.00	36	29	395.10	231.30
Mar	14.60	39	82	453.90	279.60
Apr	24.80	40	78	459.00	343.50
May	77.80	35	90	365.70	325.60
Jun	96.30	34	93	306.40	366.80
Jul	158.30	31	95	177.10	244.00
Aug	174.50	31	91	174.60	158.00
Sep	159.70	32	87	170.00	137.10
Oct	660.00	34	91	181.90	106.00
Nov	0.01	35	84	200.10	111.10
Dec	0.00	33	38	265.90	187.80

Source:UBRBDA 2012

3.7.1.5 Soil and Vegetation The soil types of the area are mainly clay and it encourages water logging of the plains during raining season. The natural vegetation is partially distributed due to deforestation as a result of fuel fire wood and agricultural activities. The zone has mixed vegetation, trees intersperse with grasses. The common tree species are *Terminaliaglancescern*, *Albaiziachevacies* (Baure), *Acacia Sieberiana* (farm kaya), *Balaniteaegytiaca* (Adua'a), *TamarindusIndica* (Tsamiya), *ZizipusSpina-christi* (Magarya), *Parkiabigalobossa* (Daurawa), *Buttraspermuparadoxa* (Kadanya), *VitexDonnia* (Dinya) and *Pilostigma reticulate* (Kargo) (Cowper, 1973). The dominant grass species in the zone are *Pennisetum*, *Adropogon*, *Hyprrhenia*, *Barachana*and *Aristida* species etc. suitable for grazing livestock.

3.7.1.6 Surface Water Use.

Mainly springs and groundwater are used for agricultural purposes in the villages. The river is used by the fauna species and by livestock to some extent. There are a number of alluvial water wells for irrigation purpose located close to Tallum. Therefore, there is no significant use of river water by the locals living in the area for drinking, irrigation or production purposes.

The irrigation network is not well developed in the area, and it is not estimated that irrigation needs were increase significantly in the future.

3.7.1.7 Terrestrial Habitats.

Five (5) distinct habitat types occur in the project area. They include: dry deciduous forest; riparian woodland; open forest with grass; termitaria vegetation; and grasslands. These habitats support a large variety of biodiversity including large fauna, birds, reptiles and rodents.

3.8 Project Description

3.8.1 Description of existing project

This description of Kiri dam project is taken from a briefing document provided by the project owner and operator, the Upper Benue River Basin Development Authority. The dam project construction was completed by the authority in 1982. It was planned and designed by Ward, Ashcroft and Parkman of Nigeria and Sir Alexander Gibb of the United Kingdom. Construction work was completed by NECCO of Nigeria.

The primary purpose of the dam is irrigation which sustains sugar production and commercialization of the sugar. Other purposes of the dam include: access over the river linking local towns, fishing in the stilling basin and reservoir, small irrigation activities

upstream and downstream of the project outside of the dam irrigation facilities and some form of recreation.

The project is located on the Gongola River near Kiri village in Adamawa state, in the north eastern region of Nigeria. The dam is about 25 km upstream of the confluence of the Gongola River with the Benue River. The Benue River is part of the Niger River basin. The project consists of a large earthen embankment with a concrete spillway with large tainter gates for high flow release. The irrigation facilities consist of intake facilities at the right abutment of the dam. These facilities (as shown in Plate 1) feed project related distribution canals with the irrigation water and some of the facilities and features are shown in Table 3.4 below. There are also low-level gates called scour sluices to release low level water through the dam and keep sediment from building up around the irrigation facilities.



Plate 1: Photograph of the Existing Structure

Table 3.4: Facilities and features of Kiri Dam

Dam	
Type	Embankment
Height	about 20m above river bed
Approximate Length	1,250 m

	Top of Dam	174.5m
	Freeboard above Flood Max elevation	3 m
Reservoir		
	Drainage	56,200Km^2
	Normal Top Water Level	170.5 m
	Lowest Level Water Level	162.7 m
	Design Flood (inflow)	4,250 m^3/s
	Design Flood (outflow)	4,000 m^3/s
	Flood Water Level	171.5 m
	Surface Area at 17.05 m	107,000,000 m^2
	Live Storage from 167.2 - 170.5 m	290,000,000 m^2
	Dead Storage below 167.2 m	325,000,000 m^2
Spillway		
	Type	Concrete
	Number and type of gates	six, radial
	Width of gate openings	12.75 m
	Approximate spillway height	37 m
Scour Sluices		
	Number and type	3 - sealed radial gates
	Openings size	3.5 m wide, 2.9 m high
	Capacity	approx 120 cm^3 at full pool
Main canal		
	Type	Lined earth
	Total length	13.5 km
	Line/ unlined lengths	6 km, 7.5 km
	Maximum discharge capacity	19 m^3/s

CHAPTER FOUR

ANALYSIS OF DATA AND DISCUSSION OF RESULT

4.1 Introduction

This chapter presents and analyses the data which have been collected from the field and other secondary sources in relation to the set objectives of the study. The main focus of the study was to assess the environmental and social impacts of `dams' hydropower development in particular the case of the proposed Kiri hydropower project in Nigeria.

4.2Hydrology Assessment of the Project The Kiri dam hydrology is highly affected by the operation of the Dadin Kowa dam. The available information was provided by the Upper Benue River Basin Development Authority (UBRBDA), who recommended that the best data for use was for the operation period of 1990-2009. The primary information utilized was the spillway releases recorded at Kiri dam as shown in Table 4.1 by the authority and the monthly mean flow release is shown in Table 4.2, plus the expected modification provided by hydropower operations at Dadin Kowa Dam as shown in Table 4.4.

The hydropower operations will change the project releases , so changes must be taken into account. Hydropower operations at Dadin Kowa will, according to the authority, require dry season releases for generation resulting in Dadin Kowa reservoir drawdown. This will allow increase flow to Kiri to enable operation during dry months as shown in Table 4.4. According to Upper Benue River Basin Development Authority (UBRBDA)'the irrigation waters are used for a period that equates to about 70% of the time and an average of $12m^3/s$ when flow is released. Second priority is for flushing flows of the sluice gates. These releases are necessary to keep sediments from building up in the reservoir and threatening

both the intakes for irrigation and usable storage. As flushing releases cannot be used for generation due to heavy sediments and debris; a basic understanding is that only flows that would be released by the tainter gates on the project would be usable for hydropower. It is unlikely that much of the project storage is available for or useful for hydropower purposes as it is utilised for irrigation. Additionally, the available Kiri Dam storage is small compared to the substantial needs for seasonal hydropower storage volume as shown in Table 4.4. The Kiri Dam storage is enough to make use of the hydropower releases from Dadin Kowa as shown in Table 4.4. Table 4.1 is a record of the releases from Kiri for the period 1999-2009.

These volumes can be related to the necessary volumes of water necessary to generate 20MW with flows of 260-311x 10^6 cubic meters. It is really seen for the four months period of July to October, there is ample flow of full generation. During the four month period of January to April, there is virtually very zero flow for generation and for the months of June, November and December there is some available flow for generation, but only partial generation. For May, the flows generally are not available for about seventeen of the years and then abundant for two of the nine year period of record shown in Table 4.1

Table 4.1:Monthly Spillway Release Volume – Historical

KIRI DAM **unadjusted**

FULL PERIOD OF SPILWAY RELEASE RECORD **1999-2009**

Release Volume in Million Cubic Meters

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
	m^3*10^6	m^3*10^6	m^3*10^6	m^3*10^6	m^3*10^6	m^3*10^6	m^3*10^6	m^3*10^6	m^3*10^6	m^3*10^6	m^3*10^6	m^3*10^6	m^3*10^6
1990	10	0	0	0	0	173	680	1697	1066	536	186	134	**6472**
1991	15	0	0	0	428	176	1291	1552	1361	482	218	111	**7625**
1992	23	0	0	0	0	167	437	2004	3007	431	101	100	**8262**
1993	39	0	0	0	28	186	408	1406	795	361	117	80	**5413**
1994	0	0	0	0	0	135	495	2430	3629	1434	374	52	**10543**
1995	54	0	0	0	0	142	706	1369	1806	932	105	80	**7216**
1996	45	0	0	0	0	173	518	1503	1690	805	187	81	**6998**
1997	12	0	0	0	398	319	512	1354	988	439	172	81	**6272**
1998	8	0	0	0	4	246	464	1934	3254	1202	244	90	**9444**
1999	0	0	0	0	0	0	673	2269	1731	1776	371	0	**8819**
2000	0	0	0	0	0	372	765	2875	1203	1414	498	44	**9172**
2001	0	0	0	0	0	316	473	3006	3474	972	187	294	**10723**
2002	0	0	0	0	0	0	595	910	1276	1079	316	0	**6178**
2003	0	0	0	0	0	584	755	2462	2848	1493	463	47	**10655**
2004	0	0	0	0	0	322	585	1632	3868	1321	326	164	**10221**
2005	0	0	0	0	0	175	1000	3106	2471	1311	201	46	**10315**
2006	0	0	0	0	0	0	687	1431	2082	1434	506	34	**8181**
2007	0	0	0	0	0	190	591	2462	3629	1684	0	0	**10563**
2008	0	0	0	0	0	192	3306	3006	2375	1169	236	0	**12290**
2009	0	0	0	0	172	137	309	578	1689	749	706	76	**6426**
MEAN	**10**	**0**	**0**	**0**	**51**	**200**	**763**	**1951**	**2212**	**1051**	**276**	**76**	**6590**

Table 4.2: Monthly Mean Flow Release

KIRI DAM RESERVOIR OPERATIONS MONTHLY MEAN DAILY SPILLWAY RELEASES (m^3/sec) 1990-2009

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEP	OCT	NOV	DEC
	m^3/Sec	m^3/Sec	m^3/Sec	m^3/Sec	m^3/Sec	m^3/Sec	m^3/Sec	m^3/Sec	m^3/Sec	m^3/Sec	m^3/Sec	m^3/Sec
1990	4	0	0	0	0	67	254	634	411	200	72	50
1991	6	0	0	0	160	68	482	579	525	180	84	41
1992	9	0	0	0	0	64	163	748	1160	161	39	37
1993	15	0	0	0	10	72	152	525	307	135	45	30
1994	0	0	0	0	0	52	185	907	1400	535	144	19
1995	20	0	0	0	0	55	264	521	697	348	41	30
1996	17	0	0	0	0	67	193	561	652	301	72	30
1997	4	0	0	0	149	123	191	506	381	164	66	30
1998	3	0	0	0	1	95	173	722	1255	449	94	34
1999	0	0	0	0	0	0	251	847	668	663	143	0
2000	0	0	0	0	0	144	286	1074	464	528	192	16
2001	0	0	0	0	0	122	177	1122	1340	363	72	110
2002	0	0	0	0	0	0	222	340	492	403	122	0
2003	0	0	0	0	0	225	282	919	1099	557	179	18
2004	0	0	0	0	0	124	218	609	1492	493	126	61
2005	0	0	0	0	0	68	373	1160	953	490	78	17
2006	0	0	0	0	0	0	257	534	803	535	195	13
2007	0	0	0	0	0	73	221	919	1400	629	0	0
2008	0	0	0	0	0	74	1234	1122	916	436	91	0
2009	0	0	0	0	64	53	115	216	652	280	272	28
MEAN	**0**	**0**	**0**	**0**	**6**	**80**	**331**	**806**	**935**	**489**	**134**	**24**

Although there is unserved needs in the vicinity, power is generally considered inexpensive and available during the wet season, when Kiri Dam would generate. It is mostly valuable during the dry season, when the weather is hotter and load is greater, and other hydropower less available. Thus, justifying any hydropower project on the basis of full generation during the wet four months and zero generation during the dryest four months is difficult.

The installation of the 34MW of hydropower at DadinKowawill result in adoption according to the authority of what would appear to be radically different release schedule from the project. As shown in Table 4.4, the DadinKowaproject will be releasing on an average basis volumes of water varying from 138-302 x 10^6 m^3 of water monthly.

Table 4.3: **Kiri Dam Estimated Flow Duration Curve for Generation With Dadin Kowa Hydropower (Unadjusted)**

Flow M^3/sec	Percent Exceedance
1279	0%
740	5%
455	10%
369	15%
278	20%
198	25%
168	30%
143	35%
129	40%
120	45%
114	50%
114	55%
107	60%
103	65%
103	70%
103	75%
60	80%
53	85%
53	90%
52	95%
18	99.2%

Table 4.4:Post-Hydropower Installation at Dadin Kowa Release Balance

DADIN KOWA DAM OPERATION SIMULATION MODEL BASED ON MONTHLY MEAN FLOWS OF GONGOLA RIVER (1955-1977)

Month	Reservoir Storage at beginning month (Mm^3)	Irrigation releases (Mm^3)	Domestic water supply releases (Mm^3)	Res. surface evaporation (Mm^3)	H.E.P releases into turbines (Mm^3)	Average generation release (M^3/sec)	Total outflow (withdrawal + evaporation) (Mm^3)	Direct rainfall in res. Surface (Mm^3)	Inflow into res. (Mm^3)	Total (inflow + rainfall on res. Surface) (Mm^3)	Res. Storage at the end of the month (Mm^3)
Jan	2434.618	21.43	2.36	27.47	276.143	103	327.403	0	29.46	29.46	2136.675
Feb	2136.675	21.43	2.36	25.47	276.143	103	325.403	0	24.071	24.071	1835.343
Mar	1835.343	21.43	2.36	25.2	276.143	103	325.133	0	24.829	24.829	1535.039
Apr	1535.039	21.43	2.36	22.36	138.072	52	184.222	3.68	25.427	29.107	1319.917
May	1319.917		2.36	21.09	138.072	52	161.522	9.75	87.763	97.513	1255.908
Jun	1255.908		2.36	14.68	276.143	103	293.183	27.85	279.025	306.875	1269.6
Jul	1269.6		2.36	10.26	302.927	113	315.547	35.4	405.51	440.91	1394.963
Aug	1394.963		2.36	9.25	302.927	113	314.537	43.05	1193.23	1236.28	2316.706
Sep	2316.706		2.36	16.43	302.927	113	321.717	28.6	1091.59	1120.19	3115.179
Oct	3115.179		2.36	24.47	302.927	113	329.757	6.5	250.1	256.6	3042.022
Nov	3042.022	21.43	2.36	20.79	302.927	113	347.507	0	58.32	58.32	2752.835
Dec	2752.835	21.43	2.36	21.94	302.927	113	348.657	0	30.44	30.44	2434.618
Total		128.58	28.32	239.41	3198.278		3456.516	154.83	3499.765	3399.765	
					266.52316				**291.6470**		
Mean	**2034.067**	**21.43**	**2.36**	**19.95083**	**7**		**299.549**	**12.9025**	**8**	**296.21625**	**2034.067**

At 34MW about 3,200 million cubic meters of water per year will be used for the Dadin Kowa hydropower generation. This volume is an engineering average. The actual amount would vary, but there is no data for this study to evaluate the impact of variability. The retiming of these flow rates will substantially change the hydrology at Kiri for generation. The 3,200 million cubic meters of volume is about half of the 6,590 million cubic meters of average spillway release volume at Kiri. The Dadin Kowa re-timed release make up virtually all of the generating flow during the five dry months of the year and a substantial boost in November and December as shown in Table 4.4.

4.3Kiri HPP Power Potential and Options **4.3.1**

Generating Potential Before evaluating the individual options, the generating potential capacity and energy was evaluated. The method used was flow duration analysis. Information for the evaluation was assumed or found as follows.

i.Hydrology used is the flow duration curve of Table 4.3

ii. Net Head on the project is the difference between the full pool elevation of 170.5 meters and a measured tailwater elevation under low flow, approximately 200 meters downstream, of 145.0 meters

iii. A tailwater increase up to 1 meter at high flow (over 600m^3/sec)

iv.A two-equal unit arrangement would be used, with two separate penstocks, due to required penstock size considerations

v. Hydraulic losses were estimated by presuming a size and length of penstock with some intake losses

vi. Total efficiency of the plant was estimated to be 86% based on individual efficiency of 90% turbine, 97.5% generator and 98% transformer

vii. The highest one percent flow and lowest one percent flows were discounted for generation

viii. A five percent loss rate for outage and other losses were included

Findings of the potential energy analysis with DadinKowa flows are:

i. For about 20MW, the plant design flow would be about 105m^3/s

ii. The plant would generate on an average annual basis about 142GWh as shown in Table 4.5. Without the DadinKowa hydropower releases, the project would only generate about one-half of this amount and all during the wet season

iii. The plant could operate at full output about 60% of the time and more than 17MW for 80% of the time.

iv. During the lowest period of 20% of the time, the plant output would drop to 7-10 MW

The analysis is provided below. It presumes two, 4.8 meter diameter penstocks feeding identical 10MW units operating at 86% efficiency, including turbine, generator and transformer efficiencies

Table 4.5: Annual Energy Production Estimate

Kiri Dam – With DadinKowa Hydropower

POTENTIAL ENERGY ASSESSMENT – FLOW FROM DADIN KOWA GENERATION

Generating Flow **105 M^3/Sec**

Gross Head **24.5 Meters**

Efficiency Assumption **86%**

Flow M^3/sec	% exceed	Interval %	Hours	Gen flow M^3/sec	Tailwater Est >Q=0	Hydraulic losses m	Net Head m	interval capacity kW	interval Energy kWh
1279	0.								
740	5	5	438	105	1	1.8	21.7	19203	8411001
455	10	5	438	105	0.8	1.8	21.9	19380	8488521
369	15	5	438	105	0.7	1.8	22	19469	8527282
278	20	5	438	105	0.5	1.8	22.2	19646	8604803
198	25	5	438	105	0.4	1.8	22.3	19734	8643563
168	30	5	438	105	0.4	1.8	22.3	19734	8643563
143	35	5	438	105	0.4	1.8	22.3	19734	8643563
129	40	5	438	105	0.4	1.8	22.3	19734	8643563
120	45	5	438	105	0.3	1.8	22.4	19823	8682323
114	50	5	438	105	0.3	1.8	22.4	19823	8682323
114	55	5	438	105	0.3	1.8	22.4	19823	8682323
107	60	5	438	105	0.25	1.5	22.75	20132	8817985
103	65	5	438	103	0.2	1.2	23.1	20062	8787074
103	70	5	438	103	0.2	1	23.3	20236	8863152
103	75	5	438	103	0.2	1	23.3	20236	8863152
60	80	5	438	60	0.2	1	23.3	11877	5202285
53	85	5	438	53	0.1	1.35	23.05	10343	4530161
53	90	5	438	53	0	0.8	23.7	10634	4657910
52	95	5	438	52	0	0.75	23.75	10313	4517164
18	99.2	4.2	365	18	0	0.75	23.75	3614	1319029
		99.2%							150210741
								losses@5%	7510537
								net energy	142700204

4.4Options for Installation

There are basically three options for implementing hydro at the Kiri Dam, utilizing:

1. Scour Gates

2. Tainter Gates

3. In Embankment (section replacement)

4.4.1 Scour Gates

There are three scour gates in the main spillway. The gates are designed to sluice flows through the spillway section at the lowest live storage level of the reservoir and release sediments that otherwise would begin to limit the storage capacity and irrigation water yield of the project. The scour gates consist of radial gates that seal against contoured concrete to provide an effective seal and release mechanism. The gates sill is at elevation 156 meters, which is considered the bottom of the reservoir pond. It is presumed that the pond has silted to this level over time. The three individually controlled gates are each capable of passing about $120m^3$/sec with a nearly full pool and gates fully open. The sluice gates are located adjacent to the intake area of the irrigation works, so that the sediment sluicing can be most effective. The $120m^3$/sec is based on free pressure downstream from the gate, unlike capturing the flow for generation and maintaining maximum pressure.

As the lowest level gates in the system, the scour gates are also the source of drawdown in the case of a dam safety emergency or the unlikely event that the reservoir must be drawn down or lowered below the gated spillway sill.

Initially, it would appear that installing one or two penstocks in the scour gate bays would be the simplest method of adding electricity generating facilities at the project. However, such an installation would require:

i. Removal of the sluicing tainter gate and the operating facilities; **ii.** Installation of a sealed penstock and transition from the existing opening because of the concrete and the limitations of space, the penstock would be limited to 3.5 meters in diameter (Φ)

iii. Design of an upstream intake modifier-essentially moving the water withdrawn from the reservoir bottom (Elevation 156) to a higher level above the silt accumulations. Such an elevation remains to be selected. However the intake would need to be fabricated to withdraw well above the bottom level and include hydraulically efficient water passages to avoid excessive head loss, a cleanable intake rack structure to keep debris or rock from the intake and a method of cleaning and maintaining the intake. The existing bulkhead and gate should be sufficient to remain in place for the water conveyance system downstream of it.

iv. The penstock will need to be protected from highly turbulent flood flows and scour debris from the maintained scour gate(s). It will likely need to be encased in substantial concrete. The route could also conflict with an overflow spillway from the irrigation canal which intersects the spillway abutment wall

v. Construction of a downstream powerhouse below the stilling basin and revetment area.

4.4.1.1 Advantages of the scour gate This option would appear to have the smallest physical impact on the overall structure. It would not conflict with flood operation of the reservoir.

4.4.1.2 Disadvantages of the scour gate

i. This option will have limited and relatively small output compared to other options. The single penstock will be limited to inflowof about 30 m^3/sec. while the open flow of the existing radial gate is rated at up to 120 m^3/sec that flow is reached by utilizing high pressure from behind the dam and low in the reservoir to a free surface. The penstock flow must be limited in velocity to a typical 3 m/sec velocity. Thus, the output of each bay used will be only about 5-6 MW depending ultimately on the head. Unless further study found conversely, it is difficult to justify utilizing more than one scour gate for hydro purposes as these are needed for emergency drawdown and sediment sluicing.

ii. The simplicity of the option is compromised due to: possible conflict with remaining scour gates, possible conflict with irrigation intake; possible conflict with canal spillway/abutment wall intersection and intake modification.

iii. Development and installation of intake modifications upstream of the existing bulkhead gate is difficult and expensive.

4.4.2 Tainter Gates This option would remove one of the spillway taintergates, replacing it with an open "box" drawing from the reservoir over the existing sill. The pressure box would have walls to the

height of maximum pond (171.5m) and have an intake into the pressure penstock. The penstock would exit the spillway and silling basin/revetment area through the left (facing downstream) with a powerhouse constructed on the left bank of the river.Because of the size of the tainter gate bays, the generating flows ofup to 105 m^3/sec can be accommodated.

Bay 1 would be used for hydropower works as it is away from the scour sluices and the irrigation works.

4.4.2.1 Advantages of the tainter gate option

i. There would be no limitations on the capacity of the plant, up to 20MW or greater, without demolition of the spillway concrete.

ii. Construction could be completed mostly in the dry season, using a bulkhead gate upstream of the existing tainter gate.

iii. There would be limited demolition work.

iv. The works would be on the opposite end of the spillway from irrigation and sluicing operations.

4.4.2.2 Disadvantages of the tainter gate option

i.The installation would result in the loss of one tainter gate bay, removing one-sixth of the flood passage capacity of the reservoir. The design flood release for the project is 4000 m^3/sec so the loss of one gate would require compensation of about 670 m^3/sec. The compensation would have to be made by lowering a section of the spillway, below 171.5 m. Such compensation will not be easy or inexpensive.

iii. Maintaining the critical transportation across the embankment area during construction and afterward will be very expensive.

iv. With the noted instability of flows in the stilling basing, the installation of the penstock and changes to release may be difficult and require some large structures.

4.4.3 New intake; penstocks through embankment The hydroelectric facilities could be constructed in the embankment part of the dam, on the left side of the spillway. Construction of much of the works could be done in the dry, however completion of the inlet channel and breach of the embankment must be done behind cofferdams placed in the reservoir, as the irrigation pond cannot be lowered due to primacy of this use and criticality of the irrigation purposes.

4.4.3.1 Advantages of new intake option

i. The facilities would have no impact on any of the existing release features of the dam including the irrigation intake, scour gates or spillway gates;

ii. The output of the project would not be limited by space limitations but dictated by cost/value considerations;

iii. The facilities would be away from the downstream river, making flood protected construction easier and less expensive.

4.4.3.2 Disadvantages of new intake option

i. The project involves partial removal of a section of embankment, which would need to be completed behind cofferdams and may include expensive treatments, grouting or other subsurface barriers to ensure the integrity of the embankment design capability.

