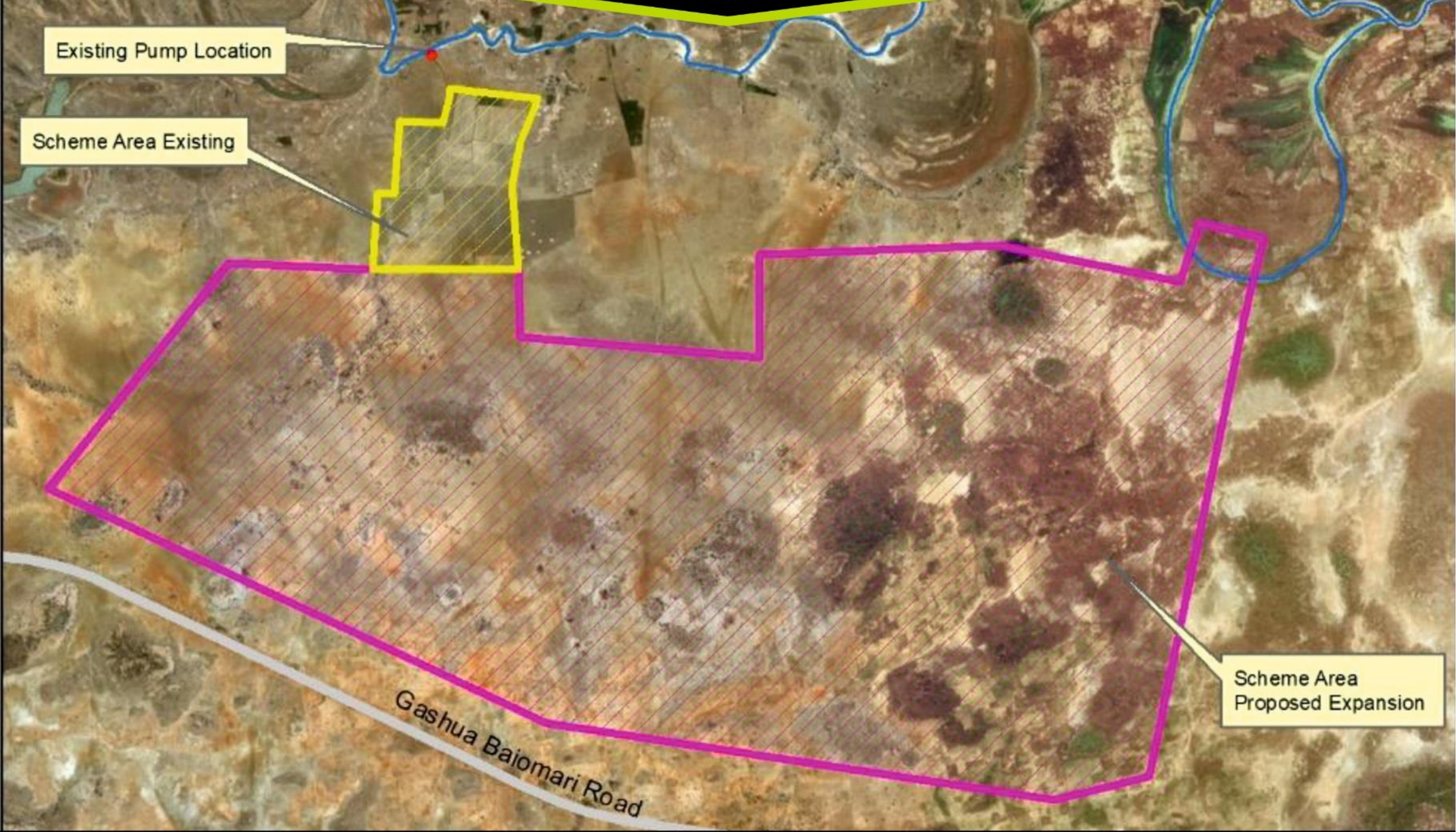
DRAFT FINAL REPORT



Environmental and Social Impact Assessment for Gashua Irrigation Scheme

SUBMITTED BY

Hadejia Jama'are Komadugu Yobe Basin-Trust Fund HJKYB-TF)
Km 6, Potiskum Road,
Damaturu, Yobe State.
Nigeria