4.5Description of the Proposed Project Installation

4.5.1 KiriDam Hydro-Power Project (HPP)

Kiri dam HPP Project which is planned to be constructed on Gongola River with a capacity of 20MW is located near the community of Kiri. It will contribute to the development of the national economy with an annual production of 142 GWh. The economic life of the project is predicted as 50 years.

4.5.2 Plan, Features and Construction

The plan consist of constructing a new intake in the reservoir of the Kiri project, placing two penstocks through the dam by breaching and replacing the dam, constructing a new power house downstream on the left side of the river with two generating units of 10 MW each. A tailrace will return generating flow to the main stream of the channel, downstream of the stilling basin and revetment area.The project is described starting at the upstream end.

As the project reservoir cannot be drained, the project upstream of the dam must be constructed with the full pool. Therefore a cofferdam must be installed. The cofferdams contemplated consist of a main section of full height of the dam or from the expected bottom of reservoir elevation of 154 up to the top of dam at 174.5. The circular cofferdam would consist of four steel circular cells, driven in section below the reservoir floor. Each

cell will be 13 meters in diameter and would be back filled to the top elevation (and slightly above for transportation and access) with sand and appropriate fill material. The cells will be connected by curved sections to fill in between the cells, with each section, six in all, and 15 meters long. These areas would also be backfilled to the top level and with the cells, create a rim around the construction area for the intake tower.

The cells will be connected to the impact dam by fill sections starting at the top of the dam and angling out to the cells. In order to remain impervious, either a special centre selection or outer geo-textile may be necessary. The fill section will be provided at both ends of the cells to maintain transportation across the dam while the tower intake is constructed and the penstock sections through the dam are placed.

The cofferdam is the most expensive cost ($20 million) element to the entire project. It may be that there are less expensive methods than the cellular cofferdams, including placing a larger fill dam on a longer footprint around the work area. However the more traditional method used in this type of construction is the cellular dam and it has been used to estimate costs.

After construction of the cofferdam, excavation of the embankment will be started. The basic excavation will be about 100 meter wide, with a bottom section 30 meters wide to the bottom and side slopes/access cut into the outside sections. The amount may vary depending on the contractors' final method selection.

After excavation, construction of the intake tower, transition area and penstock placement will take place. The intake tower will be approximately 7.7 meters wide on the upstream face, and 7 meters of the side. About 70% of the upstream and side faces will be open for

intake flow. At the bottom elevation, there will be a concrete transition section for flow to enter the two, 4.8 meter diameter penstocks. The intake tower will also have the ability to stop pressure flows through the penstocks by means of bulkhead gates. These gates would not normally be used but are necessary for dewatering the penstocks. The tower and foundation will be of reinforced concrete.

The penstocks will route through the embankment at its lowest or foundation level. The penstocks will be spaced at about 3 meters apart for total space of about 30 meter from outside to outside of the penstocks. The penstocks may be embedded in concrete or included cut-off walls or curtains to avoid any potential of piping of flows. Additionally, the embankment materials will be replaced to the original design. A concrete bulkhead will be at the exit of the penstocks on the downstream slopes.

The penstocks will proceed about 150 meters downstream from the downstream toe of the embankment. The powerhouse location should be set at a place where the flat river bottom land starts to go uphill to higher ground.

The penstocks' traverse of 150 meters will be above ground, secured to saddles. A concrete trust block will be constructed where the penstocks enter the powerhouse.

The powerhouse will be a substructure with two levels above the ground grade level. The floor of the powerhouse will be about 2 meters above the expected tailwater level of 145 meters but and will be flood proof, essentially a concrete container, eight feet above the base floor or to elevation 155. Entry to the powerhouse upper floor will be at the grade of

the back side of the powerhouse. Fill from the foundation excavation will be used to make the upper level at grade from the land side.

The powerhouse is planned to have two 10 MW horizontal Francis turbines. With a horizontal placement, the penstock can enter through the powerhouse wall. A butterfly valve for starting the unit and dewatering will be inside the powerhouse. The units will have the scroll case sitting vertically and the turbine shaft will be supported by a journal bearing and mates to the generator. The flow from the unit will exit through the powerhouse floor to a tailrace under the powerhouse. The draft tube will be an elbow tube leading to free surface departure underneath the powerhouse.

It should note that the project parameter of 52.5 m^3/sec and 23 meters of the head are on the margin of the use of Francis or Kaplan units. Because there is not a substantial variation of flow and head over a typical year and because construction is likely less expensive, horizontal Francis units are to used. A more detailed comparison will be necessary for any future phase of development, with specific input from turbine suppliers. With currently active market for hydroelectric turbines, suppliers are hesitant to provide quotations for projects that are not further along in the development path.

The powerhouse will have a footprint of about 30 meter by 20 meters. As discussed the level, up to elevation 155 will be flood proof. Access for removal of the generator or large items will be through roof hatches. Only a gantry crane will be provided in the powerhouse so a larger crane will be necessary for construction and removal of larger items. Ventilation

for cooling of the units will be done through a ducting system through the substructure roof.

The upper level of the powerhouse will be smaller, approximately 10 meter square and a pre-engineered building to minimize costs. The upper level will contain the control and the relay panel, the operating office and the access stairs to the generating floor.

The switchyard will be constructed adjacent to the powerhouse at elevation 155^0. It will consist of two 15,000 KVA rated transformers, one for each units. The switchyard will also contain two breakers to connect to the high voltage transmission lines to connect to the grid or load.

Flows from the turbines will be returned to the main channel which is approximately 200 meters long. The final length of the tailrace will depend on the final location of the powerhouse.

4.5.3 Power Evacuation Power will be evacuated by two 33 kV circuit directly to the Yola substation. The manner of evacuation was determined by Adamawa State in order to assure that Adamawa would receive all the power generated. To accomplish this power evacuation at 33 kV, two circuits will be used on one transmission pole (likely concrete) or a single lattice type tower.

Approximately 10 MW of power will be generated by each unit at medium voltage, likely at 6000 VAC as this is an accepted International Electrochemical Commission (IEC)medium voltage. Power factor will be 0.85 and the units will generate full power at this power factor. The generators will generate power in a grounded Wye configuration

with a resistance ground to minimize fault current. Power will be taken from the generator to a medium voltage, metal clad switchgear in the power building for distribution to the generator step up transformers and the transmission lines outside the generator building. In addition to the circuit control in the metal clad switchgear, a 33 kV line disconnect switch and circuit breaker will be install in the 33 kV line near the generator step up transformers. Net power metering will be done from current transformers at 33 kV circuit out of the generator step up transformers and voltage transformers at 33 kV. Net power and energy can thus be metered and totalized as required. A circuit from the main bus in the metal clad switchgear will be used for station power. This may also be metered in accordance with Yola Electricity Distribution Company requirements. Yola Electricity Distribution Company requirements will determine if an emergency power system is required.

Current transformers and voltage transformers will be place in the generator, transformers and metal clad switchgear as required for metering, synchronization and protection relays. Control of the plant can be performed from instrumentation and controls in the metal clad switchgear or remotely as Adamawa and the project Company desire.

Communication and control is currently handled by line carrier, but it is anticipated that a more sophisticated System Control and Data Acquisition (SCADA) will be employed from Kiri Dam to Yola by an Optical Ground Wire System (OPGW).

4.5.4 Construction Cost Estimate The total project costs are about $60 million, including a 20% contingency, appropriate for this level of details in an estimate. The electrical and mechanical features are based on costs from

industry and other similar projects and are in line with standard estimates. The civil works, intake, cofferdam, embankment work, penstocks and powerhouses are estimated from rough quantities necessary for implementation as shown in Table 4.6 below. Dimensions and materials are specific to each feature, although the feature design is subject to substantial modification in future development.

The cost estimate is solely for development and construction, financing costs, further environmental studies and other items not directly encountered during construction is presented in Table 4.6 below.

Table 4.6: Cost Estimate, kiri Dam Construction (Year 2014)

Item		Requirement	Unit Cost	Unit	Total Cost ($)	Comment
Engineering and Design					2,500,000	Further studies, design, bidding documents
Mobilization		Mobe, Demobe, 24 month	75,000	Month	3,300,000	Contractors site costs
Mechanical						
	General Equipment	2 x 10MW Horiz Francis	18,000,000		3,600,000	Estimated from recent supply
	Installation		750,000	Lump	750,000	Estimated from similar project
	Gates	2 x Butterfly	200,000		400,000	Recent supply estimate
	Other	Pumps, piping, valves	200,000	Lump	200,000	
	Subtotal				**10,750,000**	
Electricity						
	Generator	2 x 12 MVA Generators	2,000,000		4,000,000	Recent supply estimate
	Controls	Fully automatic operation	200,000	Lump Sum	200,000	From an example for similar size project
	Relays and Breakers	Protection and interconn.	250,000	Lump Sum	250,000	
	Transformer	2 x 14000 KVA	250,000		500,000	
	Switchyard	2 HV Breakers, yard			0	
	Communications	SCADA and other	50,000	Lump Sum	50,000	
	Subtotal				**5,000,000**	
Civil						
	Cofferdamming				20,500,000	Calculated from estimated quantities
	Dam Excavation and Replace	Breach of dam section			5,280,000	Calculated from estimated quantities
	Tower intake	25 W x 7 Long x 20 High			1,200,000	Calculated from estimated quantities
	Bridge to Intake	60 meters, 3 M wide		Lump Sum	600,000	Cost of about $500/meter
	Valves at Intake	2 gate	200,000		400,000	
	Penstock					
	Furnish	4.8 m, 2 x 3 M wide	800	ton	1,300,000	Calculated from estimated quantities
	Install	Saddles, weld, place		Lump Sum	2,000,000	Calculated from estimated quantities
	Tailrace Excavation					
	Excavation	200 M long	23,200	M^3	1,300,000	30% rock and 70 % Common
	Liming and finish	Rock or textile	1000	M^2	200,000	
	Transition to unit connection				0	

Powerhouse			1,180,000	Calculated from estimated quantities
Access Roads	Abutment area to pH		200,000	
Site Preparation			200,000	
Subtotal			**34,360,000**	
Plant and Equipment Total			50,110,000	
Contingency (approx. 20%)		Approx. 20%	10,040,000	
Transmission Lines			18,600,000	
Subtotal			**18,600,000**	
TOTAL			**78,750,000**	

4.5.5Operations Cost Estimate The 20MW Kiri Hydro Project is regarded as a small hydro project and could be operated from a mostly automated condition. The plant output would vary often and the plant could be dispatched by changing turbine settings remote. It could be operated with nearly the same staffs that operate the Kiri Dam project.

The estimate assumes the addition of one plant manager and two operators, plus labour for other activities. It does not include any taxes or other fees, as the Upper Benue Development Authority (UBRBDA) may not be subject to such payments. The cost estimate for the Operations is shown below in Table 4.7.

Table 4.7: Annual Cost Estimate; Kiri Dam Operations (Year 2014)

Operation and maintenance		Amount ($)	
Labour			
	Plant Manager	40,000	
	Plant Operation(2)	25,000	
	Maintenance Personnel	15,000	
	Plant Labour	12,000	
	Secretary/Clerical	5,000	
	Subtotal		**97,000**
Materials		40,000	
	Subtotal		**40,000**
Expenses			
	Office supplies	2,500	
	Office equipment	1,000	
	Vehicles	30,000	
	Gas, oil and maintenance	25,000	
	Spare parts	20,000	
	Travel and Lodging	10,000	
	Meal	5,000	
	Subtotal		**93,500**
Outside Services			
	Phone, FAX, email	12,000	
	Electricity	2,000	
	Equipment maintenance	5,000	
	Security	5,000	
	Miscellaneous	10,000	
	Subtotal		**34,000**
Cost of Administration			
	Plant Management Board	12,000	
	Accounting and Audit	15,000	
	Legal	6,000	
	Miscellaneous	15,000	
	Subtotal		**48,000**
Repair and Replacement Fund			
		50,000	
	Subtotal		**50,000**
Contingency Fund			
		25,000	
	Subtotal		**25,000**
	Total		**387,500**

4.5.6Energy and Production

Theenergy and production baseline for this option is the same; 142 GWh, with nominal 20 MW capacity. As noted, the production may be slightly overstated due to lowered reservoir pool elevations near the end of the dry period and the estimation of changed regulation of both DadinKowa for hydropower and Kiri. However, some compensation was taken to consider the effect.

The project would run at or near full output during more than 70% of the year. During that time, the output would only be limited by lost head due to rising tailwater during the high flow months or by flows held to reach the maximum Kiri storage level. During 25% of the year, the project would run at less output, dropping down to 8-10 MW during the driest 15% of the year. During the driest 35% (about 4 months) of the year, the generation would average about 45 GWh.

These estimates are based on current irrigation demands and the operation of the new hydroelectric capacity at DadinKowa releasing water as represented by the Upper Benue Development Authority (UBRBDA). The releases and availability of the DadinKowa generating flows are essential to any dry season generation at Kiri. Without these flows, the Kiri generation would be nearly zero during dry months.

The Authority also advised that the irrigation demands downstream of DadinKowa could increase. Further, the irrigation releases from Kiri may also increase substantially. An energy estimate was made for irrigation demands downstream of DadinKowa of 180 million cubic meters per month during the dry season and increase of irrigation from the

Kiri facilities. It was also noted by the Authority that the sugar companies who utilize the irrigation flow may double the land area currently under irrigation. The baseline numbers were using an average release of 12m^3/sec during the driest 70% of the year. The maximum channel capacity of the irrigation works, according to the summary information is $19m^3/sec$. Thus, an additional $7m^3$/sec was taken from the available flows for Kiri generation.

The plant generation essentially drops 9 GWh, all in the driest six months of the year from 45 GWh. This power is the most valuable of the year. It would drop the average capacity by 2.2MWduring this period from the current irrigation condition. During the driest 10% of the year the loss is most pronounced as it would drop capacity from 7.5MW to 4.4MW.

4.5.7Summary

The best option would be to construct the project on the left hand side of the dam spillway, about the 300-400 meters from the spillway and away from the shore line. The project penstocks need to penetrate the embankment, which requires substantial cofferdams upstream to construct the works. The project would have a large vertical intake in the existing reservoir, about 250 meters of dual 4.8 meter diameter penstocks. The power house would sit about 150 meters downstream of the dam. It would be constructed of concrete and house two-10MW generating units, likely of horizontal Francis design. An excavated tailrace returns the generating flows to the river.

The project would generate nearly 20 MW continually during the wettest 70% of the year. It would also generate substantial energy during the other 30% (about 4months) of the dry season. However generation is dependent on the DadinKowa providing substantial summer generation flows, with only a part of them used for irrigation upstream of Kiri. Otherwise,

there will be virtually no generation during the dry one-half of the year. The project will generate about 142 GWh/year under current irrigation uses with the 20 MW of installed capacity. It would cost $60,000,000 to construct and take about two and one half year or aquarter (of a year) to complete after ordering turbine-generator equipment. The transmission line to Yola substation is estimated at $18,600,000.

Table 4.8:Salient Features of the ProposedKiri HPP

Item	Detail
Location of DHP	NearKiri town,district Shelleng, Adamawa
Installed Capacity	20MW
Total Energy	142GWh/year
Catchment area at dam site	56,200 km^2
Type of dam	Embankment
Height above foundation	20m
reservoir volume	615 x 10^6 m^3
Average Reservoir width	10,344m
Diversion tunnels	2
Power house location	surface type, on the left bank of the river
Penstocks	2
Tailrace	150m
intake tower	7 x 25m
No. of Generating Units	2
Spillway Bays	6
Flushing tunnels	2
Length of transmission line	85km
Generating Flow	105m/s
Gross Head	24.5m
Efficiency Assumption	86%

4.6 Land-Use and Land Cover Changes in the Kiri Lake Basin (1976-2014) Figure 4.1 below showing the first four data set which covers a total period of 38 years are the

main images that were acquired for the monitoring of the lake basin. The first data set have a large gap of ten years, while the middle set have a close gap and the last set a very large gap. This was designed to reflect the impact of the dam in the past years of low population and the recent years when the population of the region has been increasing tremendously. All four images were acquired between late October and early December which is the transition period between the wetand dry season, and climatic conditions during this period are the same all over the lake basin (Olokor, 1995), hence the vegetation cover and land-use types appear the same on the image regardless of the year they were obtained.

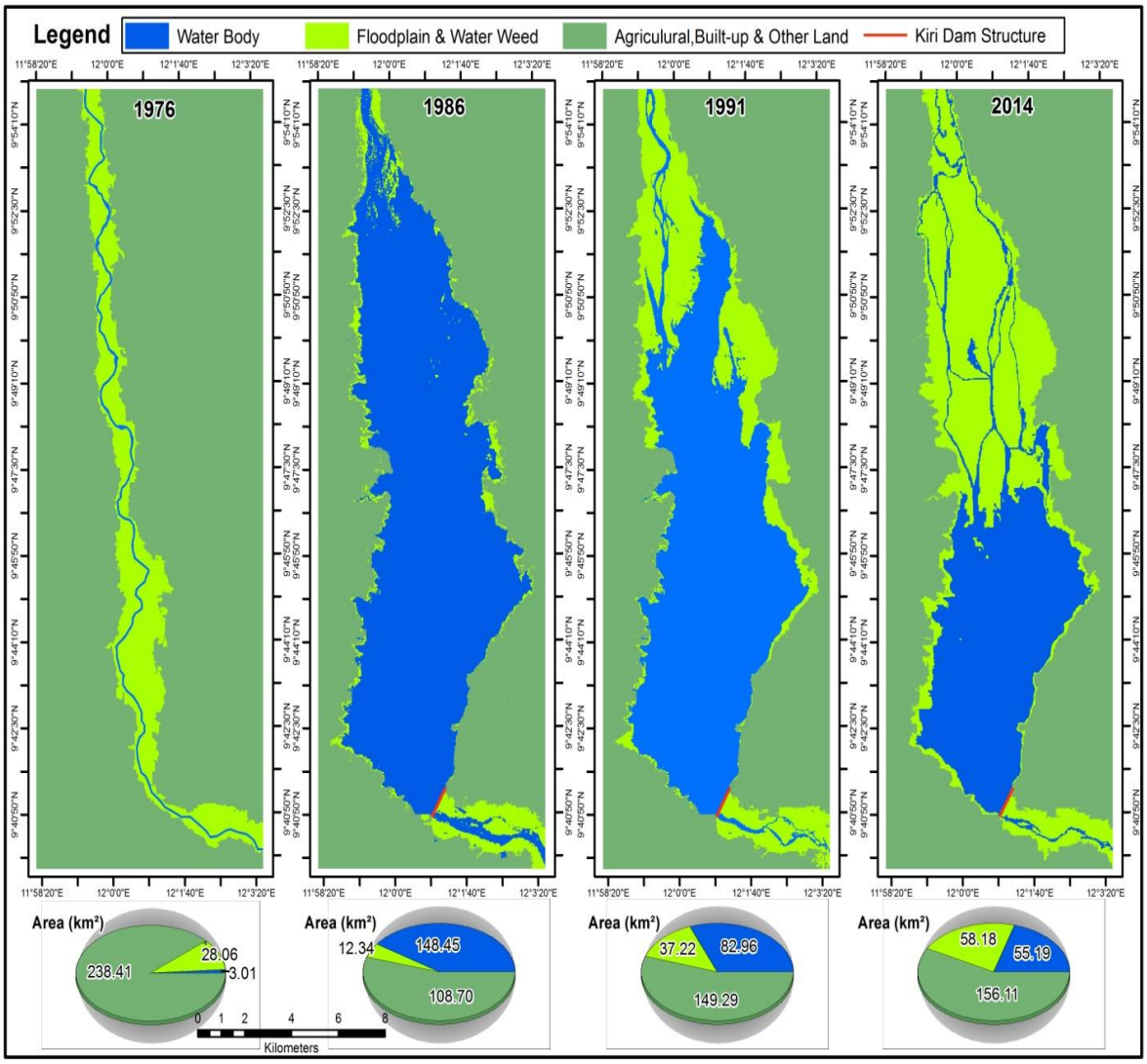


Figure 4.1 Classified Landsat images ofKiri Lake Basin in 1976, 1986, 1991, 2014.

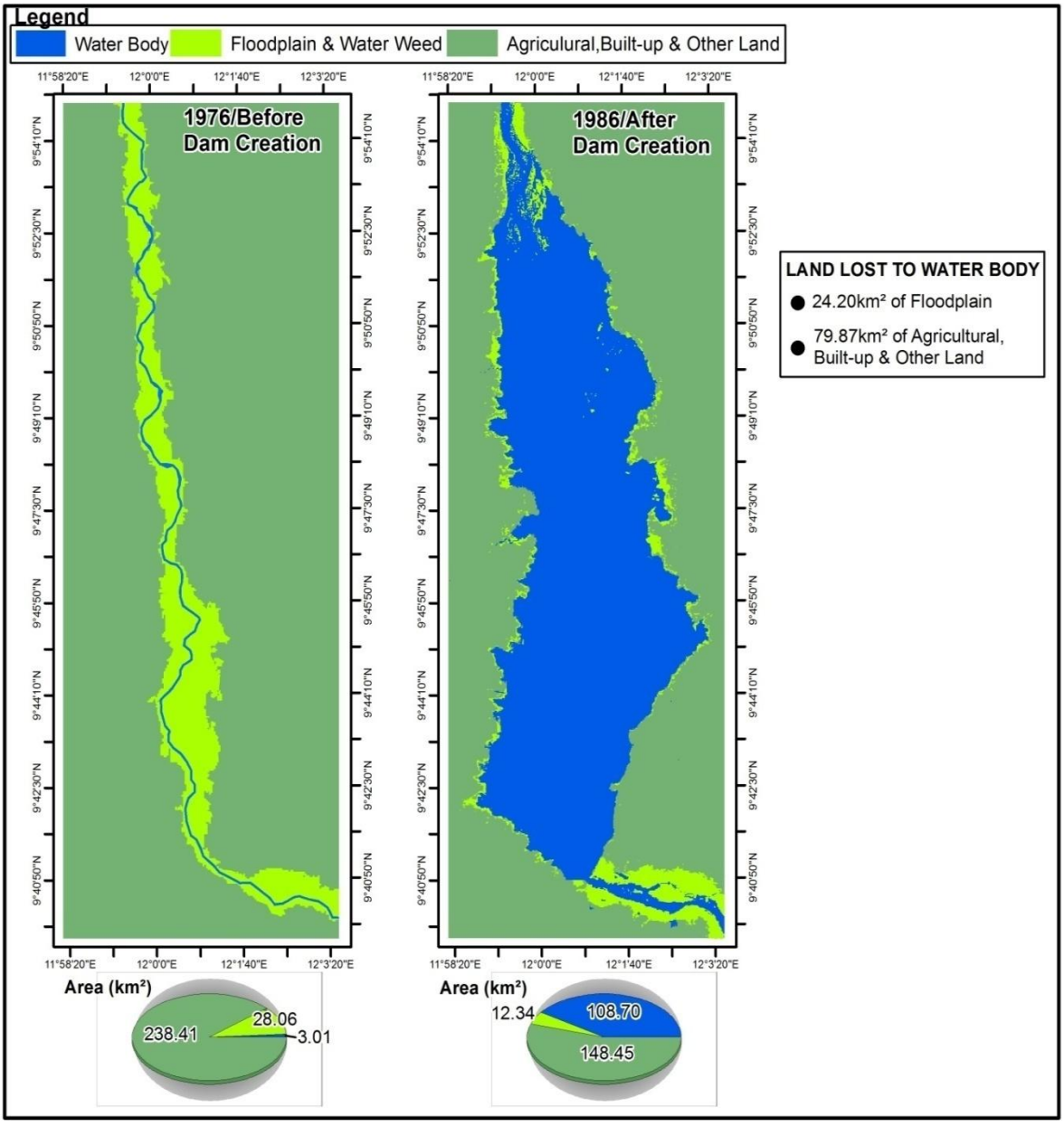


Figure 4.2 Classified Kiri Lake Basin immediately before and after the dam construction

The result of the trends of changes of the land-use and landcover of Kiri Lake basin is presented in Table 4.8, while the magnitudes, percentage changes and annual rate of changes are presented in Table 4.9, Table 4.10, Table 4.11, and Table 4.12. Moreover,

Figure 4.2 represents each of the four classified images of 1976, 1986, 1991 and 2014 respectively.

Table : 4.9 The trends of the landuse/landcover of the river basin (1976-2014)

	1976		1986		2001		2006	
Land-use/Landcover	**Area (Km^2)**	**Area (%)**	**Area (Km^2)**	**Area (%)**	**Area (Km^2)**	**Area (%)**	**Area (Km^2)**	**Area (%)**
Lake /Reservoir	3.01	1.11	148.85	55.15	82.96	30.79	55.19	20.48
Flood Plain/Water weeds	28.06	10.41	12.34	4.57	37.22	13.81	58.18	21.59
Agriculture, Settlement and others	238.41	88.47	108.70	40.28	149.29	55.40	156.11	57.93
Total	**269.48**	**99.99**	**269.89**	**100**	**269.47**	**100**	**269.48**	**100**

Table 4.10: The magnitudes, percentage and annual rate of change of the lake basin (1976-1986)

Land-use/Landcover	**1976 (km^2)**	**1986 (km^2)**	**Magnitude of Change (km^2)**	**Percentage Change (%)**	**Annual rate of change**	**Remark**
Lake /Reservoir	3.01	148.85	145.84	50.07	+19.02	Increase
Flood Plain/Water weeds	28.06	12.34	15.72	5.39	-2.05	Decrease
Agriculture, Settlement and others	238.41	108.7	129.71	44.53	-16.92	Decrease
Total	**269.48**	**269.49**	**291.27**	**99.99**	**0.049**	

Table 4.11: The magnitudes, percentage and annual rate of change of the lake basin (1986-1991)

Land-use/Landcover	**1986 (km^2)**	**1991 (km^2)**	**Magnitude of Change (km^2)**	**Percentage Change (%)**	**Annual rate of change**	**Remark**
Lake/ Reservoir	148.85	82.96	65.89	50.16	-19.06	Decrease
Flood Plain/Water weeds	12.34	37.22	24.88	18.94	7.2	Increase
Agriculture, Settlement and others	108.7	149.29	40.59	30.9	11.74	Increase
Total	**269.49**	**269.47**	**131.36**	**100**	**0.118**	

Table 4.12: The magnitudes, percentage and annual rate of change of the lake basin (1991-2014)

Land-use/Landcover	1991 (km^2)	2014 (km^2)	Magnitude of Change (%)	Percentage Change (%)	Annual rate of change	Remark
Lake /Reservoir	82.96	55.19	27.77	49.99	-18.9	decrease
Flood Plain/Water weeds	37.22	58.18	20.96	37.73	14.34	increase
Agriculture, Settlement and others	149.29	156.11	6.82	12.28	4.66	increase
Total	**269.47**	**269.48**	**55.55**	**100**	**0.106**	

Table 4.9 shows the trends in terms of the area coverage and the percentage of each class of the basin area from 1976 to 2014. Itreveals that the lake reservoir which covered 3.01 km^2 in 1976 has increased to 55.19 km^2 (addition of 52.18 km^2 lake/reservoir) in 2014. The flood plains have also increased from 10.41% in 1976 to 21.59% in 2014. Also, between 1986 and 2014 a decrease in the volume of the reservoir can be noticed indicating sedimentation due to human activities along the river banks and flood plains as noted by Mubi (2001). Finally, between 1976 and 2014 it can be seen that land meant for agriculture, human settlement and development has decreased from 88.47% to 57.93% due to flooding.

In Tables 4.10, 4.11 and 4.12the total land area that was subjected to changes (magnitude) in the lake basin is revealed to be 291.27 km^2between 1976 and 1986 which decreased to 131.36 km^2before 1991 and reduced drastically to 55.55 km^2 in 2006. This means that some parts of the lake have been subjected to changes. This was also revealed in Figure 4.2 Extensive agriculture/grazing land and human settlement had the highest percentage changes of 88.47% and 40.28%, respectively, between 1976 and 1986.

From 1986 through 2001 to 2014, extensive agriculture/grazing land reduced drastically which is a result of the policy of the Federal Government against grazing in the basin area

in order to protect the forests. This policy has always resulted in communal clashes between the communities, the park rangers and the nomads (Mayowa and Omojola, 2005; Ikusemoran, 2009b; Henry *et al.*, 2013; Wahab and Adewumi, 2013).

4.6.1 The Extent of the Changes of Each Land-Use/Land Cover

It is important to know the extent of each land-use type so as to assess the area coverage of the areas in any desired unit and percentages for proper land-use planning. The image calculator of the Arc GIS software was used to determine the extent of the changes on the lake reservoir, flood plains and agriculture/human settlement. These three classes are of great concern to the country as the lake has been a subject of concern as having the possibility of dam collapse. The values of the area of each class were also use to create Table 4.13 as shown below.

Table 4.13: The extent of changes of the lake reservoir, flood plains and agriculture/human settlement(1991-2014)

Land-Use/Land-Cover class	Magnitude of Change (%)	Percentage Change (%)
1.Lake Reservoir in 2014 but not lake reservoir in 1991	27.77	49.99
2. Agriculture/Human Settlement but not in 1991	20.96	37.73
3. Flood plains in 2004 but not flood plains in 1991	6.82	12.28

A total area of 52.18 km^2 representing 94.55% (Table 4.13) of the lake basin has been captured by the reservoir between 1976 and 2014. This means that the lake is actually expanding as has earlier been reported by Mubi (2001). The flood plain has also lost a total area of 30.12 km^2 between 1976 and 2014. Intensive agriculture is the degrading factor of the basin as 82.3 km^2 (34.52%) of the basin area have been lost to intensive agriculture

between 1976 and 2014 (Table 4.13). this conforms to earlier reports of Henry *et al*. (2010) that increased human and cattle population is continuously putting more pressure on the lake Kiri area and has ultimately caused fragmentation and degradation of wildlife habitats.

4.7 Projection of Future Changes within the Basin

Considering the geomorphologic changes that have taken place within the Gongola basin since the inception ofKiri dam, the incorporation of the proposed hydropower component to the Kiri dam and its dependence on the hydrology of DadinKowa hydro project for generating flows, It can be observed from the Figure 4.3 below that flooding flows are much likely to increase with time as power generation takes place.

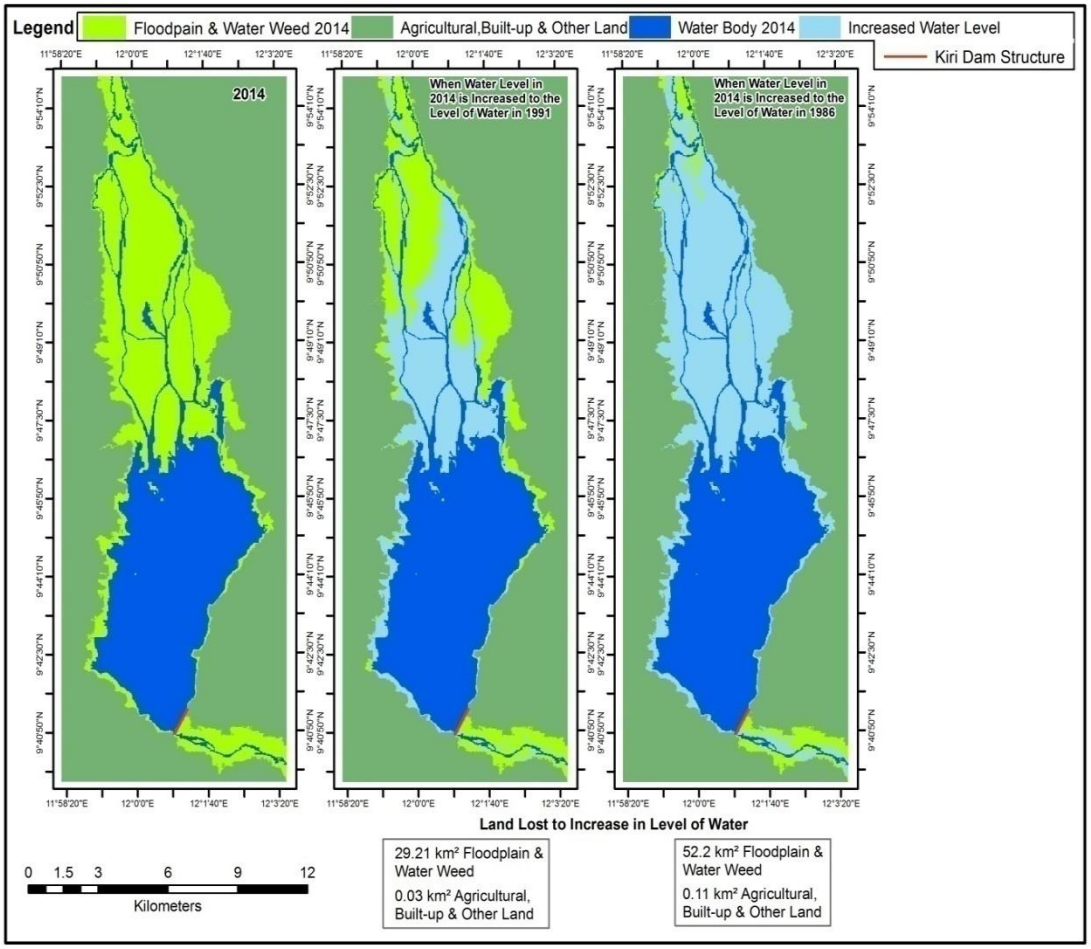


Fig 4.3: Potential Basin Characteristic after Kiri HPPInstallation

Comparing the present basin characteristics to an increase in the level of water to what it was in 1991, it can be seen that approximately 29km^2 of flood plains and 0.03km^2 of agricultural and other purpose of land will be lost to flooding flows. Similarly, if the current water level were to reach its level in 1986, approximately 52 km^2 of floodplains and 0.11 km^2 of agricultural and built-up lands will be lost to flooding flows.

4.8 Socio-Demographic Survey

The survey covered, to an appreciable extent a comprehensive cross-section of the people in the selected villages, in terms of education and gender.

Overall, 77% of the sample population had either no formal or primary school level education. Based on the above result, it can be said that quite a large proportion of the population in the selected towns have low level of education. This is exhibited in Figure 4.4and Figure 4.5 as shown below and plotted from Tables A1 and A2 (Appendix A) respectively.

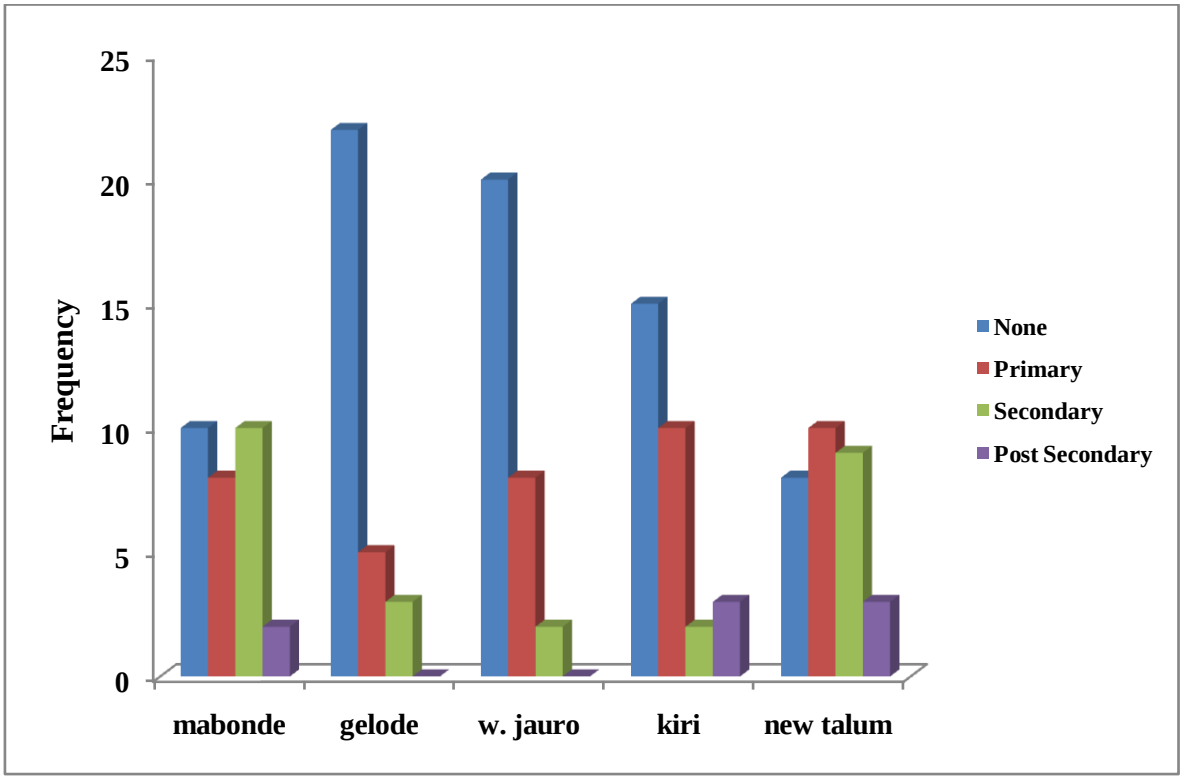


Figure 4.4: Respondents' Level of Education in Selected Towns

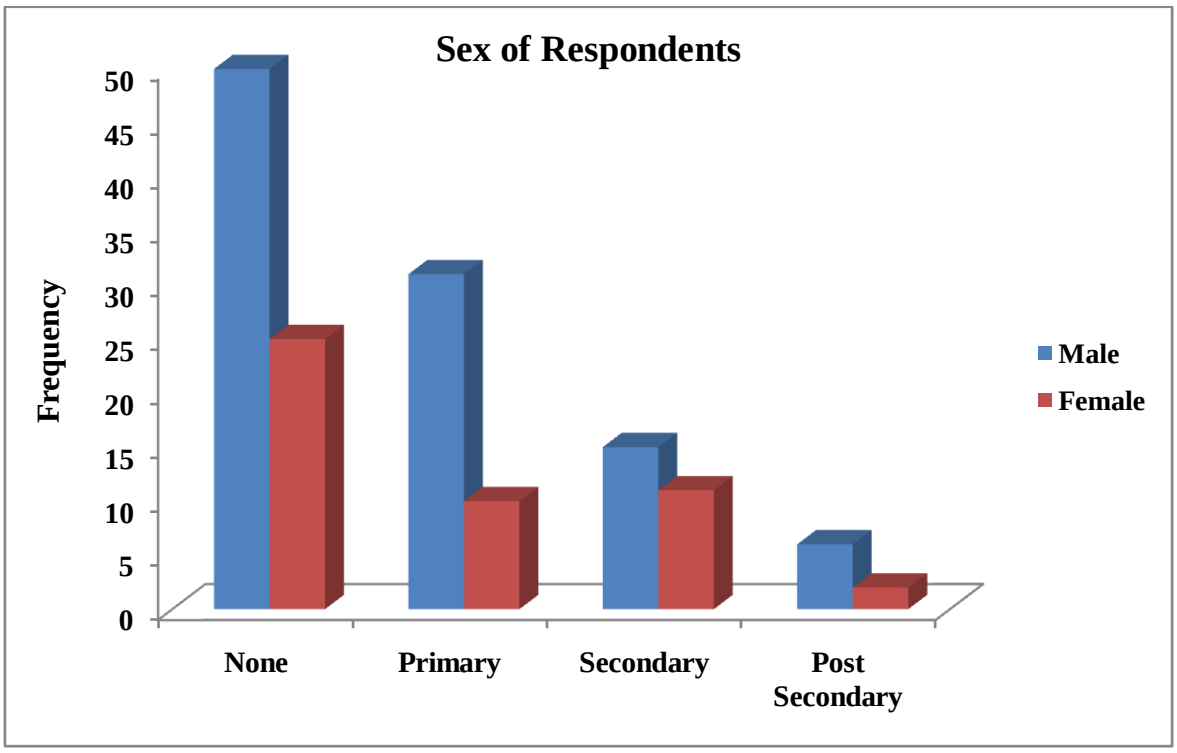


Figure 4.5:Educational Background of the Respondents according to Sex

4.8.1Socio-Demographic Background

According the field survey, a large number of the respondents engaged in theagricultural sector. The result from the study confirmed that 45.3% of the respondentswere farmers, 22.7% were fishermen, 6% were petty traders and 2% were students as shown in Figure 4.6 and plotted from Table B (Appendix B)below.Agriculture activity plays major role in the local economy as the main source of income.Some of the food crops produced in the study areaare maize, sorghum, groundnuts,vegetable and soybean. Predominantly, this activity was on subsistence basis due to thefact that the people use traditional methods of farming practices such as crop rotationand mixed cropping on relatively small land holdings. As

mentioned earlier the majorityof the people are farmers because of the farming methods they are using the socioeconomicstatus of the area can be said to be very low. None of the surveyed villagespractice modern or mechanized commercial farming despite, the closeness to the lakeand suitability of the area for irrigation farming.

The next most important source of income among all the five villages was fishing.

This comprised of about 22.7% of the total respondents. It was noticeable that thesecommunities are closer to the Gongola River and therefore convenient to work in thissector to supplement or to boost their household income. Generally, the surveyedvillages are deprived in terms of the standard of living. Usually, socio-economicindicators as improvement of housing, access to service, improvement of quality of lifeand degree of satisfaction were used to measure the living standards.

One of the main advantages of dam's development in the world is for its multiplicity ofuses, apart from the hydropower generation it is also for irrigation, fishing and watersupply for the benefit of the host/whole community. However, the studyclearly shows that the multipurpose use potential of the KiriDam has not been fully utilized by the selected villages. A possible reason is due to a lack ofunderstandable and defined collaboration between the responsible authority and thelocal people. This could be one of the contributing factors for the low state of thesocio-economic standard of the area.

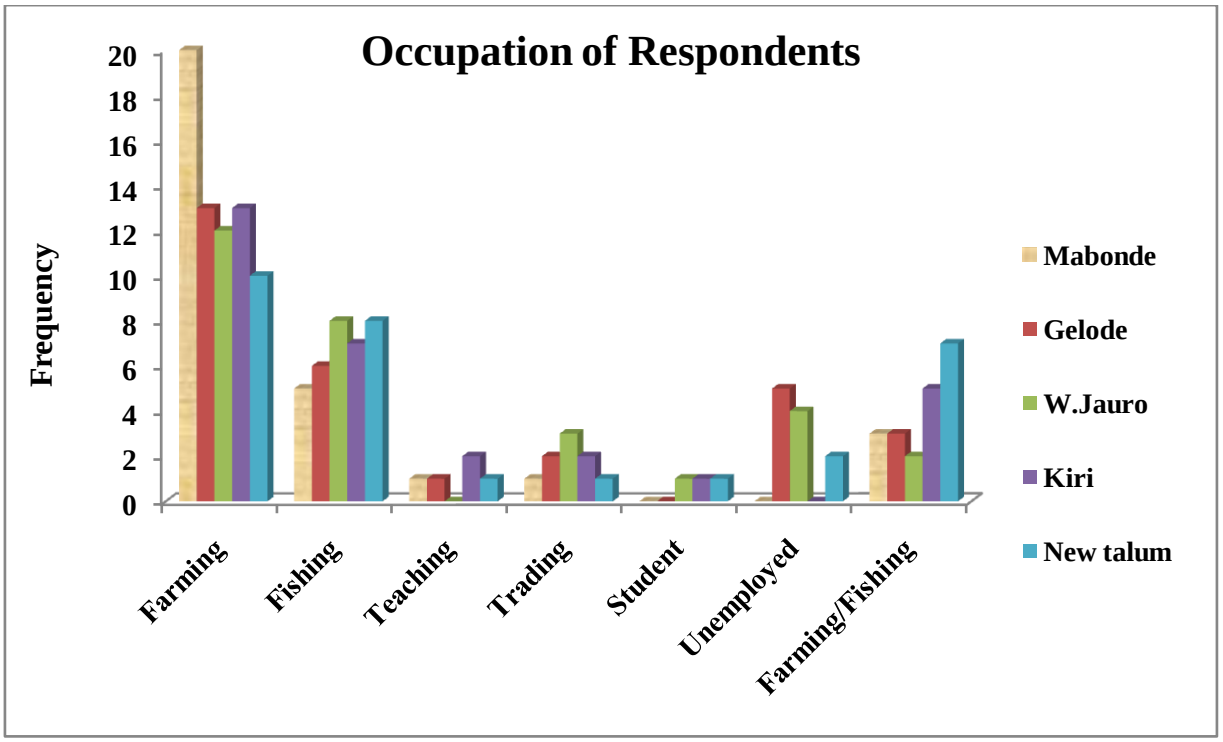


Figure4.6:Occupation of Respondents in the Selected Towns

4.9 Reported Adverse Impacts of the Dam Dam reservoir is a water expanse, which is worthwhile to see as the beauty of a man-made recourse for economic development of the region. It has been observed that the construction ofKiriDam has resulted in the depletion of the geographical scene of the region. For instance, the former dense vegetation cover and major fertile farmlands of the catchments area has been submerged and lost under the impounded water. This is because the project involved large scale alteration and utilization of land which disrupted the existing system of land use, which has been extended beyond the project area. It was gathered that the activities of the dam construction encroaches the marginal lands, which is evidence that it occupied some significant farmlands. For example, about 40.0% of the respondents were of

the view that the dam construction was responsible for environmental degradation in the area. On the other hand 23.3% of the respondents were of the view that environmental degradation was due to causes other than the dam. According to them, the causes of environmental degradation are deforestation and farming activities (16.7%), while (20.0%) attributed this to some other factors such as climatic change, nature, etc as shown in Figure 4.7 and plotted from Table C (Appendix C).

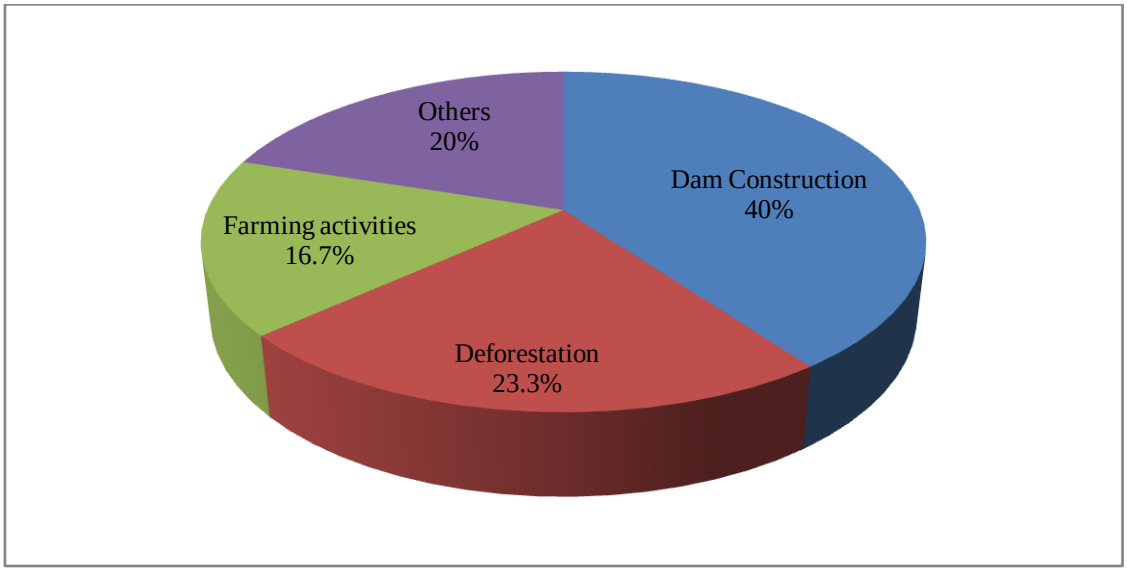


Figure 4.7:Reported Causes of Environmental Degradation

According to one school teacher in Kiri, the peasants had been dispossessed of their lands, homes and fruiting trees as a result of the creation of KiriDam. similarly, it was reported that some of their ancestral and religious shrines such as mosques, churches, missionary clinics, veterinary clinics, John-Holt buildings, fertile flood plains, twelve fishing ponds and cultural heritage such Cemeteries, `Majema' i.e. local and leather training industries,all

have gone under water. This is because Kiri settlement was mostly affected due to its proximity to the dam.