SUBMITTED TO

FEDERAL MINISTRY OF ENVIRONMENT
Mabushi District, Abuja

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QUALITY ASSURANCE

	NAME	DESIGNATION	SIGNATURE	DATE
Approval	TPL. Barnabas Atiyaye FNITP	Lead Consultant		26TH JULY, 2021
First reviewer	TPL. Nathaniel Atebije FNITP	Consultant		26TH JULY, 2021
Prepared	TPL. Samson Olusegun	Consultant		26TH JULY, 2021

EXECUTIVE SUMMARY

This ESIA is a part of consultancy services to assist the Hadejia Jama'are Komadugu Yobe Basin Trust Fund (HJKYB-TF) towards implementation in the Gashua Irrigation Scheme over the next 25 years. The project comprises two phases. The first phase is assessment and situation analysis of the various sector directly related to the water resources development of the basin and the second phase is selection of priority projects and subsequent preparation of a preliminary design report for each of the projects. This report is prepared as a part of the second phase. Four priority projects were selected and approved by the Client for preliminary study and design.

One of the selected priority projects is the Gashua Irrigation Scheme Rehabilitation and Expansion Project, intended for development of about 2,100 hectares (ha) gross command area using water pumping from Yobe River. The project comprises of construction of proposed six (6) pumping stations, drilling of sixty (60) boreholes and developing irrigation farm on a total of about 2,000 ha of land. The Gashua Irrigation Project (GIP) area is located in the South Eastern HJKY Basin, Yobe State, on right side of Yobe River and on the left side of Gashua-Damaturu road. It covers parts of Bursari Local Government Area (LGA).

The primary objective of the project is achieving food security and income generation for the local farming community, in particular, and the country, in general, through irrigation infrastructure development. Specifically, the aim of the study is to prepare technically feasible, economically viable and socially accepted preliminary designs of the project consistent with environmental protection.

The scope of this work considers technical, institutional, social, policy and financial implications and provides assessment for the justification of the project. Preliminary site visit and scooping exercise were undertaken particularly.

Although the project boundary encloses an area of about 2,100ha, a less command area is available for surface irrigation development due to limitations caused by soil textural class and drainage status. Thus, after a detailed layout of fields and network of canals, a net command of 1,767 ha was found for the proposed Irrigation Project excluding the areas lost due to network of canals, drains and project roads which constitutes about 10% of area available for surface irrigation development.

The Gashua irrigation command area is bound by the main canal which runs from the off taking points up to the end of the command area. The planned water

delivery system includes pumping of water directly from the River Yobe and delivery of the water by main canal running along the contour in the East and South border of the project.

Chapter one highlights the concept of human settlements and anthropogenic activities which has led to global warming, pollution, climate change, over population, waste disposal and disforestation. These are the reasons why anthropogenic activity needs to be checked before implementation (citing relevant laws and organization to oversee this). Furthermore, the background of the project was highlighted stating the project client and list of consultants in addition to the registration, contract, scope and objective of the ESIA study. Relevant laws were also stated in this chapter which founded the basis of the ESIA study.

The second chapter amplifies the need of the project which is agriculture, and how to maximize the benefit of the project while minimizing the environmental repercussions that might arise. In essence, filling a gap to meet a need. Here the objectives of the proposed irrigation project were clarified, while stating the projects value, sustainability and the expected benefits likely to emanate from the project future implementation. The project alternative and the No Project" options were also discussed in this chapter.

Chapter three describes the nature of the project and its backgrounds and characteristics. The location of the proposed irrigation project was clearly stated citing the exacts coordinate. The geographical and geological characteristic of the project location were also described in addition to the climatic information which includes variables like rainfall. The biological characteristics which are both flora and fauna peculiar to the project area were identified and documented with their botanical names and pictures. Summarily, the description of irrigation system and methods with reference to the Hadejia Jama'are Komadugu Yobe basin were elaborated.

The fourth chapter highlighted in totality, series of activities and methods applied in the preparation of the ESIA report and methods applied in acquiring baseline information. These preliminary activities included, Project scoping with Stakeholder workshop, socio economic survey, establishment of physical and biological parameters through analysis of collected samples. The results and statistics of the Socio-economic survey were discussed with the use of tables and charts; then inferences were made based on the responses gotten from the socio-economic survey within the targeted project affected communities. At the same time, results of the analysed samples obtained from the proposed irrigation site were displayed in line the Federal Ministry of Environments acceptable standards and limits. The samples tested were Air, Noise, water and soil both on site and in lab.

Chapter five elaborates and predicts the likely positive and negative impacts to be envisaged during the project preparation, project construction and operational phase. Potential health impact and Risk/hazard assessment of the proposed project were also discussed in this chapter.

Chapter 6 discusses the numerous mitigation methods and alternatives that are pragmatic in curbing the negative effects likely to emanate from the irrigation project as earlier identified. The highlights of this chapter include: best available control technology and Liability compensation. The proposed mitigation methods and alternatives were placed side by side in detail with their relative negative impacts in an elaborate table hence summarizing mitigation measures to be applied.

This chapter seven updated ESMP of the Gashua irrigation project with consideration to current experience in the ESMP implementation. in order to maintain environmental quality, this chapter elaborates the need to manage the project through a management plan. A tabular format was presented delineating various responsibilities to their relative units which are involved in the project in order to ensure environmental sustainability. Other notable highlights in this chapter are the “training”, “implementation of ESMP”, “environmental cost”, “HSE in totality”, “site induction Procedures” “nature of the construction site”, and the likes.

It is therefore concluded that the project is financially and economically viable and it is recommended that it proceeds to detailed design level in order to ascertain costs and benefits and project viability. It is further recommended that during the detailed design, further detail studies and alternatives be considered.

ACKNOWLEDGEMENT

I would like to thank God almighty for granting I and my team the strength and capacity to meet the expectations of this project. I also would like to appreciate the collaborative efforts of the Hadeija Jama'are Komadugu Yobe Basin Trust Fund, Africa Development Bank (AfDB), Federal Ministry of Environment, the Executive Director and staffs of the Chad Basin Development Authority (CBDA), North East Arid Zone Afforestation Programme (NEAZAP) office, SMEC Group, the Emirate of Gashua and the representatives of the five stakeholder communities (Garin Alkali, Jurgwaya, Renakunu, Laba and Mari). The collaborative inputs of all these organizations and stakeholders through the provision of support and relevant information, have been very instrumental to the preparation of this report.

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LIST OF ABBREVIATIONS

ADPs	Agricultural Development Programmes
AFDB	African Development Bank
BIU	Basic Irrigation Unit
CBDA	Chad Basin Development Authority
CBOs	Community-Based Organizations
CHX	Methane
CLO	Community Liaison Officer
Cl^-	Chloride ion
Cm	Centimetre
CO	Carbon Monoxide
CO_2	Carbon dioxide
Cr	Chromium
Cu	Copper
Co	Carbon Monoxide
CP	Critical Points
dB	Decibel
DFID	Department of International Development
DN	Net Irrigation Depth
EA	Environmental Audit
EC	Electrical conductivity
ECO	Environmental Control Officer
ED	Executive Director
EHS	Environmental Health and Safety
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMC	Environmental Management Classes
EMP	Environmental Management Plan
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESAP	Environmental and Social Assessment Procedures
FAO	Food and Agricultural Organization
FD	Field Drain
FG	Federal Government
FEPA	Federal Environmental Protection Agency
FC	Field Canal

FMARD	Federal Ministry of Agriculture and Rural Development
FMEnv	Federal Ministry of Environment
FMWR	Federal Ministry of Water Resources
FSL	Full Supply Level
GEF	Global Environmental Facilities
GHGs	Green House Gases
GIP	Gashua Irrigation Project
GIWR	Gross Irrigation Water Requirement
H_2S	Hydrogen Sulphide
H_2SO_4	Tetraoxosulhphate VI acid
HCs	Hydrocarbons
Ha	Hectare
Hg	Mercury
$HN0_3$	Trioxonitrate V acid
Hg	Mercury
$HN0_3$	Trioxonitrate V acid
HJKY_TF	Hadejia Jama'are Komadugu Yobe Basin - Trust Fund
HJKYB/KYB	Hadejia-Jama'are-Komadugu-Yobe Basin
HJKYBCC	Hadejia-Jama'are-Komadugu-Yobe Basin Coordinating Committee
HJKYB-TAC	Hadejia-Jama'are-Komadugu-Yobe Basin Technical Advisory Committee
hr	hour
HSE	Health Saftey and Environment
HSG	Hydrological Soil Group
HYV	High Yield Variety
IWRM	Integrated Water Resources Management
KYB	Komadugu Yobe Basin
KYB	Komadugu Yobe Basin
JICA	Japan International Development Agency
LGA	Local Government Area
LCBC	Lake Chad Basin Commission
m	metre
m^2/d	square metres per day
m^3/hr	Cubic metres per hours
MC	Main Canal
MCM/yr	Million cubic metres per year