4.10Environmental Impacts Identified Environmental impacts identified varied from village to village. However, data collectedfrom the field show that the large numbers of the respondents indicated that erosion isone of the main environmental problems facing the Kiri dam.

Secondly, flooding was identified as a common problem mostly in the surveyeddownstream villages, the explanation given for the flooding could be geographical incharacter since the area is located in the downstream of the dam and when the spillway of the dam opens and closes some parts of Kiri becomes inundated and water loggedfor several hours to some days.

Thirdly, deforestation or the clearance of vegetation in general has been identified asone of the major environmental problem in the study area. The causes of deforestationare common across the globe. However, it is the extent that may vary from region toregion. The most important factor worldwide as well as in the study area is thepermanent conversions of forest to agricultural land, particularly slash and burnagriculture (Thomas, 1992). Other cause of deforestation is increased populationpressure, combined with poverty and landlessness with uncontrolledhuman settlement,lack of awareness of forest fire and demand for fuel wood etc. The consequences ofdeforestation are the acceleration of soil erosion, watershed and downstream problemsof siltation. Generally, the most serious and most short-sighted consequence ofdeforestation is the loss of biodiversity, loss of export resources, drought, and shortageof fuel wood.

Lastly, pollution has also been recognized as a problem. According to the respondents, the main source of the pollution is derived from the savannah sugar company. Some of the respondents indicated that they suspect that the savannah sugar company may be discharging waste water into the river/lake. However, this issue of pollution cannot be verified without a more profound and detailed study. Due to this reason this study will not look at the problem of pollution into it detail.

The following Table D (Appendix D)shows the most commonenvironmental issues identified in the study area in Figure 4.8.

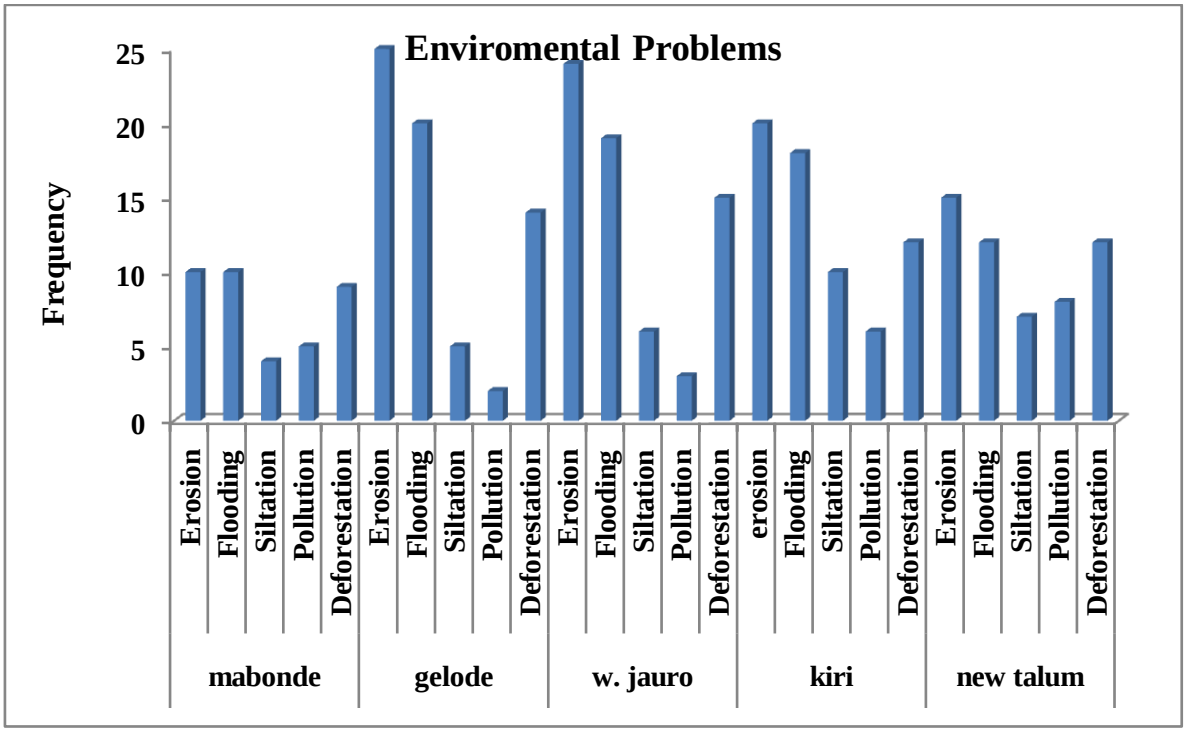


Figure 4.8:The Most Common Environmental Problems in Surveyed Villages

4.11 Environmental Health Impacts Identified

Data obtained from the field study revealed that 53.3% of Talum, 47.7% ofKiri, 24.8% of Mabonde and 48.25% of Gelade/WuroJauropopulations have specified that cholera is the

major environmental healthproblem. This findings completed with personal observation indicated that the sanitaryconditions of the surveyed townships are very poor. The main reason for this problemis the lack of proper sanitation and waste disposal facilities as well as the lack of propersource of drinking water. Based on the result, New Talumwhich is one of thesettlement townships had been affected badly by this problem. It is possible to raiseconcern for the lack of proper implementation by the UBRBDA which wasthe responsible authority for the resettlement programme.

Data gathered during the field studies indicated that 47.5% of the respondent'spopulation from Kiri, along the Kiri dam revealed river blindness(Onchocerciasis) as the major environmental health problem. The second highestprevalent of this disease was recorded in village ofNew Talum, with 36.3% of the respondents. Third was Mabonde with 31.5% and lastlyWuroJaurorecordedthe lowest of all the five surveyedcommunities with 16.3% of the respondents, the most likely reason for this result is that WuroJaurois situated far from the actual lake area and the proximity could be thepossible explanation for low rate of prevalence of the disease. According to APOC, (2009) "this disease is characterized by the depigmentation of the skin, nodules and eye lesionsthat may lead to blindness. It is transmitted from man to man by the bite of the black fly (Simuliumdamnosium) which breeds in rapidly flowing streams and rivers".Prior to the creation of the Kiri dam, the area around Kiri was known to be thebreeding ground for the black flycausing the disease, due to the rapid flowing of water. However,with the construction of the Kiri dam the disease has been alleviated owing to thereduction in the breeding condition. As a result the spread of the disease in the area hasreduced considerably as reported in Mubi, (2001).

Nevertheless, based on the survey, thedisease seems to be creating a lot of problem in the surrounding communities of thedams.

One of the most common diseases associated with water development schemes intropical environment is bilharzia (Schistosomiasis) which is caused by a parasite that lives part of its life cycle in an aquatic snail. People who come into contact withwater where infected snails live may contract the disease. Data gathered during the fieldstudies show that 36.8% of the sample population atNew Talum, 35.4% at Kiriand 26.8% at Mabondepopulation have indicated that bilharzias was the most commonenvironmental health problem in their respective villages.

The most common of all is the Urinary Schistosomiasis (Bilharzia), which is a chronicsnail-borne infection. An epidemiological survey conducted in 1969-1970 before thelake was impounded indicated that the endemicity of bilharzias was low along the GongolaRiver (Wulchibal, 1997). The prevalence among school children was about 5% (1969).After the construction of the dam the survey conducted in 1986-1990 indicated a 90%rate among school children with the ratio of two boys to one girl. There has been anongoing increase in the occurrence of the disease where previously the infection wasmoderate or nil. The prevalence of the disease in the lake area varies considerablyaccording to locality (Mubi, 2001).

Stagnant water and swampy areas are the perfect breeding grounds for malariamosquitoes. In addition, irrigation schemes, marshy reservoirs and ponds area have alsobeen identified as ideal ground for the breeding of the malaria parasites.Data obtained from the field study confirmed that 44.4% of the sample population at Kiri, 34.4% of New Talum, 29.1% of Mabonde, 15.4% of Gelode and 11.6% of WuroJaurohaverecognized that malaria is one

ofthe most common ecological health problems in the villages as shown in Figure 4.9 below and plotted from Table E (Appendix E).

In view of the fact that malaria is common in stagnant water and reservoirs, it is verydifficult to control, nevertheless, some effective methods have been used to eradicatethis disease by draining mosquito breeding grounds and by spraying the breedinggrounds with insecticides and other forms of chemicals; however, all these controlmethods have severe and devastating effects on human health and the environmental.On the other hand to control malaria would require billions of dollars. Due to the factthat this disease is most common in the Third world it is not attractive to the bigpharmaceutical companies to invest huge money for research. The reason is that thepeople would not be able to afford the cure.

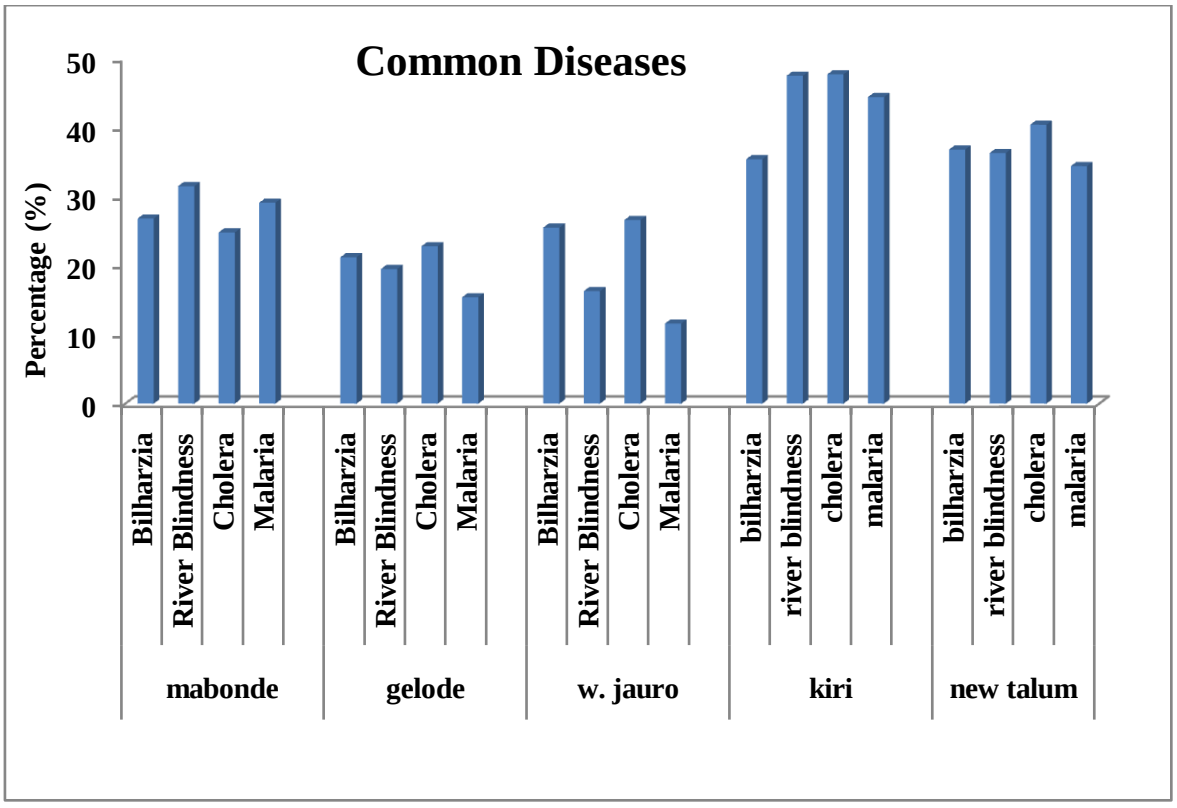


Figure 4.9: The Most Common Diseases in the Surveyed Villages

4.12 Economic Impact

4.12.1Benefits of The Dam

The interview conducted with the respondents indicated that there is no much benefit derived from the dam by the people. Interaction with the respondents indicated that only 40% of the respondents remarked that they derive some benefits from the dam, while majority 60% of them complained that disadvantages of the dam outweigh its advantages. Out of the total respondents who reported that the dam is beneficial to them, 25% say they use the dam for fishing, 30% say they use the dam for irrigation, 24% for wetland, 0% for Cultivation and 21% for domestic use/purposes respectively as shown in Figure 4.10 below and plotted from Table F (Appendix F).

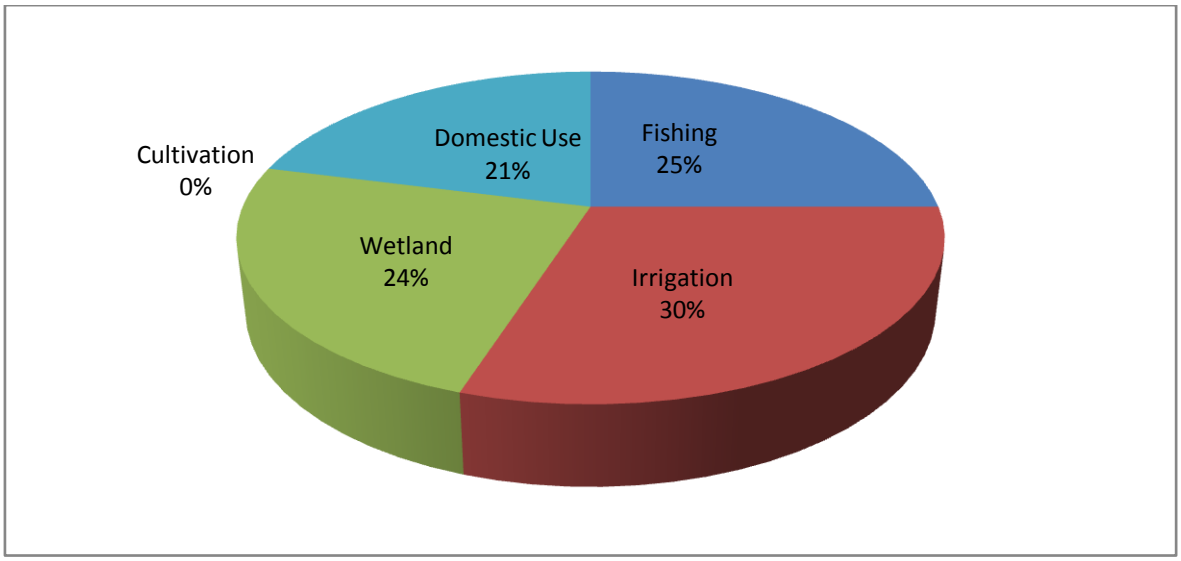


Figure 4.10: Various Uses of Kiri Dam

4.13 Perception of the Local People on the Kiri HPP

The general understanding of the local people about the project is a blend of hopefulness and wariness. During the focus group discussion in the selected communities, the participants had a unanimous positive response when asked about the development of Kiri Hydropower Project in the area with some basic stipulations:

Thank God for the government. We are happy that the Kiri hydropower project is being constructed in our area as a source of electric light for the future. But we are sceptic that the authorities will solve our immediate and future problems. This existing dam site and area intended for installing the hydropower project was our farm and grazing area. Our families' livelihoods depend on farming and livestock production. Parts of our farmlands were long ago taken by the dam without any compensation. We are worried about our future livelihoods.

Their views reflect a combination of ideas that can be examined from different perspectives. From the respondent's perspectives one can point out how the local people in particular have explained their views by intertwining faith and politics. There is a general tradition in the country and more specifically in the project area that in the hierarchy of authority, 'next to God is the state'. This idea prompted the people to authentically believe that all regulations and plans coming from the state are enforceable. Such perception can be a challenge to both the government and the people. On the other hand, the preoccupation of the local people with a perception of the state's righteous authority in all decisions of development projects will hinder them from expressing themselves in the real sense of understanding the impacts of the project.

Another point that that can be derived from the farmers' perception is the scepticism on the commitment of the decision makers to solve the present and potential problems resulting from the project development. As mentioned earlier, these people are parts of the local people that were not given a compensation of any kind while they lost their farmlands due to the dam construction long ago. But some of them are registered for compensation from the Numan-Kiri road realignment project in the future. Their response was: "*how can we believe that we will get compensated while received nothing from the one which we already have lost*?"

The farmers' understanding implies that the present practice can make the future promise a rhetoric and hollow-hope. From the respondents' explanation, it can be said that they have lost trust on the local authorities. This in turn has a daunting psychological impact subjecting the people to get worried of their future livelihoods. It needs an integrated therapeutic effort by the local administration, the project owner and the involvement of

concerned government institutions. As a representative of the local people in the project area, the local administration has to address the people's interest and present their concerns to the project owner and the federal government instead of suppressing the people not to reflect their views and problems associated with the project impacts on their living conditions.

Table 4.14a and 4.14b below is asummary of the issues raised by local people around the proposed Kiri hydropower project:

Table 4.14a: List of Key Social Issues

Issues	Description
Job and Employment	The host communities demand full employment in the project during construction and in post-construction periods. In one of the consultativemeetings, a request was made for vocational schools for boys and girls to prepare the affected persons for employment in the project.
Livelihoods	The traditional terrace cultivation and livestock herding by the sub-tribes could be affected due to construction activities such as (new access roads and camp sites) and lack of terraced land in upper elevations.
Health and Safety Issues	The health and safety issues during dam construction were discussed. Local people are concerned about migrant workers for dam retrofit, noise and air quality issues, and heavy traffic on Numan-Kiri road during the construction period.
Energy demand	The inhabitants of the villages are demanding that electricity be provided free of cost for their communities to empower them the more.
In-Migrants And Outsiders	This has been flagged in the community level meetings as a very big concern by the affected communities. The "outsiders" – for example, construction workers, and others moving in to work may lead to potential cultural and social conflict

Table 4.14b: List of Key Environmental Issues

Issues	Description
Information on KIRI Hydropower Project	Generally, the communities in both the upstream and downstream areas of the project know about development of the Kiri Hydropower project. They generally don't know how and when the project will be implemented
Wildlife	Community based wildlife conservations should be promoted
Birds migration	Gongola valley is a flyway for migratory birds. Bird collision and electrocution are potential threats on migratory birds
Monitoring of impacts	Institutional capacity of UBRBDA is weak in monitoring of impacts
Fish and aquatic ecology	They are of the opinion that the installation of the hydropower component will restrict water flow which will lead to lessen the fish in the main stream of the river. Some people have reported that in some occasions they also collect wood (during high flow season, when they were deposited on the banks) from river sand make some money
Floods and high erosion	Floods and erosion of our riverbanks and farmlands from excess water releases from the dam is currently experienced, especially during the rainy seasons could be exacerbated and pose a serious risk to the HP Project
Sedimentation	The resultants of these floods and coastal erosion have led to sedimentation of the downstream river, thereby affecting water quality and fishing activities. We are afraid the retrofit of the dam will bring the worse

4.14Consulted Local Stakeholders

The stakeholder consultative process involved meetings, open discussions and interviews with relevant government institutions at national and local level and representatives from local communities. These stakeholders include;

i. Upper Benue River Basin Development Authority (UBRBDA)

ii. Gongola Basin Development Energy Commission (GOBADEC)

iii. Adamawa State Ministry of Environment

iv. Adamawa State Ministry of Works

Through this interaction the researcher tried to establish how stakeholders understood the dynamics of the environment in which the proposed project is located and any possible

underlying causes that could lead to changes over time as a result of implementing the project.

4.14.1 Outcome of the Stakeholders Consultation

i. Generally most stakeholders welcomed the idea of constructing the hydropower project on the existing Kiri dam except UBRBDA who expressed fear that water requirements of the existing user of the dam (savannah Sugar Company) might be altered.

ii. The need to observe the priority of use by existing downstream water right holders.

iii. The need for relevant authorities to establish permanent gauging stations within Guyuk catchment for accurate water planning in the future

iv. The need to develop a public health action plan to address public health issues such as safe drinking water, safe disposal of sewage, safe collection and disposal of solid waste, protection against dust and community health should be considered

v. The need to identify landslide prone areas within the Kiri reservoir and catchment to protect against sedimentation

vi. The need to design the project complying with guidelines of International Commission on Large Dams (ICOLD) to deal with geological and geomorphologic hazards

vii. Birds collision and electrocution are potential threats to migratory birds

viii. Community should be educated more about infectious diseases. Necessary vaccination should be provided.

ix. Capacity of UBRBDA in terms of human resource needs to be increased to address social and environmental issues

x. Floods could be a serious risk to the project. Early warning systems from flood forecasting is necessary for the safe operation of the project

xi. Low flow season operation of the Kiri HPP and its impact on aquatic life is to be considered

xii. Security issues are to be considered during implementation of the project

xiii. Electromagnetic waves from transmission lines and their impact on human health is to be considered

xiv. Involvement of local community in planning and development process is very important and must not be overlooked.

xv. The developer should take into account future water requirements of other stakeholders with reference to existing water rights

4.15 Potential Environmental and Socio-Economic Impacts of Kiri Hydropower Project

4.15.1 General Impacts

A number of impacts (positive and negative) were identified with due consideration to issues discussed in the earlier section of this chapter. These impacts are based on the design

of the dam, project details, environmental and socio-economic baseline study as well as expert judgment.A systematic approach in classifying impacts was used.

4.16Impact Criterion and Classification

Types of Identified Probable Impacts: After field investigations of Kiri dam local environment and the proposed sites of the components of the Hydroelectric project, as well as a thorough evaluation of the project characteristics, the following categories of likely impacts were identifiable. These have been summarized in Table 4.15below

Table 4.15: Types of Probable Impacts Identified During the Study

Significant Impacts	They are likely significant positive and negative impacts which are direct consequences of the city complex project and its characteristics on the environment and its characteristics.
No Significant Impact	No significant Impact occurs where the correlation of the project characteristic components with those of the environment do not result in likely significant impacts
Impacts not Immediately foreseen	These are probable impacts not likely to be significant but may be indirectly caused by the relationship of the project components and the environment. They may also include secondary and tertiary spin offs of the project which may not likely be within the immediate construction and operation phases of the project. Due to cumulative effects, these impacts, may likely occur and be significant.

4.17Nature of Impacts

This section discusses and assesses the nature of the impacts of the Kiri Hydroelectric Power Project is likely to have on the local and immediate environment in particular and the regional environment in general in which the proposed project is planned. It also discusses the enhancement and remediation measures considered appropriate for the

resolution of some of the likely impacts that are positive and negative or adverse to the environment.

4.17.1 Positive/Beneficial Impacts of the Proposed Kiri Hydroelectric PowerProject

4.17.1.1Construction Stage

Impact: Skills Transfer to Locals: When the local people are employed during the Kiri HPP installation, they will acquire skills in construction which they will use later in future. By employing as many as1000 local people as possible there will be skills transfer thus building human capacity in the area.

Enhancement:

KiriDam retrofit works will require skilled manpower to ensure dam safety. Since it is company policy to give priority to local people when employing, skills will be imparted in them. This impact is high and of great importance and therefore it will be enhanced by;

i) Ensuring there is skill transfer through an elaborate programme

ii) Categorize staff and each group to be supervised by dedicated skilled personnel to ensure on job training

iii) Encourage job on training through observation and trial under supervision

Impact: Increased Employment Opportunities:

Construction and operation of a dam will create opportunities for jobs mainly for the local communities. At preparatory and construction stage, local people will be engaged and consequently livelihood for family members will be guaranteed.

Enhancement:

Construction of the Kiri HPP creates opportunities for jobs mainly for the local communities. To enhance this, Local people will be given priority for employment as a deliberate company policy.

Impact: Increase in Local Economic Activities:

Kiri dam Hydropower addition will provide trading opportunities to the local people. Farm produce and food stuffs will be sold to construction workers. It is also expected that theKiri HPP once operational will result in more fish production thereby providing a long term positive addition to the livelihood of the community due to increase in income.

Enhancement:

It is also expected that the presence of the HPP will result in more fish production and other trading activities in the area. To enhance this, developer will;

i) Ensue that the hydropower scheme is operated in a professional manner.

ii) Promote formation of small holder schemes to be run by small scale farmers within the community

4.17.1.2 Operation Stage

Impact: Increase in Employment Opportunities:

Construction and operation of hydropower dams create opportunities for jobs mainly for the local communities. At operation stage, local people will be engaged and consequently livelihood for family members will be guaranteed. In a long term, increased productivity in the area as a result of irrigation will equally further create job opportunities.

Enhancement: Construction of KiriHPP creates opportunities for jobs mainly for the local communities. To enhance this, Local people will be given priority for employment as a deliberate company policy.