mm/yr	Millimetres per year
NEAZAP	North East Arid Zone Afforestation Programme Office
NEMA	National Emergency Management Agency
NESREA	National Environmental Standard and Regulation Enforcement Agency
NFDP	National Fadama Development Programme
NGOs	Non-Governmental Organizations
NIWR	Net Irrigation Water Requirement
Na	Sodium
Nd	Neodymium
NH_3	Ammonia
Ni	Nickel
NO_2	Nitrogen Oxide
NO^-_3	Nitrate ion
NOx	Oxides of Nitrogen
NWRMP	National Water Resources Master Plan
NNJC	Nigeria-Niger Joint Commission for Cooperation
OSGOF	Office of the Surveyor General of the Federation
PACs	Project Affected Communities
PCA	Project Command Area
pH	Hydrogen ion Concentration
PHCN	Power Holding Company of Nigeria
PM	Particulate matter
Ppm	part per million
RAP	Resettlement Action Plan
RBDA	River Basin Development Authority
RBOs	River Basin Organizations
SAP	Strategic action plan
SCs	Secondary canals
SDGs	Sustainable Development Goals
SO^{2-}	Sulphate ion
SO^2	Sulphur Oxides
SOx	Oxides of sulphur
SP	Suspended particulate
SPM	Suspended particulate matter
Sq.km	Square kilometre

SWA	State Water Agency
TCs	Tertiary canals
TDS	Total dissolved solids
UN	United Nations
UNCED	United Nations Conference on Environment and Development
WHO	World Health Organization
WUAs	Water User Associations
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds
%	Percentage

EIA PREPARERS

For this study, the following members of my team have made valuable contributions

S/N	Name	Position
1.	Tpl. Barnabas ATIYAYE FNITP	Team lead/ Environmental Management
2.	Tpl. Nathaniel ATEBIJE FNITP	Socio-Economics/ Land use
3.	Seth Dauda	Water/Ecology/Fisheries
4.	Prof. Abraham. ONUGBA	Geology/Hydrology/Soil
5.	Theophilus Usman, Lawal Lawal	Air/Noise/GIS
6.	Tpl. Samson Olusegun	Vegetation/Waste Management/Climate Change
7.	Dr. Taiye Oluwafemi Adewuyi	Wildlife/Biodiversity
8.	Dr. Ndubisi Mokogwu	Public Health
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10.	Silas Barnabas	Technical Assistant

The consultant collaborated with the following agencies:

i. CBDA: to work with the consultant and has attached a technical expert to the team

ii. HJKY_TF: provided the consultant with a counterpart officer, Mr. Markus Maina

iii. The consultant is also in contact with the Federal Ministry of Environment.

CHAPTER ONE

1.0 INTRODUCTION

The Human environment is a combination of the physical space, atmosphere, lithosphere and the hydrosphere. Hence the human environment is wider than meets the eye. It spans between the totality of the interactions under and above the earth's surface as well as those on land. Activities of humans need to be properly guided and articulated to ensure that these activities and interactions do not create negative impacts that may threaten the existence of man's other co-tenants of the planet earth. This makes the essence of understanding the components of proposed developments and their procedures of production and operation through the environmental and social impact studies important.

The desire to improve on the livelihoods of man has put the human environment under pressure. Each passing day presents its own challenge. There are pressures to create jobs through building of expansive industries, to provide residential accommodation for the teeming population being born as well as the migrant inhabitants of cities, to create avenues for the exchange of goods and services in commercial centres, to provide farmlands where food is to be cultivated to meet the needs of the population, and to create recreation areas where people can relax at the end of the day. In the case of this project, it is the desire of the Project Proponent to provide an irrigation scheme that will improve food security and the economy of communities around the project, Yobe State and Nigeria at large. These proposed activities shall place new demands on the human environment. To meet these needs, several actions have been taken on land and against nature. While some advantages are harnessed, the disadvantages have put man in jeopardy. With a massive influx of natural disasters, warming and cooling periods, different types of weather patterns, several types of environmental problems have been created on our planet earth.

The purpose (objective) of the ESIA, and the project overview respectively should precede the underlisted subheadings.

Global warming has become an undisputed fact about our current livelihoods due to human activities in the wanton destruction of environmental attributes. All across the world, people are facing a plethora of new and challenging environmental problems. Some of them are small and only affect a few ecosystems, but others are drastically changing the landscape. Indeed, the human environment is on the brink of a severe environmental crisis. Current environmental problems make us vulnerable to disasters and tragedies, now and in the future. We are in a state of planetary emergency, with environmental problems piling up high around us. Human beings therefore must tread on the path of caution if the crisis is to be mitigated. Current environmental problems require urgent attention. In this cautionary effort, it is important to draw attention to major environmental and social challenges being faced as a result of human activities. These include air pollution, climate change, global warming, acid rain, over-population, poor waste disposal, deforestation, ozone layer depletion, urban sprawl, public health issues among others.

Pollution of air, water and soil require millions of years to rectify. These are generated through industries and motor vehicle exhaust pipes. In fact, these are the principal pollutants. Others include heavy metals, nitrates and plastic which are toxins as well as water pollution through oil spill, acid rain, urban runoff; air pollution as a result of various gases and toxins released by industries and factories and combustion of fossil fuels. Soil pollution is majorly caused by industrial waste that deprives soil from essential nutrients.

Climate Change, Global Warming, Acid Rains and Natural Resource Depletion have been occasioned by fossil fuel consumption which result in emission of Greenhouse gases. Global warming leads to rising temperatures of the oceans and the earth' surface causing melting of polar ice caps, rise in sea levels and also unnatural patterns of precipitation such as flash floods, excessive snow or desertification.

Overpopulation of the earth is becoming unsustainable due to shortage of resources like water, fuel and food. This is straining the already scarce resources. Intensive agriculture practiced to produce food damages the environment through use of chemical fertilizer, pesticides and insecticides.

Waste Disposal: The over consumption of resources and creation of plastics are creating a global crisis of waste disposal. Developed countries are notorious for producing an excessive amount of waste or garbage and dumping their waste in the oceans and, less developed countries. Nuclear waste disposal has tremendous health hazards associated with it. Plastic, fast food, packaging and cheap electronic wastes threaten the well-being of humans. Waste disposal is one of urgent current environmental problem.

Deforestation and Loss of Biodiversity: Our forests are natural carbon sinks and produce fresh oxygen as well as help in regulating temperature and rainfall. About 31% of Earth's land surface is covered by forests, just over 4 billion hectares, this is down from the pre-industrial area of 5.9 hectares (earthpolicy.org, 2012) representing at 33 percent decrease. Deforestation can directly lead to biodiversity loss when animal species that live in the trees no longer have their habitat, cannot relocate, and therefore become extinct. Deforestation can lead certain tree species to permanently disappear, which affects biodiversity of plant species in an environment. With demand for more food, shelter and clothing. Many plant and animal species are being depopulated on a daily basis leading to the extinction of species and habitats and loss of bio-diversity further destabilizing the environmental system humanity relies on.

The challenge that human activities pose to the environment are innumerable. Others include ozone layer depletion, urban sprawl, public health Issues, etc.
The modern environmental consciousness began in the mid-19th century when resource depletion and pollution posed more serious problems. Ecological disasters such as the nuclear reactor explosion near the Ukrainian town of Chernobyl' in 1986 served as catastrophic reminders of the effects of human carelessness. In 1972, the United Nations Environment Program was formed to encourage international cooperation in environmental management and development strategies. Collaboration on environmental conservation issues included the 1987 Montreal Protocol to protect the ozone layer, the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil, and the 1994 United Nations Conference on Population and Development in Cairo, Egypt.