Impact: Increase in Aeration: Installation of hydropower at existing dams can replace poorly aerated spill flows with well aerated flows through turbines. This impact is important at many high-head plants, especially irrigation dams on large rivers. At high head dams without hydropower, flows are spilled over spillways or through gates that may or may not provide important aeration (Rrailsback*et al.,* 1990). Such spill flows may be aerated up to or above the saturation concentration of DO. This aeration can be very important for water quality since impounded rivers receive relatively little aeration because they are deep and have reduced flow.

Enhancement: i) Much more water should be aerated per unit of power generated.

ii) low-head turbines are typically designed so that water pressures are never less than atmospheric pressure, so self-aeration by venting air into the turbine at low-pressure zones is infeasible.

Impact: Boost to Economic Growth:

Reliable water supply throughout the year will effectively enable 'Savannah Sugar Company' to increase its production levels. This entails enough production to satisfy local demand while at the same time export. As a result, earn the country the much needed foreign exchange consequently contributing to overall economic growth.

Enhancement:

Reliable water supply throughout the year will effectively enable Guyuk to increase its production levels to satisfy local demand while at the same time export thus earn the country the much needed foreign exchange and contributes to overall economic growth. To enhance this, the developer will:

i) Ensured effective management of the irrigation scheme

Impact: Increase in Local Economic Activities:

The KiriHPP scheme will provide both permanent and temporal employment to the local people. This means more income for the community in the area resulting into increased economic activities.

Enhancement:

The Kiri hydropower construction will provide temporal employment to the local people as well as fishing and other trading activities. To enhance this, the developer proposes to;

i) Ensure that the irrigation scheme is operated in a professional manner.

ii) Encourage cooperatives to take an active role in trading activities

Impact: Skills Transfer to Locals: Operation of the dam and the Hydropower scheme will result into skills beingtransferred to the local people which they can use later in future. Thus humancapacity will be built in the area.

Enhancement:

Kiri hydropower operation works will require skilled manpower to ensure dam safety. Since it is company policy to give priority to local people when employing, skills will be

imparted in them. This impact is high and of great importance and therefore it will be enhanced by;

i) Ensuring there is skill transfer through an elaborate programme

ii) Categorize staff and each group to be supervised by dedicated skilled personnel to ensure on job training

iii) Encourage job on training through observation and trial under supervision

Impact: Energy Production:

Another positive impact of Kiri HPP project on socioeconomic environment is contribution to the local and national electricity interconnection system. In this respect, it is clear that Kiri HPP project will make a significant contribution to the local electricity production. There will be HPPs operating concurrently in the catchment area within Scenario. These amounts of energy will make a significant contribution to the local and national electricity interconnection system.

Enhancement:

Kiri HPP should be operated in a manner that is economically viable, environmentally sustainable and socially responsible in order to enhance energy production and represent the best concept of sustainable development.

Impact: Decrease of Pollution: The incorporation of the hydropower component to the existing Kiri dam would bring about a tremendous decrease of pollution in the area. Hydropower replacing diesel generation, electricity replacing pollution energy sources will go a long way in controlling air pollution in the area. ***Enhancement***

i. Making hydropower energy readily available.

ii. Discourage the use of petrol and diesel engines for power generation

Impact: Deforestation Control Kiri hydropower installation will bring about better alternatives for cooking, such as electric cookers. This will help check deforestation which is taking place to meet food, fodder and fuel demand in these rural areas. It will also further bring forth improvement towards vegetation and plantation (compensatory afforestation).

Enhancement : i. encourage use of electrical cooking and processing appliances

ii. Discourage use of forest resources as fuel sources

Impact: Increased Tourism Potential: The incorporation of the Kiri HPP will bring about increase in the flow of the river to about $105m^3/s$. This will in turn boost the tourism potential of the region through improved water sports, boating and fishing etc. as a result, generating more income for the locality and state at large ***Enhancement:***

i. encourage investment in the tourism industry

4.17.2 Negative/Adverse Impacts of the proposedKiri Dam Hydroelectric Project

4.17.2.1 Construction Stage

Impact: Loss of Productive Land, Historical and Cultural Sites:

No historical and cultural sites are located within the impoundment area. However, new access roads can induce major land use changes particularly deforestation, with resulting loss of biodiversity, accelerated erosion, and other environmental problems. In some projects, the environmental impacts of access roads can greatly exceed those of reservoir by approximately 22%.

Mitigation:

No mitigation is required for loss of historical and cultural sites since none are located within the impoundment area. However, the sitting of any new access roads should be in environmentally and socially least damaging corridors. Forest and other environmentally sensitive areas along the chosen road corridor should receive legal and on-the-ground protection. Road engineering should ensure proper drainage, to protect waterways and minimize erosion.

Impact: Reservoir Sedimentation:

The nature of the project demands use of heavy machinery during construction mainly for earth movement and levelling. This may lead to instability of the soil in the area and as a result cause soil erosion mainly of top soil. Consequently this may lead to siltation and sedimentation of rivers/ reservoirs in the Catchment if not controlled.

Mitigation:

Disturbed top soil in the area due to use of heavy machinery may lead soil erosion consequently silting the stream and if not checked the impact can be significant. To minimize soil erosion the following measure will be undertaken;

i) Carryout reforestation of the disturbed area after construction activities.

ii) Limit movement of heavy machinery only to designated access routes and operational areas

Impact: Air Pollution:

The air quality impacts of retrofitting dams with hydroelectric plants are expected to be local, short term, and minor. Impacts such as fugitive dust emissions from excavation and blasting activities, and emissions from machinery and vehicle use would only occur during construction. And in most regions would be very minor compared with other emissions Dust pollution is expected to pose a negative impact that can affect human health.

Mitigation: Air emissions from the construction activities have to meet with Government of Nigeria's National Environmental Quality Standards. Monitoring and enforcing lies with Project Director Safeguard.

Impact: Likely Increase of Flood:

The construction of hydropower projects at low-head dams may, depending on design, increase the magnitude and frequency of flooding upstream (Schmitt and Varga, 1988). For example, hydraulic modelling studies for power house built at two existing navigation dams on the Allegheny River predicted that water levels during extreme floods would increase up to 2 ft. as a result of the hydraulic resistance of the powerhouse. (Floodwaters would flow over the power house less smoothly than over the existing dam.) During

construction of projects, any obstruction (especially cofferdams) in the path of flood flows would increase the upstream flood elevations.

In addition, since the Kiri HPP will be dependent upon water releases from the Dadinkowa HPP, flows are expected to increase from a 12 m^3/s to 105 m^3/s thereby posing serious flooding threats especially to the downstream inhabitants.

Mitigation:

The potential increase in upstream and downstream flooding caused by the retrofit can be studied with hydraulic models. The project should be designed to minimize effects of flood elevations

Impact: Increase In Local Population: The operation of the KiriHPP will have an influence on the population size of the area. The HPP is anticipated to attract people seeking employment thus putting pressure on the available natural resources.

Mitigation*:*

During the retrofit, skilled personnel will add to the population of the local community. There is also a possibility that the community will receive more people looking for employment which will further add on to the local population. Measures will include;

i) Adopt selective employment opportunities targeting locals.

ii) Ensure adequate facilities are provided for staff such as sanitation facilities

Impact: Dam SafetyConcerns:

Some dam safety concerns are associated with retrofitting dams with hydropower. Removal of some parts of existing dams is usually required for installation of powerhouse and penstocks. The present plan is to replace about a 100m of the embankment through which

the penstocks would penetrate. This demolition must be conducted properly to avoid weakening the structure or foundation of the dam. The new structure or cofferdams must be properly designed and constructed to avoid failure.

Mitigation:

This demolition must be conducted properly to avoid weakening the structure or foundation of the dam. The new structure or cofferdams must be properly designed and constructed to avoid failure. The Project should be designed and executed complying with guidelines of International Commission on Large Dams (ICOLD)

Impact: Loss of Wildlife Habitat, Indigenous Flora And Fauna: The creation of borrow pits will not interfere directly with any existing wildlife reserves or national parks. However, formation of borrow pit will lead to limited loss of some wildlife habitat for small animals such as rabbits and flora.

Mitigation:

The project area has been subjected to years of human agricultural activities and as such not much wildlife habitat, flora and fauna is left. Therefore this impact will be low. However, the following mitigation measures are proposed;

i) Limit clearance of vegetation only to critical areas

ii) Conduct awareness campaigns among staff and community on the need to conserve nature

iii) Adopt strict good conservation practices

Impact: Dust Pollution: Dust pollution is the most expected negative impact that will pose a health hazard. The project

construction works will take place in the dry season known for dust circulation thus posing a danger to human health.

Mitigation:

Dam construction normally takes place in the dry season which is well known for dust circulation thus posing a danger to human health. Proposed mitigation measure will include

i) Undertake watering of the area and surroundings regularly during construction stage

Impact: Deterioration in Water Quality Due to Oil Spills and Liquid Waste:

There is a risk of small fuel spills resulting from the use of construction equipment near and in the streambed. Contaminated sediments existing at a dam may be disturbed and distributed by construction. Water quality may also be affected by receiving untreated human waste. Absence of proper sanitation facilities for construction workers may result in human waste finding itself in the stream water thus polluting it and posing a health risk to people who depend on the stream water for domestic use.

Mitigation:

Water quality can be affected by receiving untreated human waste. The developer will

i) Provide portable sanitation facilities for construction workers

Impact: Withdrawal of Recreation:

Long-term effects of expanding reservoirs to accommodate new hydropower generation regimes could result in both negative and positive impacts for recreational resources. Greater impoundments of the Kiri reservoir would be needed to accommodate the flow requirements of the new generation capability; a variety of impacts can be expected. Construction could bring erosion and sedimentation impacts to water quality, affecting

fishing, swimming, and boating. Recreational activities could be directly affected by construction noises, aesthetic impacts of heavy machinery in a recreational environment, and temporary cessation of activities because of safety concerns. On the other hand, increased impoundment size could mean greater expanses of calm water for sailing, rowing, fishing and swimming.

Mitigation:

Mitigation can be provided for many impacts to recreation. Horns or warning whistles could notify recreational users just below retrofitted dams of the dangers of sudden water releases and the associated potential for rapid changes in water levels. Warning signs could also be posted on both riverbanks. Funds could be made available to compensate riparian owners who might have to lose lakeshore property, move docks or boat ramps, or otherwise change or redesign their use of the reservoir area. Fishing platforms could be installed to facilitate fishing access and safety along tail waters areas.

Impact: Solid Waste: Solid waste generation is expected from the personnel in the construction camps as well as excavation wastes resulting from construction activities on Kiri HPP project. Improper handling and disposal of solid wastes may cause land, surface water and groundwater contamination.

Mitigation:

Domestic solid wastes will be collected in the closed containers at the project site and handled by related municipalities at their waste disposal sites. Solid wastes will be transported to the waste disposal sites by trucks with necessary license and transportation costs will be paid by the contractor.

Impact: Noise and Vibration : Noise is expected to be generated from construction activities at the project site. Sources of noise include operation of heavy duty equipment and machineries such as excavators, bulldozers etc, and tunnel blasting activities. These machines are also capable of disturbing the earth crust thereby resulting in ground vibrations.

Mitigation: Adopting International standards on occupational Health and safety as well as noise minimization program (in Contractor's Environmental Monitoring and Management Plan (EMMP). Acceptable noise levels to be specified.

4.17.2.2 Operation Stage

Impact: Threat to Riparian and Terrestrial Ecosystems:

The project site will not interfere directly with any existing wildlife reserves or national parks. Wildlife is in fact expected to resurface in the area due to improved water supply. However, the installation of new power lines, in addition to disturbing habitat, may pose collision hazards for birds and bats and electrocution hazards for large raptors.

Mitigation:

The current plan is for the power to be evacuated from the Kiri dam approximately 85km to the Yola substation. This line will be a double circuit 33 kv line on steel lattice towers. Power lines should be sited to minimize these concerns and built using good environmental practices

Impact: Threat to Public Health:

Development of reservoirs in tropic countries usually leads to change in incidence of water-borne diseases. In Kiri, this may imply the spread of mosquitoes and vectors of malaria. This may threaten public health if no special attention and mitigation measures are put in place.

Mitigation: Spread of mosquitoes and vectors of malaria are prone to reservoirs and immediate environs. This may threaten public health if no special attention and mitigation measures are put in place.

i) Employ disease vectors disruption techniques such as regulated reservoir operation to curb vectors for malaria and water borne diseases.

ii) Encourage natural aquatic life that takes care of mosquito larva as part of the food chain

Impact: Changes in Tailwater Quality Due to Changes in Release Elevation A retrofit hydropower project can withdraw water from elevations different from the withdrawal elevations of the original impoundment. In the case of deep storage reservoir, water quality commonly varies with elevation, especially in the summer. Thermal stratification results in an impoundment having cold water, often with low DO concentrations, in its lower elevations and warm water with relatively high DO concentrations in the higher elevations. In stratified impoundments where the release is from the top (over a spillway through high elevation gates), the installation of a hydropower withdrawing from low elevations would cause downstream water quality to change in summer from high to low temperatures and from high to low DO concentrations.

Mitigation:

The release of deoxygenated water from the bottom of reservoir can be mitigated in several ways. One way is to construct the hydropower with a multilevel intake so that water can be withdrawn from the reservoir selectively from different elevations. Such selective withdrawals allow the project operator to release water with acceptable temperatures and DO concentrations.

Another way to mitigate the release of deoxygenated water is to aerate the water as it is released through turbines.

Impact: Changes In Flow Release Patterns: Hydropower projects can generate more valuable power by releasing water during periods of peak daily power demands and storing it during off-peak periods. This peaking mode of operation is possible at retrofit projects built at dams with least minimal storage capacity. The daily flow cycles that result can have adverse impacts downstream such as stranding fish(including spawning nests and juvenile fish), posing hazards to recreational users, and increasing bank erosion. ***Mitigation:***

These impacts can be mitigated by;

i. not allowing daily flow cycles (a common requirement)

ii. Building some kind of re-regulation structure (such as another small reservoir or a low-head weir) downstream to even out daily flow cycles.

Impact: Threat to Human Health:

The operation of the Kiri HPP scheme will result in increased economic activity in the area.Consequently,more people will be attracted to the area. This will expose the community to foreign people who may lead to the spread of HIV/AIDS and other STIs.

Mitigation:

Dam operation will also expose the community to the foreign people who may lead to the spread of HIV/AIDS and other STIs. Measures to minimize this will include;

i) Sensitize staff and community on the dangers of HIV/AIDs and STIs

ii) Support local programmes by Ministry of Health regarding HIV/AIDs

For a summary and evaluation of potential impacts see Table 4.16 during Construction Stage and Table 4.17 during Operation Stage.

TABLE 4.16 : EVALUATION OF POTENTIAL ENVIRONMENTAL IMPACTS FOR Kiri DAM HPP:- CONSTRUCTION STAGE								
ITEM	**POTENTIAL ENVIRONMENTAL IMPACT**	**IMPACT CRITERION**						**OVERALL IMPACT RATING**
		POSITIVE (+VE) OR NEGATIVE (-VE) IMPACT	**LIKELIHOOD OF OCCURRING**	**DURATION**	**TIMING**	**SIGNIFICANCE**	**EXTENT**	
ENVIRONMENTAL ISSUE: CONSTRUCTION (RETROFIT)								
1	Displacement of people:	-VE	Unlikely	N/A	N/A	N/A	N/A	Insignificant
2	Loss of productive land	-VE	Certain	Permanent	Immediate	Medium	Project Area	insignificant
3	Historical and cultural sites	-VE	Unlikely	N/A	N/A	N/A	N/A	Insignificant
4	Loss of wildlife habitat, flora and fauna	-VE	Certain	Short Term	Immediate	Low	Project Area	Low
5	Reservoir sedimentation:	-VE	Possible	Short Term	Immediate	Low	Surrounding Environs	Low
6	Skills Transfer to Locals:	+VE	Certain	Medium Term	Immediate	High	Project Area	High
7	Dust Pollution	-VE	Possible	Short Term	Immediate	Medium	Surrounding Environs	Low
8	Withdrawal of Recreation	-VE	Possible	Short term	immediate	Low	Project area	Low
9	Likely increase of Floods	-VE	Possible	Medium term	immediate	High	Surrounding environs	Moderate
10	Dam safety concerns	-VE	Possible	Short term	immediate	High	Surrounding environs	Low
11	Safety hazards	-VE	Possible	Short term	immediate	Medium	Project area	Low

TABLE 4.16 Cont'd: EVALUATION OF POTENTIAL ENVIRONMENTAL IMPACTS FOR KIRI DAM HPP:- CONSTRUCTION STAGE								
ITEM	**POTENTIAL ENVIRONMENTAL IMPACT**	**IMPACT CRITERION**						**OVERALL IMPACT RATING**
		POSITIVE (+VE) OR NEGATIVE (-VE) IMPACT	**LIKELIHOOD OF OCCURRING**	**DURATION**	**TIMING**	**SIGNIFICANCE**	**EXTENT**	
ENVIRONMENTAL ISSUE: PRODUCTIVE AND SETTLEMENT LAND								
12	Displacement of people:	-VE	Unlikely	N/A	N/A	N/A	N/A	Insignificant
13	Loss of productive land	-VE	Certain	Permanent	Immediate	High	Project area	Low
14	Loss of wildlife habitat, flora and fauna:	-VE	Certain	short Term	Immediate	Medium	Project Area and surrounding environs	Moderate
ENVIRONMENTAL ISSUE: BORROW PIT AND MATERIAL HANDLING								
15	Loss of productive land, historical and cultural sites:	-VE	Possible	Short Term	Immediate	Low	Project Area	Insignificant
16	Loss of wildlife habitat, flora and fauna:	-VE	Possible	Short Term	Immediate	Low	Project Area	Low
17	Dust Pollution	-VE	Possible	Short Term	Immediate	Medium	Surrounding Environs	Moderate
18	Loss of Cultural Sites	-VE	Unlikely	N/A	N/A	N/A	N/A	Insignificant
19	Disposal of earth and rock spoils	-VE	Certain	Short term	Immediate	Low	Project area	Low

TABLE 4.16 Cont'd : EVALUATION OF POTENTIAL ENVIRONMENTAL IMPACTS FOR KIRI DAM HPP :- CONSTRUCTION STAGE

ITEM	POTENTIAL ENVIRONMENTAL IMPACT	IMPACT CRITERION						OVERALL IMPACT RATING
		POSITIVE (+VE) OR NEGATIVE (-VE) IMPACT	LIKELIHOOD OF OCCURRING	DURATION	TIMING	SIGNIFICANCE	EXTENT	
ENVIRONMENTAL ISSUE: WASTE MANAGEMENT								
20	Deterioration in Water Quality due to oil spills	-VE	Possible	Short Term	Immediate	Medium	Surrounding Environs	Moderate
21	Environmental pollution due to solid and liquid wastes	-VE	Possible	Short Term	Immediate	Medium	Project area and surrounding environs	Moderate
ENVIRONMENTAL ISSUE: EQUIPMENT MOBILISATION AND OPERATION								
22	Air pollution	-VE	Certain	Short Term	Immediate	Low	Project Area	Low
23	Reservoir sedimentation	-VE	Possible	Short Term	Immediate	Medium	Project Area	Moderate
24	Noise and vibration due to construction and transportation	-VE	certain	Short term	Immediate	Low	Project area	Low

TABLE 4.16 Cont'd: EVALUATION OF POTENTIAL ENVIRONMENTAL IMPACTS FOR KIRI DAM HPP :- CONSTRUCTION STAGE								
ITEM	**POTENTIAL ENVIRONMENTAL IMPACT**	**IMPACT CRITERION**						**OVERALL IMPACT RATING**
		POSITIVE (+VE) OR NEGATIVE (-EV) IMPACT	**LIKELIHOOD OF OCCURRING**	**DURATION**	**TIMING**	**SIGNIFICANCE**	**EXTENT**	
ENVIRONMENTAL ISSUE: SOCIO-ECONOMIC AND CULTURAL								
25	Increase in Local Economic Activities:	+VE	Certain	Medium Term	Immediate	Medium	Surrounding Environs	Moderate
26	Loss of Social & Cultural Infrastructure:	-VE	Unlikely	N/A	N/A	N/A	N/A	Insignificant
27	Boost to Local Industry	+VE	Certain	Short Term	Immediate	Medium	Surrounding Environs	Moderate
28	Skills Transfer to Locals:	+VE	Certain	Medium Term	Immediate	High	Project Area	High
29	Threat to Human Health	-VE	Possible	Short Term	Near Future	High	Surrounding Environs	High

TABLE 4.17 : EVALUATION OF POTENTIAL ENVIRONMENTAL IMPACTS FOR KIRI DAM HPP:- OPERATION STAGE								
ITEM	**POTENTIAL ENVIRONMENTAL IMPACT**	**IMPACT CRITERION**						**OVERALL IMPACT RATING**
		POSITIVE (+VE) OR NEGATIVE (-VE) IMPACT	**LIKELIHOOD OF OCCURRING**	**DURATION**	**TIMING**	**SIGNIFICANCE**	**EXTENT**	
ENVIRONMENTAL ISSUE: POWER GENERATION AND TRANSMISSION								
1	Threat to terrestrial ecosystems	-VE	Possible	Long Term	Near Future	High	Surrounding environs and beyond	High
2	Increase in aeration	+VE	Certain	Long Term	Near future	High	Project Area	High
3	Changes in flow release patterns	-VE	Certain	Long Term	Immediate	Low	Project Area	Low
4	Changes in tailwater quality due to changes in release elevation	-VE	Possible	Long term	Near future	Medium	Project area and beyond	Moderate
5	Likely increase in flooding flows	-VE	Possible	Long term	Immediate	High	Project area	Moderate
6	Decrease of pollution	+VE	Certain	Long term	Near future	High	Surrounding environs	High
7	Deforestation control	+VE	Certain	Long term	Near future	High	Surrounding environs	High

ITEM	POTENTIAL ENVIRONMENTAL IMPACT	IMPACT CRITERION						OVERALL IMPACT RATING
		POSITIVE (+VE) OR NEGATIVE (-EV) IMPACT	LIKELIHOOD OF OCCURRING	DURATION	TIMING	SIGNIFICANCE	EXTENT	
ENVIRONMENTAL ISSUE: SOCIO- ECONOMIC AND CULTURAL								
8	Employment Opportunities:	+VE	Certain	Medium Term	Immediate	High	Beyond Surrounding Environs	High
9	Boost to Economic Growth:	+VE	Certain	Long Term	Distant Future	High	Beyond Surrounding Environs	High
10	Increase in Local Population:	-VE	Possible	Long Term	Near Future	Medium	Project Area	Moderate
11	Increased tourism potential	+VE	Certain	Long term	Distant future	High	Project area and surrounding villages	
12	Threat to public health	-VE	Possible	Long term	Near future	High	Surrounding environs	High
13	Increase in Local Economic Activities:	+VE	Certain	Long Term	Immediate	Medium	Project Area	High
14	Energy production	+VE	Certain	Long term	Distant future	High	Beyond surrounding environs	High

Table 4.18: Summary of Mitigation andEnhancement Measures Kiri HPP

Potential Impact	Proposed Mitigation and Enhancement Measures
Employment opportunity	Give priority to local people
Increase in local economic activities	Promote formation of small holder schemes.
Increased fish production	Ensure only sustainable methods of fishing are used
Economic growth	Effectively manage the hydropower scheme
Energy production	Kiri HPP should be operated in a manner that is economically viable, environmentally sustainable
Loss of cultural and historical Assets	No cultural and historical site is present at the site and therefore no loss is expected
Reservoir sedimentation	Limit movement of heavy machinery only to designated access routes and operational areas
Air pollution	Air emissions from the construction activities have to meet with Government of Nigeria's National Environmental Quality Standards
likely Increase in flood	The project should be designed to minimize effects of flood elevations
Increase in local population	Giving priority of employment to locals as a matter of company policy
Dam safety concerns	The Project should be designed and executed complying with guidelines of International Commission on Large Dams (ICOLD)
Loss of vegetation, wildlife habitat	Prohibit unnecessary cutting of trees and vegetation clearing
Dust pollution	Dust will be minimized by regularly watering of construction area.
Deterioration in water quality due to oil spills and liquid waste	Prohibiting discharging of waste or any form of effluent into the reservoir
Change in flow release pattern	Building some kind of re-regulation structure (such as another small reservoir or a low-head weir) downstream to even out daily flow cycles
Withdrawal of Recreational	Safety and warning signs should be posted on river banks
Threat to vegetation, wildlife and bird sanctuaries	Power lines should be sited to minimize these concerns and built using good environmental practices
Threat to public health	Regulating withdraw of water from the dam to disrupt mosquitoes breeding cycle, and introducing larva eating fish into the reservoir.
Likely increase in aeration	Much more water must be aerated per unit of power generated.
Threat to human health	Putting in place an awareness campaign programme for its workers

Potential Impact	Proposed Mitigation and Enhancement Measures
Noise and vibration	Adopting International standards on occupational Health and safety as well as noise minimization program
Increased tourism potential	Encourage investment in the tourism industry
Decrease in pollution	Making hydropower energy readily available Discourage the use of petrol and diesel engines for power generation
Deforestation control	promote use of electrical cooking and processing appliances Discourage use of forest resources as fuel sources
Solid wastes	Constructing approved-offsite disposal facilities and develop management program. (in Contractor's EMMP)
Safety hazards for villagers and project employees	Develop or adopt the international best practices on occupational Health and safety at the work place (in Contractor's EMMP and Health and Safety Plan) Establish local and village security committee

4.18Environmental Monitoring and Management Plan

From the above identification of adverse/positive impacts and taking recognition of increased pressure on upland areas above the dam, on-site environmental deterioration as well as decrease in water quality and increase in sedimentation rates in the reservoir resulting from clearing of forest land for agriculture, grazing pressures, and tree cutting for timber or fuel wood, it's imperative that measures are put in place for mitigation. Similarly, land use in the watershed of the lower river basin affects the quality and quantity of water entering the river. It is therefore essential that hydropower projects are planned and managed. Inorder to achieve this, a monitoring and environmental management plan (EMP) has to be put in place.