This has made governments to spend substantial public resources on managing environmental problems as well as signing many international agreements and enacted domestic laws and regulations on environmental issues. To this end, project proponents have been mandated to carry out environmental audits to confirm compliance with standards (including waste management, water and air pollution, forest loss, land degradation or impaired ecosystems). Environmental audit is a systematic, documented and objective assessment of an organization's activities and operations. It aims at assessing the nature and extent of harm, or risk of harm, to the environment posed by an environmental activity. Habitat II emphasizes the need for sound environmental considerations during project conception and development to promote environmental sustainability as highlighted in the Sustainable Development Goals. (SDGs)

In Nigeria, as desirable and necessary as development is, it became an albatross not of itself but because of the lack of appropriate policies to guide it. There have been several sectoral regulations aimed at controlling environmental degradation which were unsuccessful due to the absence of effective sanctions. Economic considerations and fundamental lack of knowledge of interdependent linkages among development processes and environmental factors, as well as human and natural resources, resulted in unmitigated assault on the environment. The reality of environmental challenge became glaring with the illegal dumping of toxic wastes in Koko, in the former Bendel (now Delta) State, in 1987. The Nigerian Government promulgated the Harmful Wastes Decree which provides the legal framework for the effective control of the disposal of toxic and hazardous waste into any environment within the confines of Nigeria. This was immediately followed by the creation of a regulatory body, the Federal Environmental Protection Agency (FEPA) in 1988. FEPA was charged with the overall responsibility of protecting and developing the Nigerian environment. To put this into action a National Policy on the Environment was developed. This became the main working document for the preservation and protection of the Nigerian environment. States and Local Government Councils were also encouraged to establish their own environmental regulatory bodies for the purpose of maintaining good environmental quality as it applies to their particular terrain.

The EIA Decree No. 86 of 1992 is an additional document with the same aim of protecting the Nigerian environment. It is particularly directed at regulating the industrialization process with due regard to the environment. By this Decree, no major development activity falling under the FEPA's mandatory list can be executed without prior consideration of the environmental consequences of such a proposed action, in the form of an environmental impact assessment.

1.1 Project Overview

The Komadugu Yobe Basin (KYB) covers an area of about 84,000km^2. It is of strategic national and international importance as it supports primarily the livelihood of over 15 million people in Nigeria, especially people living in Bauchi, Borno, Jigawa, Kano, Plateau, and Yobe; and enhances food security in other parts of Nigeria and neighbouring countries (Cameroon, Chad and Niger). The KYB is located in the semi-arid portion of north-eastern Nigeria and represents approximately 35% of the Lake Chad Basin. It is an important transboundary water resource. The Federal Government of Nigeria (through financing by the African Development Bank) has prepared the Komadugu Yobe Basin Strategic Action Plan (KYB-SAP) which is a long-term development strategy for promoting the use and management of the basin water resources to achieve inclusive and sustainable growth and development