Under the Environmental Management Plan (EMP), various mitigation measures have been organized into well formulated plan, which will serve as a guide for construction and

operation phases of the proposed Kiri hydro-electric power project. The proposed EMP for Kiri hydroelectric power project is presented in Table 4.19

Table 4.19: Environmental Management/Monitoring Plan for Kiri hydro-electric power project

Potential Impact	Impact Areas	Mitigation/Enhancement Measure	Objective	Monitoring Action	By Who	By When
Skill transfer to locals	surrounding area and beyond	Design a programme for job on training for employees	To build capacity among locals	Monitoring the job training programme	General Manager Operations manager	Construction and Operation stages
Increase employment opportunities	Project areas, and surrounding villages	Local people should be given priority for employment as a deliberate company policy.	Boost income levels among locals	Monitor the employment process	General Manager	Construction and Operation stage
Increase local economic activities	Project areas, and surrounding villages	Promote formation of small holder schemes to be run by small scale farmers within the community	Boost income levels among locals	Monitor formed small holder schemes	General Manager	Construction and Operation stage
Loss of productive land	Project areas	Limit vegetation removal to designated areas for development	To minimize loss of vegetation	Monitor vegetation removal	General Manager	hydropower construction
Historical and cultural sites	Construction areas	No cultural and historical site is present at the site and therefore, once any are discovered, appropriate authorities will immediately be informed	To preserve cultural sites and articles of historical value	Not required	Construction Team and Operation Manager	Construction Stage
Reservoir sedimentation	Construction areas,And embankment Areas subjected to drawdown	Control land use in watershed, prescribed distances of fields in relation to the dam. Provision of measures to control silt/sediments during construction phase, provision of check walls, check dams and spurs.	To avoid loss of dam storage capacity	Monitor the sedimentation process. Monitor water quality downstream during flushing.	HPP operators. Water quality monitoring jointly by operators and MoENV.	Ongoing during the operation of the Hydro project

Likely increase in flood	Kiri HPP area	The project should be designed to minimize effects of flood elevations. An early warning system from flood forecasting is necessary for the safe operation of the project.	To avoid loss of dam storage capacity	Monitor flood forecasting	Operation Manager and Dam operators	Construction stage and operation stage
Air pollution	Construction areas and surrounding villages	Air emissions from the construction activities have to meet with Government of Nigeria's National Environmental Quality Standards. Compulsory use of respiratory personal protective equipment.	To minimize air pollution emissions from combustion of machineries	Check contractors schedule and records of vehicles and equipment servicing and repairs. Observe implementation of dust suppression program.	Client or Supervision, Consultant on behalf of client, MoENV local branch.	Construction stage
Increase in local population	Kiri HPP area	Give priority of jobs to locals	To minimize pressure on local resources	Monitor job allocation	General Manager Operations Manager	All stages of project development
Dam safety concern	Kiri river downstream	The new structure orcofferdams must be properly designed and constructed to avoid failure.	To avoid weakening the structure	Monitor compliance to proper design and construction	General Manager	Construction stage
Loss of wildlife habitat	Kiri HPP area	Undertake to revegetate disturbed areas	To minimize loss of wildlife habitat	Monitoring of biodiversity conservation and wildlife Management.	Kiri HPP EMO	Construction stage
Deterioration in water quality due to oil spills and liquid waste	Project areas and nearby villages	Prohibit discharge of effluent in the reservoir	To Maintain water quality in the reservoir	Random visual monitoring by Kiri HPP EMO. Violations will require action from Contractor to achieve compliance	Kiri HPP EMO	Operation stage

Threat to public health	Project areas and nearby villagers	Regulating withdraw of water from the dam to disrupt mosquitoes breeding cycle	To ensure a health workforce	oversight monitoring of health issues, in cooperation with provincial and district health authorities	Ministry of health	Construction and Operation stage
Changes in Tailwater quality due to changes in release elevation	Construction areas, And embankment Areas subjected to drawdown	One way is to construct the hydropower with a multilevel intake so that water can be withdrawn from the reservoir selectively from different elevations.	To Maintain the water quality in the reservoir	Monthly or weekly inspections of tailwater quality changes.	HPP operation, monitoring consultants on behalf of HPP MoENV local branch.	Operation stage
Changes in flow release patterns	Kiri Reservoir.	Use recommended devices in dam design to take care of flow operation of dam Planning and management of dams will be in context of existing laws and regulations	To maintain the minimum flow requirements Ensure equitable allocation of water among users	Monitor amount of water to be released.	HPP operator, joint monitoring program, with MoENV.	Operation stage
Increase in aeration	Kiri River	Much more water should be aerated per unit of power generated	To improve water quality and boost DO concentrations	Not required	Dam operators	Operation stage
boost to Economic Growth	Project areas and nearby villages	Developing infrastructure throughout the region and improve exports	To be competitive on the local and international market	Ensure and monitor proper infrastructural development within the region	General manager	Operation stage
Energy production	Affected and surrounding villages	Kiri HPP should be operated in a manner that is economically viable and environmentally sustainable.	To boost economic growth	Tracking power generation, power market rates and power revenue.	General manager operations manager	All stages of project development

Frequent increase in flooding flows	Kiri HPP area	The project should be designed to minimize effects of flood elevations	To avoid soil erosion and inundation of productive land	Develop forecasting and early warning system	Operations manager	Operation stage
Threat to riparian and terrestrial ecosystem	Kiri HPP area and beyond	Power lines should be sited to minimize these concerns and built using good environmental practices	To prevent collision hazards for birds and bats and electrocution hazards for large raptors.	Not required	General manager	Operation stage
Withdrawal of recreation	Project areas, and surrounding villages	Horns or warning whistles could notify recreational users just below retrofitted dams of the dangers of sudden water releases and the associated potential for rapid changes in water levels.	To protect recreational users of the water	Random visual monitoring by KiriHPP EMO	Operation manager	Construction and Operation stage
Dust pollution	Project areas and nearby villages	Undertake watering of the area and surroundings regularly during construction stage	To Minimise danger to human health	Traffic management through daily arrangements for fleet management. Observe implementation of dust suppression program.	Client or Supervision, Consultant on behalf of client, MoENV local branch.	construction stage
Safety hazards for Villagers, workers and project employers at work place	Workers, project employees, surrounding villagers	Develop or adopt the international best practices on occupational Health and safety at the work place (in Contractor's)	To prevent construction related accidents	Contractor responsible for establishing and implementing an effective EH&S plan, including monitoring.	Construction engineer and Kiri HPP EMO	Construction stage

Solid wastes	Construction sites and workers camps	Constructing approved-offsite disposal facilities and develop management program. (in Contractor's EMMP)	To avoid pollution of land and water resources	Random visual monitoring by Kiri HPP EMO	Kiri HPP EMO	Temporary/ During the construction
Disposal of earth, rock spoils	Construction areas and dump sites	Identify earth rock disposal sites and develop best practice management program (in Contractor's EMMP)	To avoid sedimentation of the reservoir	Random visual monitoring by Kiri HPP EMO or designee during construction to ensure compliance with Contractor's EMMP and contract clauses. Violations will require action from Contractor to achieve compliance	Kiri HPP EMO	Temporary/ During the construction
Noise and vibration due to construction and transportation	Construction areas; movement of vehicles, blasting, excavation, construction activities	Adopting International standards on occupational Health and safety as well as noise minimization program (in Contractor's EMMP). Acceptable noise levels to be specified.	To minimize noise disturbance	Monitoring will consist of one-hour continuous samples by a sound level meter (SLM) placed approximately 1.5 m above the ground in the center of affected residential area. Information to be archived by EMO.	Construction engineer and Kiri HPP EMO	During the construction
Tourism	Project areas and nearby villages	Promoting a good image of Kiri for tourists by good advertisement. Development of tourism event base on the attraction of mass	To boost income generation for the state	Monitoring visitor impacts. Monitoring service quality	Project owner and general manager	During and after the project decommissionin g

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1. Summary This study was aimed at assessing the potential environmental impacts of Kiri hydropower project on its hosting communities. The study was deemed expedient considering the fact that such impacts have both short and long term consequences on the people living around such projects. Data for the study were sourced through three main methods. These are the use of structured questionnaires; field observation, interviews and focus group discussions. 150 questionnaires were administered to the respondents and 8 persons in each of the surveyed communities around Kiri dam consulted for focus group discussion. Field observations were carried out using GIS to observe the areas around the bank of dam water and by the river downstream and to identify the extent of foldable areas, hydro-geomorphic features and human activities in the area. Approximately 55 km^2 of productive land has been lost to flooding and erosion in the past decade. Local stakeholders were also consulted to seek their views on the potential impacts of the proposed hydropower project on the immediate environment.Findings indicate that the establishment of the dam has impacted both negatively and positively on the life of the inhabitants. However, negative effects seem to far outweigh the advantages of the dam.

5.2. Conclusion This study focused on investigating the potential impact of the proposed Kiri HPP on the immediate environment and economic lives of the inhabitants. It has been established that

the dam has impacted negatively on the environment and the economy. This is because farmers' farmlands have been taken over by the dam water. The inhabitants have to resettle, thereby subjecting them to a lot of inconveniences and loss of properties. Foreign birds and animals are now common in the area imposing various sorts of threats and intimidation to lives and properties. The dam is most advantageous to Savannah Sugar Company, Numan, because it draws virtually all its water for irrigation from it. Environmental components have also been tampered with in a great way. The incorporation of the hydropower component to the existing facility will see positive effects outweighing these existing negative impacts through:

i. Clean, renewable and low-cost alternative to other energy sources.

ii. Host communities are given employment opportunity for different activities of division of work in hydroelectricity generation.

iii. Support for various kinds of aesthetic and recreational activities, adding to the state income.

iv. Floodwater management and minimization of soil erosion, amongst others.

5.3. Recommendations Based on the findings of this work, the researcher wish as to recommend the following:

i. The author strongly suggests that the main solution to deforestation has to start from local action. In other words a bottom-up approach between the UBRBDA and local people to work together in partnership to check, deforestation is highly recommended.

ii. Tree planting and protection of existing vegetation from fire and land clearing should be also encouraged, as the restoration of degraded lands.

iii. To control water-related disease such as malaria, river blindness, cholera, and bilharzias, proper sanitation and waste disposal facilities as well as proper source of drinking water should be provided to the communities affected by the project

iv. In addition to controlling bilharzias (Schistosomiasis), the author advocates for the use of Endod (Phytolaccadodecandra) which is a berry plant commonly known as the African soapberry.

v.Remote Sensing and GIS techniques are recommended for use in environmental monitoring and management of our already fragile environment.

Immediate Measures to Improve Local People's Livelihood Conditions;

i.Encourage small scale irrigation farming

ii. Promote small scale industry (cottage industry)

iii. Improve the provision of basic infrastructure to the area

iv. Promote the use of Liquefied Petroleum Gas (LPG), clean cooking stove and electric cookers, to solve wood fuel problem

v.Eradicate illiteracy

Responsibilities of UBRBDA and Adamawa State;

i.Organize and finance tree planting

ii. Promote and finance soil conservation programmes

iii. Set up a bilharzia and other water related diseases eradication program.

Finally, there is a need for more profound study to investigate the real source of pollution into the river according to two of the surveyed villages. The responsible authority should conduct further research on this matter.

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Appendix A

Table A1: Respondents' Level of Education in Selected Towns

Level of Education	Name of Town						
	Mabonde	Gelode	W. Jauro	Kiri	New Talum	Total	%
None	10	22	20	15	8	75	50
Primary	8	5	8	10	10	41	27
Secondary	10	3	2	2	9	26	17
Post Secondary	2	0	0	3	3	8	6
Total	30	30	30	30	30	150	100

Table A2 : Educational Background of the Respondents according to Sex

Level of Education	Number of Respondents by Sex			
	Male	Female	Total	%
None	50	25	75	50
Primary	31	10	41	27
Secondary	15	11	26	17
Post-Secondary	6	2	8	9
Total	102	48	150	100

Appendix B

Table B:Occupation of Respondents in the Selected Towns

Name of Town	Occupation of Respondents						
	Farming	Fishing	Teaching	Trading	Student	Unemployed	Farming /Fishing
Mabonde	20	5	1	1	0	0	3
Gelode	13	6	1	2	0	5	3
W. Jauro	12	8	0	3	1	4	2
Kiri	13	7	2	2	1	0	5
New Talum	10	8	1	1	1	2	7
Total	**68**	**34**	**5**	**9**	**3**	**11**	**20**
%	**45.3**	**22.7**	**3.3**	**6**	**2**	**7.3**	**13.4**

Appendix C

Table C: Reported Causes of Environmental Degradation

Factor	Respondents	Percentage (%)
Dam Construction	12	40.00
Deforestation	7	23.30
Farming activities	5	16.70
Others	6	20.00
Total	**30**	**100**

Source: Field survey 2008

Appendix D

Table D: The Common Environmental Problems in surveyed villages

Name of Town	Environmental Problem	Frequency
Mabonde	Erosion	10
	Flooding	10
	Siltation	4
	Pollution	5
	Deforestation	9
Gelode	Erosion	25
	Flooding	20
	Siltation	5
	Pollution	2
	Deforestation	14
W. Jauro	Erosion	24
	Flooding	19
	Siltation	6
	Pollution	3
	Deforestation	15
Kiri	Erosion	20
	Flooding	18
	Siltation	10
	Pollution	6
	Deforestation	12
New Talum	Erosion	15
	Flooding	12
	Siltation	7
	Pollution	8
	Deforestation	12

Source: Field survey, 2014

Appendix E

Table E: The Most Common Diseases in the Surveyed Villages

Name of Town	Common Diseases	Percentage (%)
Mabonde	Bilharzia	26.8
	River Blindness	31.5
	Cholera	24.8
	Malaria	29.1
Gelode	Bilharzia	21.2
	River Blindness	19.5
	Cholera	22.8
	Malaria	15.4
W. Jauro	Bilharzia	25.5
	River Blindness	16.3
	Cholera	26.6
	Malaria	11.6
Kiri	Bilharzias	35.4
	river blindness	47.5
	Cholera	47.7
	Malaria	44.4
New Talum	Bilharzias	36.8
	river blindness	36.3
	Cholera	40.4
	Malaria	34.4

Source: Field Survey, 2014

Appendix F

Table F:Various uses of Kiri Dam

Uses	Respondents	Percentage (%)
Fishing	15	25
Irrigation	18	30
Wetland	14	24
Cultivation	0	0
Domestic Use	13	21
Total	**60**	**100**

Source: Field survey, 2014

Appendix G

Environmental Impact Assessment (EIA) Report for the Proposed Kiri Hydro-Electric Power Project

Executive Summary The Adamawa state government in collaboration with the federal government of Nigeria is proposing to construct a 20 MW hydro-electric power plant in guyuk in order to meet the increasing power demand in the region.This Environmental Impact Assessment (EIA) is to provide information on the potential negative and positive environmental and social impacts of the project. It also aims to make recommendations for the mitigation of the potential negative impacts and enhancement of the positive ones. A field survey of the project site was conducted and potential environmental impacts of project activities were identified, assessed, and documented. The EIA author carried out consultations with various stakeholders, particularly lead agencies, local authorities and the affected people.

Both the Nigeria and World Bank's social safeguard policies have been considered during the assessment. The EIA study has been carried out according to requirements of the current EIA Regulation of the NigeriaGovernment (EIA act of 1992) and theEnvironmental Assessment Policies and Procedures of the World Bank OP 4.01 Environmental Assessment (Annex B - Content of EA and Annex C - Environmental Management Plan). Aim of the EIA study is to meet both the requirements of the Nigeria EIA Legislation and World Bank for a "Category A" Environmental Assessment Study (OP 4.01 Annex B Content of an EA Category a Report). For this purpose, EIA has been prepared according to the special EIA format regarding the requirements of the World Bank and Nigeria

Ministry of Environment. The proposed project meets both the requirements of the World Bank and Nigeria Ministry of Environment. This EIA study has been conducted by YugudaTaitiya Kenneth.

Project Description

The intended power plant will comprise 2 units of 10 MW generating units, likely of Horizontal Francis design, a large vertical intake in the existing reservoir, about 250 m of dual – 4.8 m diameter penstocks yielding a total capacity of 20 MW, which will be operated as combined cycle turbines that will be driven by water only. The plant will be constructed on the left hand side of the dam spillway and away from the shore line. The plant will cover a land of 600 m^2.

Project Impacts

The potential ecological impacts identified in the operation of the power plant are:

(i) Water pollution related to disposal of domestic solid wastes generated by the personnel and domestic wastewater generated by the personnel.

(ii) Water pollution from oil type wastes and/or spills used for the maintenance of equipment.

(iii) Noise pollution resulting from the operation of turbines and other equipment.

(iv) Air pollution resulting from the stack emissions during energy generation.

All those wastes with potential impacts on the environment will be treated with most recent technology available in accordance with the relevant national and internationallegal framework. The positive impacts that will be benefited from the project are basically the additional power availability and reliability in the region which is currently experiencing frequent power outages. The impact of power reliability will improve infrastructural

conditions for further investments, basically related to tourism sector, in the area. Accordingly, this will enable increased employment opportunities to the youth in the area and hence help to improve the social well-being also with improved life standards due to satisfactory electricity supply.

The project will contribute positively to air and noise quality of the whole Guyuk region by replacing the existing distributed diesel driven high speed generating sets with a modern centralized combined cycle power plant. This will bring economical advantages by the reduction of the energy costs to end users which are mainly in tourism sector.

Recommendations

A number of mitigation measures are recommended against the adverse activities during the construction and operation phases of the project. Measures recommended during the construction phase include control of noise pollutions from heavy equipment and vehicles through proper inspection and maintenance, and use of noise suppressors or mufflers for heavy equipment, control of air pollution from construction works and movement of vehicles through proper inspection and maintenance to reduce exhaust emissions, watering of unpaved roads, control of adverse impacts from construction debris by proper handling and immediate removal, control of water pollution through proper storage and handling of oil wastes and treatment of wastewaters at site, control of solid wastes through sanitary storage and frequent collection for sanitary disposal. Quality of air and water will be monitored on a regular basis where noise will be measured periodically. While during the operation phase, emphasis has been on the control of; noise pollution (particularly for the workers) which will be treated with building a noise insulated power room and satisfactory maintenance of related equipment, possible water pollution from oil wastes which will be

treated with employing proper handling and storage of oils/oil wastes and stringent management of oil spills, all of which will be assured with periodic monitoring of noise and emission levels and drinking water quality. All precautions against fire accidents and electrocution will also be taken. In all phases occupational health and safety will be carefully considered and controlled through continuous inspection to prevent disease and accidents, and workers will undergo an environmental and safety briefing on safety, sanitation measures, and emergency rescue procedures before development begins. Adequate sanitary facilities, potable water, and garbage bins will be provided. From the study findings, it has been concluded that the impacts of the proposed project are minor and easily mitigable. The developer is strongly advised to implement the recommendations made by the EIA author.

Policy, Legal and Administrative Framework

Policies

This chapter discusses the policy, legal and institutional arrangement/ framework within which this EIA was drawn.

National Environmental Impact Assessment Regulation

Prior to the establishment of the FEPA there were sectoral environmental regulations with various significant responsibilities relating to environmental protection and improvement. Also in existence were commissions with advisory capacity in environmental matters and environmental NGOs.Due to various activities and the complex combination of interdependentoperations of the oil industry it, more than any other sector, adversely affects the environment.In the oil industry DPR adopted remedial, though inadequate, enforcementtools which included compliance monitoring and the issuing of

permits/licences. Studies indicated the extent of devastation the oil industry has caused to aquatic and terrestrial ecosystems and cultural and historical resources. This, coupled with the community's dissatisfaction and agitation, especially in the Ogoni and Ijaw homelands, reinforced the need for the sector to plan, protect and enhance prudently the environmental resources for a better environment. The need to control new installations or projects with capacity to degrade the environment was also identified. This compelled DPR to issue updated Environmental Guidelines and Standards (EGAS) in 1991 providing for the first time, together with pollution abatement technology, guidelines and standards and monitoring procedures, a mandatory EIA report as enforcement tool. There are other regulatory bodies within the sector. FEPA, charged with the protection and development of the environment, prepared a comprehensive national policy, including procedures for environmental impact assessment for, amongst others, all development projects. Enforcement powers were also prescribed. In the National Policy on the Environment (NPE), FEPA adopted a strategy that guarantees an integrated holistic and systemic view of environmental issues that leads to prior environmental assessment of proposed activities.

The other regulators including State EPAs (unnecessarily charged with similar and identical responsibilities to those of FEPA) rather than cooperating with FEDA undermine its efforts as they demand a role in the state of the environment within their areas. This occurs particularly where FEPA involves them only at the review stage in the EIA process. This creates a lot of confusion and bureaucratic delays in implementing the EIA process leading to enormous cost and unnecessary waste of time.

World Bank Policy on Environmental Assessment (OP 4.01)

The World Bank requires EIA of projects proposed for Bank financing to help ensure that theyare environmentally sound and sustainable in order to improve decision making of the Bank on the project. The Environment Strategy outlines the Bank's approach to address the environmental challenges and ensures that Bank projects and programs integrate principles ofenvironmental sustainability. This study is in line with the Bank's requirements. The Bank's guideline regarding the conduct of an EIA has been adequately followed by the EIA author.

Legal and Regulatory Framework

The relevant laws that promote environmental management in Nigeria have been adequately reviewed and applied by the EIA author including the following:

National Environmental (Sanitation and Wastes Control) Regulations, (Regulations No. 28 of 2009, Vol. 96, No. 60. 07-10-2009)

National Environmental (Permitting and Licensing System) Regulations, 2009 (Federal Republic of Nigeria, Abuja, Regulations No.29 of 2009, Official Gazette, Vol. 96, No. 61 dated 7th October 2009.)

National Environmental (Mining and Processing Of Coal, Ores and Industrial Minerals) Regulations 2009 (Federal Republic of Nigeria, Abuja, Regulations No. 31 of 2009, Official Gazette, Vol. 96, No. 63 dated 12th October, 2009.)

National Environmental (Ozone Layer Protection) Regulations, 2009 (Federal Republic of Nigeria, Abuja, Regulations No. 32 of 2009, Official Gazette, Vol. 96, No. 64 dated 13th October, 2009.)

National Environmental (Noise Standards and Control) Regulations, 2009 (Federal Republic of Nigeria, Abuja, Regulations No. 35 of 2009, Official Gazette, Vol. 96, No. 67 dated 19th October 2009.)