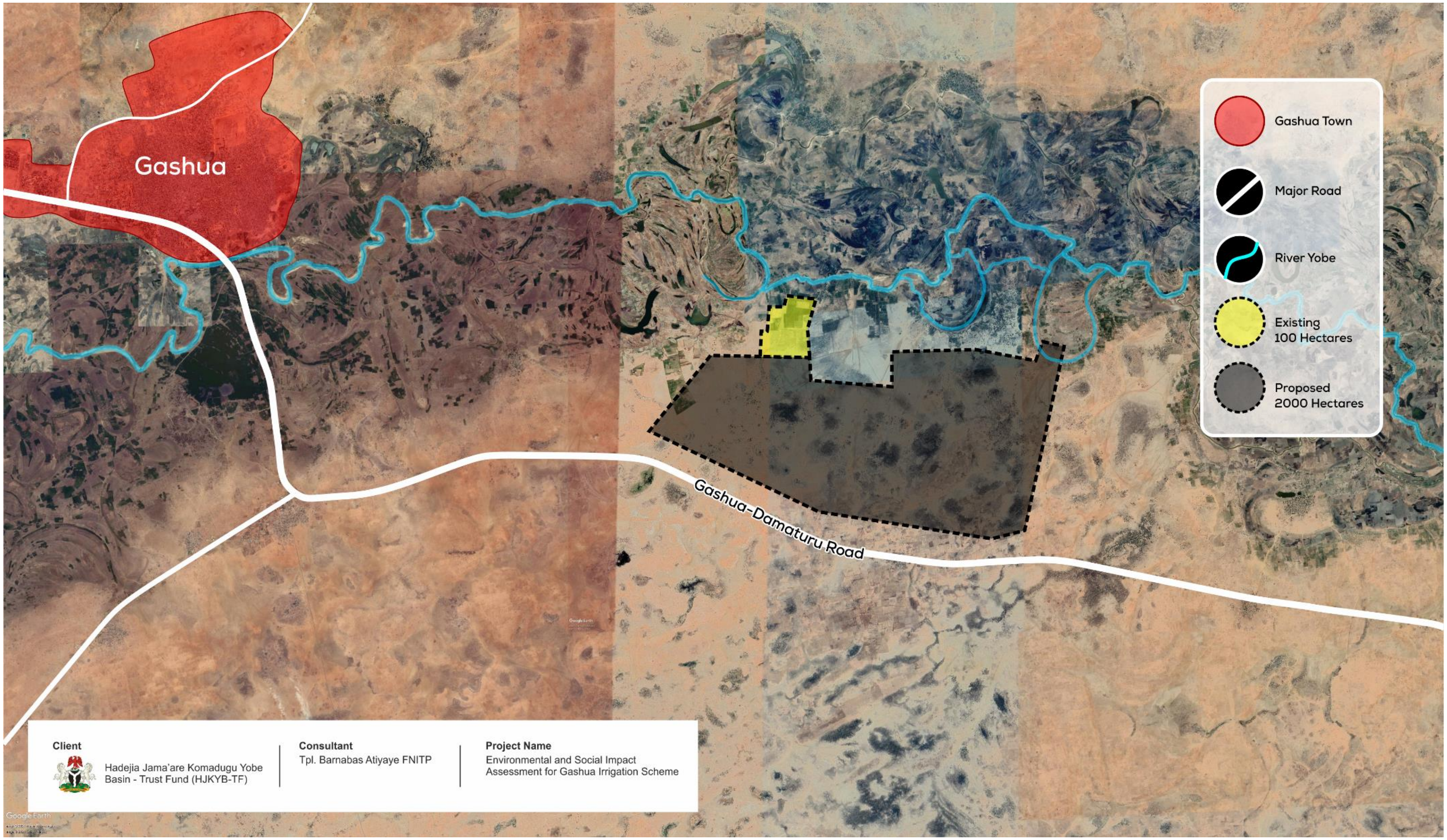

Figure 1.1: Gashua Irrigation Scheme site within context of Gashua Town

The KYB-SAP is a twenty-year development plan for water resources development which was prepared in the year 2019 to last up to 2040. The plan identified four priority sub-programs/schemes of which the Gashua Irrigation Scheme is part.

The Government of Nigeria through funding from the Bank (AfDB) is also financing additional studies for the priority investment projects. The studies include Environmental and Social Impact Assessment (ESIA) studies for the Gashua Irrigation Scheme. To this end, Hadejia Jama'are Komadugu Yobe Basin - Trust Fund (which is the Implementing Agency) engaged a consultant to provide this service. The aim of the Environmental and Social Impact Assessment (ESIA) is to assess the potential environmental impacts (positive and negative) of the proposed Irrigation Scheme and related activities.

This Draft Final report of the Environmental and Social Impact Assessment (ESIA) for Gashua Irrigation Scheme is the third of four reports to be submitted as stated in the contract signed for the Consultancy Services.

1.2 Registration

As a pre-requisite, this ESIA Study has been duly registered with the Federal Ministry of Environment for review and other processes.

1.3 The Contract

Hadejia Jama'are Kumadugu Yobe Basin-Trust Fund has commissioned Tpl. Barnabas Atiyaye (hereafter referred to as the Consultant) to prepare the Environmental and Social Impact Assessment (ESIA) and Environmental and Social Management Plan (ESMP) for Gashua Irrigation Scheme in line with the bank safeguards policies and adhering to country environmental standards and approved mechanisms for permit issuance.

1.4 Objective of the Study

The objective of the study is to prepare the Environmental and Social Impact Assessment (ESIA) including the Environmental and Social Management Plan (ESMP) of the proposed Gashua Irrigation Scheme, in line with the bank's safeguard policies and national environmental standards. The land acquisition, resettlement, compensation and valuation of land required or affected by the infrastructure shall be fully determined by the Consultant including stakeholder consultations and disclosure requirements consistent with the applicable environmental laws and regulations.

1.5 Specific Scope of the Study

Under the supervision of the Hadejia Jama'are Komadugu Yobe Basin - Trust Fund and with technical support from the Federal Ministry of Water Resources, the scope of the study includes the following specific activities.