National Environmental (Soil Erosion and Flood Control) Regulations, 2011, S.I. No 12, Gazette No 39, Vol. 98 of 2nd May 2011.

National Environmental (Wetlands, River Banks and Lake Shores) Regulations, 2009 (Federal Republic of Nigeria, Abuja, Regulations No. 26 of 2009, Official Gazette, Vol. 96, No. 58 dated 2nd October, 2009.)

National Environmental (Protection of Endangered Species in International Trade) Regulations, 2011, S.I. No. 15 Gazette No. 42. Vol. 98 of 6th May, 2011.

National Environmental (Desertification Control and Drought Mitigation) Regulations, 2011, S.I. No. 13 Gazette No. 40. Vol. 98 of 3rd May, 2011.

National Environmental (Coastal and Marine Areas Protection) Regulations, 2011, S.I. No. 18 Gazette No 45, Vol. 98 of 13th May 2011.

National Environmental (Construction Sector) Regulations, 2011, S.I. No. 19, Gazette No. 46. Vol. 98 of 17th May, 2011.

National Environmental (Control of Vehicular Emissions from Petrol and Diesel Engines) Regulations, 2011, S.I No. 20, Gazette No 47. Vol. 98 of 17th May, 2011.

National Environmental (Surface and Groundwater Quality Control) Regulations, 2011, S.I. No. 22, Gazette No. 49, Vol. 98 of 24th May, 2011.

Institutions

The related institutions related to the installation of a new natural gas driven power plant are listed as below:

i. Ministry of Works

ii. Ministry of Environment

iii. Upper Benue River Basin Development Authority

iv. Gongola Basin Development Energy Commission

v. Power Holding Company of Nigeria

vi. National Electricity Regulation Commission

These institutions listed above are actually the stakeholders that form the framework conditions for encouragement and support of power market.

Project Description

The proposed power plant will comprise 2 units of 10 MW generating units, likely of horizontal francis design, a large vertical intake in the existing reservoir, about 250 m of dual – 4.8 m diameter penstocks yielding a total capacity of 20 MW, which will be operated as combined cycle turbines that will be driven by water only. The plant will be constructed on the left hand side of the dam spillway and away from the shore line. The plant will cover a land of 600 m^2.

The structures and buildings in the plant will be as followed:

i. The existing dam

ii. The water reservoir

iii. Intake or control gates

iv. The penstocks

v. Water turbines

vi. Generators

The proposed power plant will not use materials that are classified as hazardous or toxic during the construction and operational phases of the project. Oil tanks will be isolated with concrete lining to prevent any leakage and the waste oils, generated less than 10 m^3/year, will be removed by a licensed hauler.

Project Location

The plant will be installed in guyuk local government area, kiri village, Shelleng district covering a total of 600 m^2 on surveyed land, neighboring the savannah sugar Industrial District. The general location of the power plant is illustrated in Figure 1.

The nearest residential area is at approximately 3 km distance from the power plant. The project site is identified as agricultural land in the land registry. The site is reached by land road which takes approximately 25 km from the numan City center and it is right next to the Yola-Gombe highway.

Plan, Features and Construction

The plan consist of constructing a new intake in the reservoir of the Kiri project, placing two penstocks through the dam by breaching and replacing the dam, constructing a new power house downstream on the left side of the river with two generating units of 10 MW each. A tailrace will return generating flow to the main stream of the channel, downstream of the stilling basin and revetment area.

The project is described starting at the upstream end.

As the project reservoir cannot be drained, the project upstream of the dam must be constructed with the full pool. Therefore a cofferdam must be installed. The cofferdams

contemplated consist of a main section of full height of the dam or from the expected bottom of reservoir elevation of 154 up to the top of dam at 174.5. The circular cofferdam would consist of four steel circular cells, driven in section below the reservoir floor. Each cell will be 13 meters in diameter and would be back filled to the top elevation (and slightly above for transportation and access) with sand and appropriate fill material. The cells will be connected by curved sections to fill in between the cells, with each section, six in all, and 15 meters long. These areas would also be backfilled to the top level and with the cells, create a rim around the construction area for the intake tower.

The cells will be connected to the impact dam by fill sections starting at the top of the dam and angling out to the cells. In order to remain impervious, either a special centre selection or outer geo-textile may be necessary. The fill section will be provided at both ends of the cells to maintain transportation across the dam while the tower intake is constructed and the penstock sections through the dam are placed.

The cofferdam is the most expensive cost element to the entire project. It may be that there are less expensive methods than the cellular cofferdams, including placing a larger fill dam on a longer footprint around the work area. However the more tradition method used in this type of construction is the cellular dam and it has been used to estimate costs.

After construction of the cofferdam, excavation of the embankment will be started. The basic excavation will be about 100 meter wide, with a bottom section 30 meters wide to the bottom and side slopes/access cut in to the outside sections. The amount may vary depending on the contractors' final method selection.

After excavation, construction of the intake tower, transition area and penstock placement will take place. The intake tower will be approximately 7.7 meters wide on the upstream face, and 7 meters of the side. About 70% of the upstream and side faces will be open for intake flow. At the bottom elevation, there will be a concrete transition section for flow to enter the two, 4.8 meter diameter penstocks. The intake tower will also have the ability to stop pressure flows through the penstocks by means of bulkhead gates. These gates would not normally be used but are necessary for dewatering the penstocks. The tower and foundation will be of reinforced concrete.

The penstocks will route through the embankment at its lowest or foundation level. The penstocks will be spaced at about 3 meters apart for total space of about 30 meter from outside to outside of the penstocks. The penstocks may be embedded in concrete or included cut-off walls or curtains to avoid any potential of piping of flows. Additionally, the embankment materials will be replaced to the original design. A concrete bulkhead will be at the exit of the penstocks on the downstream slopes.

The penstocks will proceed about 150 meters downstream from the downstream toe of the embankment. The powerhouse location should be set at a place where the flat river bottom land starts to go uphill to higher ground.

The penstocks' traverse of 150 meters will be above ground, secured to saddles. A concrete trust block will be constructed where the penstocks enter the powerhouse.

The powerhouse will be a substructure with two levels above the ground grade level. The floor of the powerhouse will be about 2 meters above the expected tailwater level of 145

meters but and will be flood proof, essentially a concrete container, eight feet above the base floor or to elevation 155. Entry to the powerhouse upper floor will be at the grade of the back side of the powerhouse. Fill from the foundation excavation will be used to bring make the upper level at grade from the land side.

The powerhouse is planned to have two 10 MW horizontal Francis turbines. With a horizontal placement, the penstock can enter through the powerhouse wall. A butterfly valve for starting the unit and dewatering will be inside the powerhouse. The units will have the scroll case sitting vertically and the turbine shaft will be supported by a journal bearing and mates to the generator. The flow from the unit will exit through the powerhouse floor to a tailrace under the powerhouse. The draft tube will be an elbow tube leading to free surface departure underneath the powerhouse.

It should note that the project parameter of 52.5 m^3/sec and 23 meters of the head are on the margin of the use of Francis or Kaplan units. Because there is not a substantial variation of flow and head over a typical year and because construction is likely less expensive, horizontal Francis units were used. A more detailed comparison will be necessary if any future phase of development, with specific input from turbine suppliers. With currently active market for hydroelectric turbines, suppliers are hesitant to provide quotations for projects that are not further along in the development path.

The powerhouse will have a footprint of about 30 meter by 20 meters. As discussed the level, up to elevation 155 will be flood proof. Access for removal of the generator or large items will be through roof hatches. Only a gantry crane will be provided in the powerhouse

so a larger crane will be necessary for construction and removal of larger items. Ventilation for cooling of the units will be done through a ducting system through the substructure roof.The upper level of the powerhouse will be smaller, approximately 10 meter square and a pre-engineered building to minimize costs. The upper level will contain the control and the relay panel, the operating office and the access stairs to the generating floor.

The switchyard will be constructed adjacent to the powerhouse at elevation 155. It will consist of two 15,000 KVA rated transformers, one for each units. The switchyard will also contain two breakers to connect to the high voltage transmission lines to connect to the grid or load.

Flows from the turbines will be returned to the main channel which is approximately 200 meters long. The final length of the tailrace will depend on the final location of the powerhouse.

Power Evacuation Power will be evacuated by two 33 kV circuit directly to the Yola substation. The manner of evacuation was determined by Adamawa state in order to assure that Adamawa would receive all the power generated. To accomplish this power evacuation at 33 kV, two circuits will be used on one transmission pole (likely concrete) or a single lattice type tower.

Approximately 10 MW of power will be generated by each unit at medium voltage, likely at 6000 VAC as this is an accepted IEC medium voltage. Power factor will be 0.85 and the units will generate full power at this power factor. The generators will generate power in a

grounded Wye configuration with a resistance ground to minimize fault current. Power will be taken from the generator to a medium voltage, metal clad switchgear in the power building for distribution to the generator step up transformers and the transmission lines outside the generator building. In addition to the circuit control in the metal clad switchgear, a 33 kV line disconnect switch and circuit breaker will be install in the 33 kV line near the generator step up transformers. Net power metering will be done from current transformers at 33 kV circuit out of the generator step up transformers and voltage transformers at 33 kV. Net power and energy can thus be metered and totalized as required. A circuit from the main bus in the metal clad switchgear will be used for station power. This may also be metered in accordance with Adamawa requirements. Adamawa and the project company will determine if an emergency power system is required.Current transformers and voltage transformers will be place in the generator, transformers and metal clad switchgear as required for metering, synchronization and protection relays. Control of the plant can be performed from instrumentation and controls in the metal clad switchgear or remotely as Adamawa and the project Company desire.

Communication and control is currently handled by line carrier, but it is anticipated that a more sophisticated SCADA will be employed from Kiri Dam to Yola by an Optical Ground Wire system (OPGW).

Construction Cost Estimate The total project costs are about $60 million, including a 20% contingency, appropriate for this level of details in an estimate. The electrical and mechanical features are based on costs from industry and other similar projects and are in line with standard estimates. The civil works,

intake, cofferdam, embankment work, penstocks and powerhouses are estimated from rough quantities necessary for implementation. Dimensions and materials are specific to each feature, although the feature design is subject to substantial modification in future development.The cost estimate is solely for development and construction, financing costs, further environmental studies and other items not directly encountered during construction.

Operations Cost Estimate The 20MW Kiri Hydro Project is regarded as a small hydro project and could be operated from a mostly automated condition. The plant output would vary often and the plant could be dispatched by changing turbine settings remote. It likely could be operated with nearly the same Staff that operates the Kiri project.The estimate assumes the addition of one plant manager and two operators, plus labor for other activities. It does not include any taxes or other fees, as the Authority may not be subject to such payments.

Energy and Production

The energy and production baseline for this option is the same; 142 GWh, with nominal 20 MW capacity. As noted, the production may be slightly overstated due to lowered reservoir pool elevations near the end of the dry period and the estimation of changed regulation of both DadinKowa for hydropower and Kiri. However, some compensation was taken to consider the effect.

The project would run at or near full output during more than 70% of the year. During that time, the output would only be limited by lost head due to rising tailwater during the high flow months or by flows held to reach the maximum Kiri storage level. During 25% of the

year, the project would run at less output, dropping down to 8-10 MW during the driest 15% of the year. During the driest 30% (about 4 months) of the year, the generation would average about 45 GWh.

These estimates are based on current irrigation demands and the operation of the new hydroelectric capacity at DadinKowa releasing water as represented by The Authority. The releases and availability of the DadinKowa generating flows are essential to any dry season generation at Kiri. Without these flows, the Kiri generation would be nearly zero during dry months.

The Authority also advised that the irrigation demands downstream of DadinKowa could increase. Further, the irrigation releases from Kiri may also increase substantially. An energy estimate was made for irrigation demands downstream of DadinKowa of 180 million cubic meters per month during the dry season and increase of irrigation from the Kiri facilities. It was also noted by the Authority that the sugar companies who utilize the irrigation flow may double the land area currently under irrigation. The baseline numbers were using an average release of 12m^3/sec during the driest 70% of the year. The maximum channel capacity of the irrigation works, according to the summary information is 19m^3/sec. Thus, an additional 7m^3/sec was taken from the available flows for Kiri generation.

The plant generation essentially drops 9 GWh, all in the driest six months of the year from 45 GWh. This power is the most valuable of the year. It would drop the average capacity by 2.2MWduring this period from the current irrigation condition. During the driest 10% of the year the loss is most pronounced as it would drop capacity from 7.5MW to 4.4MW.

Summary

The best option would be to construct the project on the left hand side of the dam spillway, about the 300-400 meters from the spillway and away from the shore line. The project penstocks need to penetrate the embankment, which requires substantial cofferdams upstream to construct the works. The project would have a large vertical intake in the existing reservoir, about 250 meters of dual 4.8 meter diameter penstocks. The power house would sit about 150 meters downstream of the dam. It would be constructed of concrete and house two-10MW generating units, likely of horizontal Francis design. An excavated tailrace returns the generating flows to the river.

The project would generate nearly 20 MW continually during the wettest 70% of the year. It would also generate substantial energy during the other 35% (about 4months) of the dry season as presented in the Table below. However generation is dependent on the DadinKowa providing substantial summer generation flows, with only a part of them used for irrigation upstream of Kiri. Otherwise, there will be virtually no generation during the dry one-half of the year. The project will generate about 142 GWh/year under current irrigation uses with the 20 MW of installed capacity. It would cost $60,000,000 to construct and take about two and one half year or quarters (of a year) to complete after ordering turbine-generator equipment. The transmission line to Yola substation is estimated at $18,600,000.

Table:Salient Features of the ProposedKiri HPP

Item	Detail
Location of DHP	NearKiri town,district shelleng, Adamawa
Installed Capacity	20MW
Total Energy	142GWh/year
Catchment area at dam site	56,200 km^2
Type of dam	Embankment
Height above foundation	20m
reservoir volume	615 x 10^6 m^3
Average Reservoir width	10,344m
Diversion tunnels	2
Power house location	surface type, on the left bank of the river
Penstocks	2
Tailrace	150m
intake tower	7 x 25m
No. of Generating Units	2
Spillway Bays	6
Flushing tunnels	2
Length of transmission line	85km
Generating Flow	105m/s
Gross Head	24.5m
Efficiency Assumption	86%

Environmental Baseline Data **Bio-physical**

Environment

Location and Extent Kiri-dam is located on the flood plain of lower Gongola river basin, about 25 km upstream of its confluence with river Benue at Numan, while Gongola valley is located within the upper Benue trough. It was formed as a rift phase due to the development of triple junction at a location close to the present Niger delta. The rift was due to lithospheric peak thinning which caused long narrow complex depressions, which develop in some places filled with variety of sedimentary environment (Whiteman, 1982, reported in Mubi, 2001). Specifically, Kiri-dam is located in Shelleng Local Government Area of Adamawa state and situated on latitude 09^0 39'00" N – 09^0 54'00"N and longitude 11^0 57' 00" E– 12^0 06' 00" E as shown in Figure below, the map linking DadinKawo and Kiri dam is also shown below in the figure below

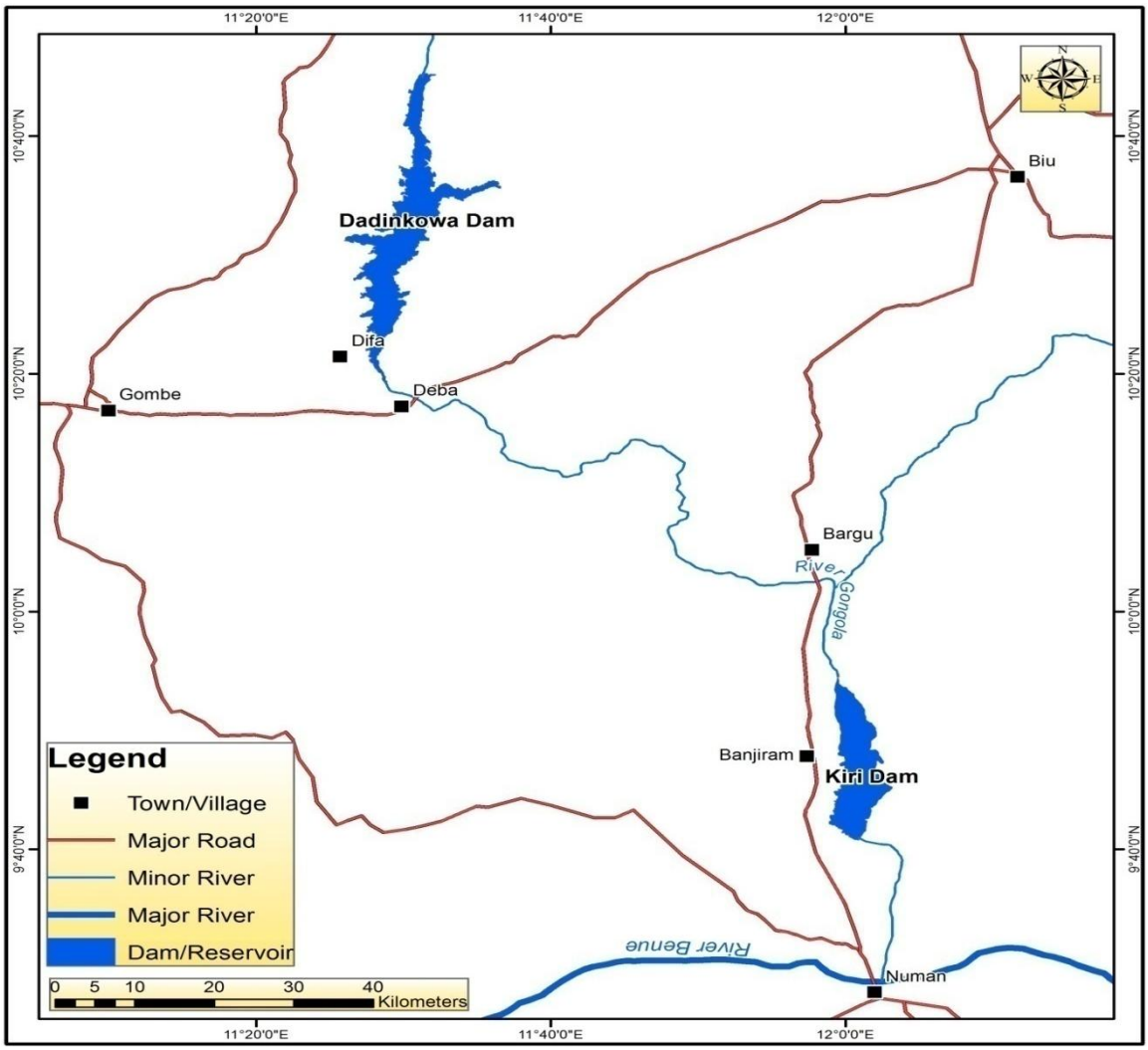


Figure: Map Showing the location of the proposed project
Source: Modified from the Drainage Map of Nigeria

Geology This study area is situated on sedimentary rock made up of shale and thin bands of shale of limestone and lignite. It contains wide range of alluvial deposit along wide channels of river Benue and Gongola which overlies the cretaceous deposit.

Relief and Drainage The study area is low land between 500-700 meters above sea level. The land forms are extensive flood

plains and alluvial swamps. Most of the areas are liable to flooding, water logging or swamps along river catchments. The subsoil and shale formation allow underground flow of water, which raises water table during raining season and drops low during dry season.

Climate Kiri-dam is located in the lower Gongola valley. It has a lower rainfall valley. The upper part of Gongola valley is the northern guinea with the high ground and higher rainfall. Geneally, Kiri is within one of the Gongola zones known as the Hawul catchment of the sudan zone. The climate has two distinct single peaks and usually recorded, in the months of June and September. The rainfall regime in the area is tropical continental types of single peak toll usually in the month of August. The wet season ranges from April to September, with annual rainfall values between 510-1040 mm and dry season last for 7 months.

Kiri area of the Gongola valley has warm temperature with a mean annual of 18^0 C in December (minimum) to a mean annual of 38^0 C in March (maximum). The evapotranspiration is very high throughout the year. Relative humidity varies greatly throughout the year. It is high from May to October, which ranges from 60-78% but has lowest values during dry season, which ranges from 27-35%. Table shows mean monthly values of some climatic elements of the area.

Table: Agro - Meteorological Data (Station: Tallum)

Months	Rainfall (mm)	Temperature (℃)	Relative/ Humidity (%)	Evaporation	Wind Speed (Km/day)
Jan	0.00	35	28	310.50	189.50
Feb	0.00	36	29	395.10	231.30
Mar	14.60	39	82	453.90	279.60
Apr	24.80	40	78	459.00	343.50
May	77.80	35	90	365.70	325.60
Jun	96.30	34	93	306.40	366.80
Jul	158.30	31	95	177.10	244.00
Aug	174.50	31	91	174.60	158.00
Sep	159.70	32	87	170.00	137.10
Oct	660.00	34	91	181.90	106.00
Nov	0.01	35	84	200.10	111.10
Dec	0.00	33	38	265.90	187.80

Source:UBRBDA 2012

Soil and Vegetation The soil types of the area are mainly clay and it encourages water logging of the plains during raining season. The natural vegetation is partially distributed due to deforestation as a result of fuel fire wood and agricultural activities. The zone as mixed vegetation, trees intersperse with grasses. The common tree species are *Terminaliaglancescern, Albaiziachevacies* (Baure), *Acacia Seibberiona* (farm kaya), *Balaniteaegytiaca* (Adua'a), *TamarindusIndica* (Tsamiya), *ZizipusSpina-christi* (Magarya), *Parkiabigalobossa* (Daurawa), *Buttraspermuparadoxa* (Kadanya), *VitexDonnia* (Dinya) and *Pilostigma reticulate* (Kargo). The dominant grass species in the zone are *Pennisetum, Adropogon, Hyprrhenia, Barachana* and *Aristida* species etc. suitable for grazing livestock.

Surface Water Use Mainly springs and groundwater are used for agricultural purposes in the villages. The river is used by the fauna species and by livestock to some extent. There are a number of alluvial water wells for irrigation purpose located close to Tallum. Therefore, there is no significant use of river water by the locals living in the area for drinking, irrigation or production purposes.The irrigation network is not well developed in the area, and it is not estimated that irrigation needswill increase significantly in the future.

Terrestrial Habitats Five (5) distinct habitat types occur in the project area. They include: dry deciduous forest; riparian woodland; open forest with grass; termitaria vegetation; and grasslands. These habitats support a large variety of biodiversity including large fauna, birds, reptiles and rodents.

Social Environment

The selected location for the plant is near the savannah sugar Industrial District, and there are no residential areas in the 3 km radius of the plant.

Demography

According to the 2006 census the population of Adamawa is 3,178,950. Population data is shown in Table 2. The population has grown by approximately 66% in the last decade and it is anticipated that it will be growing at a similar rate in the future due to several facts. The major motive of population growth is the migration to the city as a result of developing tourism sector, which is already the main income source of the city.

Table : Adamawa State Population Census (1991 and 2006)

S/No	LGA	Population 1991-11-26	Population 2006-03-21
1	Demsa	95,149	178,407
2	Fufore	158,137	209,460
3	Ganye	-	169,948
4	Girei	-	129,855
5	Gombi	88,635	147,787
6	Guyuk	70,526	176,505
7	Hong	117,240	169,183
8	Jada	124,856	168,445
9	Lamurde	-	111,254
10	Madagali	90,159	135,142
11	Mailia	83,192	110,175
12	Mayo-Belwa	125,073	152,803
13	Michika	117,684	155,238
14	Mubi North		151,515
15	Mubi South		129,956
16	Numan		91,549
17	Shelleng	52,477	148,490
18	Song	-	195,188
19	Toungo	-	52,179
20	Yola North		199,674
21	Yola South		196,197
	Total	**2,102,053**	**3,178,950**

Potential Environmental Impacts

Construction Phase

Physical and Chemical

This section of the report describes the potential environmental impacts, both negative and positive, that are likely to result from the construction and operation of the thermal-power plant in Guyuk. The possible mitigation measures identified for the significant negative

impacts are presented in the next section of this report. Physical and chemical impacts of power plant construction may include those on geology, soils, topography, landforms, and meteorology, climate, air and water quality, and noise. Potential environmental impacts on each are presented as the following:

Geology and Soils

There will be no significant soil disturbances and no significant impacts on local geology since the site will not need any preparation activities such as drilling, blasting. The whole system will be brought to site as a compact unit requiring no heavy construction at site. There will be minor work in the construction of the site which will cause insignificant amount of excavation soil, construction and debris waste, which will be handled according to the Regulation on excavation soil, construction and debris waste.

Topography and Landforms

Local topography will not be altered.

Climate and Meteorology

Impacts on the microclimate and meteorology of the local area will be negligible. There will be no changes in surface albedo and no aerodynamic disturbances.

Air Quality

Air quality emissions problems resulting from the construction activities will be limited to fugitive windblown dust, internal combustion engines in heavy equipment and onsite power generators. These impacts will be low and short-lived. There will be no burning of vegetation and/or other refuse.

Noise

Noise impacts may occur as a result of operation of heavy equipment, pile drivers, and onsite power generation. Estimated noise level outputs were obtained from equipment manufacturers and the impacts are assessed to be insignificant since the national and World Bank standards will not be exceeded.

The article of National Environmental Standards and Regulations Enforcement Agency 'Noise Regulation' (Date: 19.10.2009, and No: 67) will be considered and complied.

Hydrology

Groundwater

Fresh water required by the personnel will be supplied from the wells to be dug at and/or around the site with necessary permissions taken from the State Hydraulic Works as required by the Groundwater Law (Date: 24.05.2011, No: 22). The daily discharges from the well will not have any adverse affect on the local hydrology.

The water demand is estimated based on the assumption of 75 l/cap/day consumption. The number of workers together with possible visitors is estimated as 250 people. Hence the water demand is calculated as:

250 x 75 lt/cap/day= 18 750 lt/day

Surface Water

There will be no surface water use. There will be no discharges to a receiving surface body. The wastewater generated at the site will be treated by independent compact treatment units and the treated wastewater will be used for irrigation.

Water Quality

Water quality issues associated with power plant construction are often minor. In this particular case, there will be no liquid or solid wastes generated from the plant which will be disposed directly to cause any adverse affect on environment.

The amount of domestic wastewater generated by the plant's personnel is assumed to be equal to the estimated amount of water usage, which is approximately $20m^3$/day. The wastewaters generated at the plant will be treated with individual treatment units to give an effluent appropriate for irrigational purposes.

Solid Waste

Solid waste during the construction phase will be minimal since the system will be installed as a whole unit. Solid wastes such as rejected components and materials, packing and shipping materials (pallets, crates, Styrofoam®, plastics, etc.), and human garbage will be disposed properly to sanitary landfills as required by the national Solid Waste Control Regulation (Date: 7.10.2009, No: 60).

The amount of solid was generated by the personnel is estimated based on 1kg/cap/day solid waste generation assumption. Hence the generated solid waste is calculated as:

250 x 1 kg/cap/day= 250 kg/day

Biological

The presence of local flora and fauna were determined and evaluation of construction impacts was made.

Flora and Fauna

There are no endangered flora and fauna determined on the project site; therefore, construction should have no adverse effects on endangered flora and fauna.

The plant patterns in the project site will be removed from as a result of clearance forconstruction. The project site is near the industrial zone, therefore there will be no concerns for wild life disturbance as there is no suitable habitat in terms of suitable natural flora cover and related fauna. There are no endangered species present at the project site. There will be very minor impacts on fauna due to the construction of the plant.

Ecosystems

Impacts of construction on ecosystem will be negligible since there will be:

i. No removal or interference with prey of predatory animals;

ii. No effluent discharges;

iii. No significant siltation from run-off, altering aquatic and marine flora and fauna populations and hence population dynamics of dependent organisms;

iv. No noises disrupting breeding behavior or use of breeding grounds, resulting in shifts inpopulation dynamics; and

v. No removal of predatory animals resulting in increased prey populations that exceed the carrying capacity of the local environment.

Socio-economic

Demographic

The construction of plant will have limited effects on the demographic conditions since the number of workers in the construction phase will be 200 people. There will be no permanent living quarters associated with this power plant. Hence there will be no increased demand on local infrastructure, such as utilities, housing, medical facilities, schools, water, and food. The project will not cause any displacement of individuals whose livelihood depends on the land that will be occupied by the Project. The labor force for the

construction of the plant will be supplied also from Antalya, which will result in increased disposable income of plant employees.

Land Use

The primary changes in land use during the construction will be basically at the plant site, which is currently registered agricultural land. However, the project site is in the close vicinity of Antalya Organized Industrial District and unimproved agricultural land devoid of any agricultural plantation. Outside the project site, change in land use will be limited to infrastructures that will be installed to support the plant such as the road access and storm water collection system.

Occupational Health and Safety

Health and safety impacts of the project on workers and communities in the area of influence of the project will be reasonably managed according to the national Occupational Health and Safety Regulation (Date: 17.05.2011, No: 19) in order to reduce the likelihood of accidents and work-related illnesses on the job as well as accidents occurring between construction related equipment and local vehicles. Since the project site is near the industrial district and minimum 3 km away from the nearest residential area possible impacts on local people and pedestrians are assumed to be negligible.

Operation Phase

Environmental impacts from the power plant operation that will be quantified and reported include those on existing air, water, and soil quality, and the disposal of solid wastes. Long and short-term impacts on flora, fauna, human populations, and the health and safety of workers in the surrounding community were evaluated.

Physical and Chemical

Physical and chemical impacts of thermal power plant operation typically include those on geology, soils, topography, landforms, meteorology, climate, air and water quality, and noise. These impacts for this particular case are estimated as follows.

Geology and Soils

Soil impacts consist of negligible effects of windblown fugitive dust. Since the plant will run on hydropower only, and the plant will need not be equipped with dry low NOx technology hence deposition of sulphates, nitrates and metals from the stack plume, as adsorbed or incorporated into particles, will be of no concern.

Topography and Landforms

Local topography will not be altered and there will be no possible effects on landforms such as swamps and shorelines.

Climate and Meteorology

There will be no significant impact on the microclimate and meteorology of the local area caused by changes in surface albedo and aerodynamic disturbances. There will be no significant impact on precipitation patterns by increased availability of condensation nuclei downwind of the power plant as there will be no particulates in the stack plume.

Air Quality

Air quality emissions problems will be limited to only the construction stage of the hydropower project

Noise

Noise sources from the plant during energy production will include the generators and turbines. However the power house will be insulated for noise and vibration and hence it is

estimated that the workers will not be affected. The Power Plant will be located approximately 3 km away from the nearest residential area and the gas turbine packages are equipped with standard silencing to keep noise levels below 85 dBA at 1 meter and below 55 dBA at 154 meter. In addition, the noise insulation will ensure compliance with the Nigeria Standards and World Bank Guidelines as shown in the Table.

Table : Noise Standards

Location Category	**Nigeria Standards**		**World Bank Guidelines Limits in Decibels, dB(A)**	
	Day Time	**Night Time**	**Day Time**	**Night Time**
Residential, Institutional, Education	60	50	55	45
Commercial/Industrial	70	60	70	70

Hydrology

Groundwater

Groundwater will be exploited from the wells to be dug at and around the site with necessary permissions taken from the State Hydraulic Works as required by the Groundwater Law (Date: 24.05.2011, No: 22). Groundwater use during the operation phase will be limited to domestic use by the personnel. The estimated total amount of water use by the personnel is calculated on the basis of assumed per capita water consumption rate of 75 lt/cap/day. The total number of people using freshwater is assumed as 80, of which 37 will be the staff and the rest is assumed to be visitors.

80 x 75 l/cap/day = 6 000 L/day .The water discharge rates from the wells will not affect local hydrology.

Surface Water

There will be no use of surface water during the operation of the plant apart from that to be drawn for hydropower generation.

Solid Waste

The solid waste generated by the plant will be only domestic solid waste which will be properly disposed of in sanitary landfills as required by the national Solid Waste Control Regulation (Date: 7.10.2009, No: 28). The amount of solid waste generated in the operation phase is estimated based on the daily generation rate of 1 kg/cap/day. Accordingly the amount of solid waste generation is estimated as: 80 x 1 kg/cap/day = 80kg/day.

Biological

Flora and Fauna

The project site will not interfere directly with any existing wildlife reserves or national parks. Wildlife is in fact expected to resurface in the area due to improved water supply. However, the installation of new power lines, in addition to disturbing habitat, may pose collision hazards for birds and bats and electrocution hazards for large raptors.

Ecosystems

Impacts of operation of the plant on ecosystem will be negligible since there will be:

i. No removal or interference with prey of predatory animals;

ii. No wastewater discharges to receiving bodies;

iii. Limited emission of stack gases well below the national and World Bank standards;

iv. No significant siltation from run-off, altering aquatic and marine flora and fauna populations and hence population dynamics of dependent organisms;

v. No noises disrupting breeding behavior or use of breeding grounds, resulting in shifts in population dynamics; and

vi. No removal of predatory animals resulting in increased prey populations that exceed the carrying capacity of the local environment.

The frequent power outages experienced in Antalya caused increased use of fossil powered generators which discharge greenhouse gasses. The operation of power plant will result in continuous power availability, which will reduce the adverse effects of additional pollutants from such applications.

Socio-economic Structure

Demographic

The operation of plant will have limited effects on the demographic conditions since the number of workers in the operation phase will be around 100 people. There will be no permanent living quarters associated with this power plant. Hence there will be no increased demand on local infrastructure, such as utilities, housing, medical facilities, schools, water, and food.The project will not cause any displacement of individuals whose livelihood depends on the land that will be occupied by the Project.

The labor force for the operation of the plant will be supplied also from Antalya, which will result in increased disposable income of plant employees.

The Guyuk region has been experiencing frequent power outages in the last years due to the insufficient power supplies. This has been a major problem in the city which heavily depends on tourism sector. The seasonal fluctuation of population due to tourism activity could not be compensated in terms of electricity supply.

The power plant, by itself, will be able to meet the electrical energy demand of the whole city, as the only producer of electricity in the area. Hence it will positively impact the social economical environment for tourism and service sectors by providing improved power availability and reliability.

The use of clean energy i.e. hydropower will also help to improve local conditions to support the development of tourism sector.

Land Use

The plant's site is currently unimproved agricultural land; hence the shift in land use is from unimproved land to industrial area. Additional changes in land use may occur as a result of the development of new industries in the area, constructed to take advantage of local, reliable, and oftentimes cheaper electrical power. There may be increased local industrial development as a result of additional power availability and reliability in the future.

Occupational Health and Safety

Health and safety impacts of the project on workers and communities in the area of influence of the project will be reasonably managed according to the national Occupational Health and Safety Regulation (Date: 17.05.2011, No: 19) in order to reduce the likelihood of accidents and work-related illnesses on the job as well as accidents occurring between construction related equipment and local vehicles. Since the project site is near the industrial district and minimum 3 km away from the nearest residential area possible impacts on local people and pedestrians are assumed to be negligible.

Mitigation Measures

The purpose of impact mitigation is to look for alternative and better ways of implementing the proposed project or associated activities so that the negative impacts are eliminated or minimized, while benefits are enhanced. Impact mitigation requires that the full extent of the anticipated environmental problems are understood. In view of this, this section of the EIA presents mitigation measures resulting from the impacts identified. The mitigation measures are presented for the construction phase and the operation phase in the Table below

Table: Summary of Mitigation andEnhancement Measures Kiri HPP

Potential Impact	Proposed Mitigation and Enhancement Measures
Employment opportunity	Give priority to local people
Increase in local economic activities	Promote formation of small holder schemes.
Increased fish production	Ensure only sustainable methods of fishing are used
Economic growth	Effectively manage the hydropower scheme
Energy production	Kiri HPP should be operated in a manner that is economically viable, environmentally sustainable
Loss of cultural and historical Assets	No cultural and historical site is present at the site and therefore no loss is expected
Reservoir sedimentation	Limit movement of heavy machinery only to designated access routes and operational areas
Air pollution	Air emissions from the construction activities have to meet with Government of Nigeria's National Environmental Quality Standards
likely Increase in flood	The project should be designed to minimize effects of flood elevations
Increase in local population	Giving priority of employment to locals as a matter of company policy
Dam safety concerns	The Project should be designed and executed complying with guidelines of International Commission on Large Dams (ICOLD)
Loss of vegetation, wildlife habitat	Prohibit unnecessary cutting of trees and vegetation clearing
Dust pollution	Dust will be minimized by regularly watering of construction area.
Deterioration in water quality due to oil spills and liquid waste	Prohibiting discharging of waste or any form of effluent into the reservoir
Change in flow release pattern	Building some kind of re-regulation structure (such as another small reservoir or a low-head weir) downstream to even out daily flow cycles
Withdrawal of Recreational	Safety and warning signs should be posted on river banks
Threat to vegetation, wildlife and bird sanctuaries	Power lines should be sited to minimize these concerns and built using good environmental practices
Threat to public health	Regulating withdraw of water from the dam to disrupt mosquitoes breeding cycle, and introducing larva eating fish into the reservoir.

Likely increase in aeration	Much more water must be aerated per unit of power generated.
Threat to human health	Putting in place an awareness campaign programme for its workers
Potential Impact	**Proposed Mitigation and Enhancement Measures**
Noise and vibration	Adopting International standards on occupational Health and safety as well as noise minimization program
Increased tourism potential	Encourage investment in the tourism industry
Decrease in pollution	Making hydropower energy readily available Discourage the use of petrol and diesel engines for power generation
Deforestation control	promote use of electrical cooking and processing appliances Discourage use of forest resources as fuel sources
Solid wastes	Constructing approved-offsite disposal facilities and develop management program. (in Contractor's EMMP)
Safety hazards for villagers and project employees	Develop or adopt the international best practices on occupational Health and safety at the work place (in Contractor's EMMP and Health and Safety Plan) Establish local and village security committee

Environmental Management Plan (EMP) An environmental management plan (EMP) was formulated to manage impacts, to adopt the best available proven control technologies and procedures, to ensure a continuing process of review and positive action in the light of available monitoring results, and to consult with local communities on a continued basis. An environmental and safety officer will be hired to oversee implementation of the EMP, the environmental monitoring program, and compliance with ECC conditions. The officer will closely coordinate with the plant general manager, the management staff, and the monitoring team.

The EMP will aim to achieve an exemplary environmental performance during construction and operation. To meet this goal, the following activities, measures and programs will be implemented

(i) Environmental policy

(ii) Application of all mitigation and management measures

(iii) An environmental monitoring program

(iv) An emergency and contingency plan

(v) An institutional plan

(vi) An environmental and safety officer.

Environmental monitoring is an important component of the EMP. It provides the information for periodic review and refinement modification of the EMP as necessary, ensuring that environmental protection is optimized at all project phases. Through monitoring, unwanted environmental impacts are detected early and remedied effectively. It will also validate the impacts predicted in the Environmental Impact Assessment (EIA) and the effectiveness of the proposed mitigation measures. Lastly, it will also demonstrate compliance with national and World Bank regulatory requirements.

A comprehensive monitoring program for the plant complex has been developed, covering the measurement of relevant environmental indicators. At the plant, it will involve noise, safety concerns, site drainage, solid waste and wastewater disposal, groundwater abstraction, and structural integrity of the tanks and buildings. The results of the monitoring program, which will be implemented by the Monitoring Team (MT) to be created for the project, will be used to optimize plant operations and adjust to management practices.

The monitoring of required parameters to check the environmental impacts, frequency of their measurement, recording and reporting to related national authorities will be carried out strictly as required by the related national regulations. The legal framework to be complied for environmental monitoring is provided in the Table below.

All measurements for the required parameters will be done with methods described under National Environmental Standards and Regulations Enforcement Agency(NESREA), Federal Environmental Protection Agency (FEPA), and European Committee for Standardization (CEN) norms.

In the event that monitoring indicates that any environmental quality is deteriorating to unacceptable levels, the proponent will correct operation procedures that are contributing to the problem and/or undertake necessary engineering installations.

Table : Legal Framework For Environmental Compliance

Monitoring of;	**Regulation to be Complied**
Air Emissions	Regulation on prevention and control of industrial Air Pollution (Date: 17:05:2011: No: 47: Vol 98)
Well water quality	Regulation on Water Intended for Human Consumption (Date: 24.05.2011: No: 25 : Vol 98)
Waste water quality used for Irrigation	water pollution Control regulation (Date: 21:12: 2009, No: 29) and standards set out in Technical Procedures notification (Date: 7.1.2009, No: 48)
Handling and disposal of wastes	Regulation on Control of Waste oils (Date: 07.10.2009, No: 28)

Appendix H

QUESTIONNAIRE FOR THE HOST COMMUNITIES

SECTION A: LOCATION AND BACKGROUND OF RESPONDENTS

1. Name of community ……

2. Sex (a) Male …….. (b) Female ……..

3. Age …… 4.Occupation ……..

5 Educational Level (a) None ……..
(b) Primary……
(c) Secondary……
(d) Post Secondary/University (specify)……

6. For how long have you lived here? ……..

SECTION B: ENVIRONMENT, HEALTH ISSUES

7. Do you think the construction of the dam has lead to deforestation?
(a) Yes [ ] (b) No [ ] (c) Don't know [ ]

8. Since the dam was constructed what are the three (3) most important -major problems you people in the community have been facing.

a…….
b…….
c…….

9. Do you have health post (hospital) in the area? (a) Yes [ ] (b) No [ ]

10. What are the common diseases/ illnesses in the area in this area?

a.Billharzia[ ] b. Cholera [ ] c. Malaria [ ] d. River Blindness [ ]

11. Do you have any health education about Bilharzia and river blindness?

(a) Yes [ ] (b) No [ ] (c) Don't know [ ]

12. Do the URBDA authorities involve members of the community in the management of the dam? (a) Yes [ ] (b) No [ ]

13. Do you experience flooding in this area before the dam was built and now?

(a) Yes [ ] (b) No [ ]

If yes, explain ……

14. How would you rate the environmental management of the dam?

Poor [ ] Satisfactory [ ] Good [ ] Very Good [ ]

SECTION C: SOCIO-ECONOMIC ISSUES

15 what are the main forms of occupation in this area?

……..

16 what farming methods are mostly used in this area?

…….

17. Since the construction of the dam, have your living standard improved?

(a) Yes [ ] (b) No [ ]

18. Have you got compensation for loss of property?

(a)Yes [ ] (b) No [ ] (c) I have been promised [ ]

19. If yes are you happy about what you have got?
Explain……

20. Do you have a good source of drinking water? (a) Yes [ ] (b) No [ ]

21. Do you have electricity? (a) Yes [ ] (b) No [ ]

22. Do you have any good toilet facilities? (a) Yes [ ] (b) No [ ]

23. Are you happy with the house you are living in? (a) Yes [ ] (b) No [ ]

24. Who provided these facilities in this area? (a) URBDA [ ] (b) Self [ ] (c) Other. [ ]
Explain…….

FOCUS GROUP DISCUSSION

1. Did you or your representatives from your community participate in any formal discussion about the government's plan to construct the kiri HPP?

2. If no, how did you get the first information about the plan to construct a hydropower project on the kiri dam?
- by government and local authorities - explain
- by the NGOs - explain

3. How did you understand the information that you received from each party?

4. Are you displaced from your local area due to the kiri dam construction?

5. While you were informed about the construction and the purpose of the hydropower project, did u perceive the program positively or or negatively?
Why?

6. Have you raised some issues such as environmental and socio-economicconcerns that should be considered by the decision makers in the project planning? List.

7. Do you expect future benefits from the hydropower project development?

Are you informed about that from the authorities? If yes, explain

8. Is there any infrastructural facility established in response to the project development in your area?
   - education
   - health facilities
   - transport services
   - electric supply

9. Did you or anyone else from your community participate in the decisionmaking process? Were your views heard?

10. In the near future, what do you expect from the hydropower project? For example, economic benefits such as increased fish farming and tourism.

Are you informed you will participate in these economic activities?

11. What is your view on the hydropower project as a source of employment for people from your village?

12. Can you explain your feelings about the construction of the hydropower projectin your area? Do you feel secured or …….. Do you expect a change in your lifestyle upon the completion of the project? Explain.

Appendix I

INTERVIEW GUIDE FOR UBRBDA/GOBADEC/MoENV

1. Name of responding URBDA officer

2. Designation

3. Are you privileged to express the views of the URBDA/GOBADEC on the Kiri dam?
   Yes [] No []

4. If no, Can you please direct the Assessor to the appropriate Officer?

5. Was there an EIA report for Kiri dam? Yes [] No []

6. If no: why?

7. How many hydropower plants do you have in the north-east region? .....

8. Please give the specifications of the hydropower project under the following sub heads

a) How many turbines will be installed
b) What is the capacity of each turbine
c) What is the expected output of electricity for the facility
d) Who will be managing the hydropower project URBDA [] PHCN []
e) If not URBDA, will the generated power be sold Yes [] No [ ]
f) Who is the proponent or financer of the project URBDA [] FGN [] OTHERS []
g) Who is responsible for the operation and maintenance of the project?
h) Are the host communities' parts of the beneficiary of the project?YES[] NO []
i) If no, why?
j) If yes, on what terms?At a discounted rate [] Like other consumers []
k) Any compensatory facilities or projects to the communities? Yes [] No []
l) If yes, list

Road Improvement []
Hospital []
Potable water supply from Borehole of Water Treatment plant []
Town hall []
Market []
Bus transport system []
Police post []

m) Do you think the project has benefited the communities? Yes [] No []
n) If no, why?
o) If yes, in what sense?
p) List three most important ways in which the hydro project will benefit the host communities

……
……
……
……

9. What do you consider to be the most significant environmental issues facing Kiri dam before the introduction of the hydropower component. Is the problem technical or managerial?

10. Is the dam regularly monitored? Yes [] No []

If yes why the monitoring

a) Dam stability/failures or dam collapse []
b) Fishing potentials []
c) Disease vectors []
d) Water levels []
e) All of these []
f) a and d only []

g) Siltation []

11. What is the location of your community to the dam?

a) dam level [] b) above the dam [] c) below the dam []

12. Has the dam caused changes to the water reaching or available to your community?

a) Increased [] b) decreased [] c) no change []

13. If it had decreased what is the effect of the reduced amount of water

a) Decrease in agricultural production []
b) Reduced fish catch from the river []
c) Made it easier for people to move to nearby communities especially in the rainy season []
d) Made goods to be transported easily. []

14. How has the reduced amount of water downstream affected your people?

a) Many farmers had to leave farming because of low water for their crops and become traders if they had the starting capital. []
b) Others without the capital became unemployed []
c) Fishermen lost their occupation and either moved into other profession like trading if they had the capital or become unemployed or laborers []
d)

15. If this dam now had a hydro component to generate electricity, do you think that it will benefit you and the community i)Yes [] ii)No [] iii) Don't Know []

If yes, How?.....

If No, How?.....

16. Please explain how you think the community can best maximize their gains from the construction of the hydropower project in addition to this dam already existing here. Give at least 5 suggestions.

i……
……..
ii……
……
iii……
……
iv……
……
v……
……

17. Have you conducted a detailed impact assessment before the construction phase of the Kiri hydropower project?

17.1 If yes, what elements did the evaluation team take into account during the process of impact assessment?

18. The planning and decision making process of the Kiri HPP construction is a multi-spectral issue involving a number of actors at local, national and international levels. Was your policy open to invite those actors?

19. If yes, who were those actors? And are their views included in the decision making process?

20. The Kiri dam covers a large geographical area of about 56,200km^2. How does the policy treat the environmental impacts of the area-on vegetation and wildlife?

21. Can you explain the reaction of the local people for or against the construction of the project?

22. Among the local people, there could be some hopes and expectations from the hydropower project development: economic and social. What is your plan to entertain those expectations?

23. Your contact with the local people at and below the dam site: have your office had a regular meeting to inform about the HPP construction on Kiri dam?

24. Are there institutional setups established or planned to help the local people, for example water, electricity, health, transport facilities.

25. What are the main sources of livelihood of the local people? And how do you plan to mitigate the issues of future livelihoods for the people residing along the project site?

26. There is seasonal variation in the amount of rainfall in the country. So, how sustainable will the water-dependent hydropower project be?

27. Does the PHCN have a short term plan to electrify the local people along the project area?

28. How aware are these people on the access and sustainable utilization of the electricity to be supplied?

29. Do they claim access to energy supply as a basic human need?
30. At the upstream of the Gongola River, there is the dadinkowa hydropower project. Can you explain if there are any learned experiences that have been considered in the planning process of the Kiri HPP?