1.5.1 ESIA Study

The ESIA study shall be carried out in conformity with the ESAP of AfDB and FMEnv's EIA standards. The consultant shall assess and summarize collected data on the major environmental and social characteristics of the proposed project area vis-à-vis water, air, land, biological, socio-economic, health and historical/cultural aspects. The consultant shall also carry out site visits to the project site and the project affected communities within the defined catchment area. Specifically, the consultant shall:

i. give a general overview and background of the project, with emphasis on the Terms of Reference, Legal and Administrative Framework for the study.
ii. discuss the objective, need and value of the project, project alternatives.
iii. describe give a background of the project and timeline
iv. detail the project characteristics and features
v. present the social and environmental baseline information of the project affected communities and project site respectively
vi. outline the associated and potential impacts of the project at different stages
vii. proffer mitigation measures
viii. develop and environmental and social management plan and monitoring guidelines
ix. assessed potential social impacts by giving an answer to the questions:

1.5.2 Mitigation Measures

The Consultant shall identify cost-effective mitigation measures to reduce or avoid adverse impacts or to enhance beneficial impacts. As necessary, these comprise both appropriate design and introduction of general and specific environmental protection measures within the immediate environs. The general and specific protection measures are incorporated in the Environmental Management Plan. The extent to which the different mitigation measures will reduce the scale of impacts arising from the construction was evaluated, and unavoidable residual impacts were identified. The proposed mitigation measures to the adverse/negative impacts and the enhancement measure to the beneficial/positive impacts is consistent with Nigeria's laws.

1.5.3 Environmental and Social Management Plan (ESMP)

The Consultant has prepared a site-specific ESMP (draft version at this point). The project and site-specific ESMP emanating from the baseline data of the project area identified in detail relevant impacts, specific measures and practices suited to avoid or minimize adverse effects, enhance the beneficial and positive impacts, as well as specific monitoring program, institutional and implementation arrangements together with related cost estimates. The ESMP identified in detail socio-economic conditions, relevant impacts, specific recommendations to avoid or minimize social risks, determine magnitude of adverse social impacts, identify social safeguard instruments and develop a mitigation plan. The site-specific ESMP is suitable for direct inclusion in the construction specifications and bid documents.

In addition, the Consultant reviewed relevant information, recommending appropriate mitigation and enhancement measures in site-specific ESMPs for rehabilitation of irrigation infrastructure in order to comply with the AfDB environmental and social safeguards policies

1.6 Policy, Legal and Administrative Framework.

There are policies, legal and administrative frameworks that are in place to safeguard the environment and social conditions of projects such as the Gashua Irrigation Scheme.

Prior to the establishment of the FEPA there were sectoral environmental regulations with various significant responsibilities relating to environmental protection and improvement. There were also commissions and Non-Governmental Organizations with advisory capacity in environmental matters. Due to various activities and the complex combination of interdependent operations, enforcement tools which included compliance monitoring and the issuing of permits/licenses were provided.

An institutional framework was set up to deal with the problems of our environment. The Federal Environmental Protection Agency (FEPA), established by Decree 58 of 1988 and amended by Decree 59 of 1992, was given responsibility for control over our environment and for the development of processes and policies to achieve this. It published the National Policy on the Environment (NPE) in 1989, with the policy goal of achieving sustainable development. Other sectoral regulations such as Pollution Abatement in Industries and Facilities Generating Wastes Regulation 1991 were published. This made EIA obligatory only when so demanded by FEPA and compliance should be within 90 days of such demand. States and Local Government Councils (LG) which comprise the second and third tiers of government were encouraged under Decree 59 of 1992 to set up their own environmental protection agencies. Separate EIA legislation, the EIA Decree 86 of 1992, was promulgated and made FEPA the apex regulator.

A number of national and international environmental guidelines are applicable to the Gashua Irrigation Scheme. This ESIA shall be prepared in consonance with relevant Yobe State and Federal Government policies, laws, regulations, guidelines, and applicable AfDB Operational Policies. The relevant policy and regulatory instruments are summarized in the sections below

1.6.1 National Legislations

There are specific laws, guidelines and standards that regulate all developmental activities in Nigeria. These include the following:

(i) The Federal Environment Protection Agency (FEPA) Act of 1988 (as amended by Decree 59 of 1992) which established penalty for discharging hazardous wastes in the environment.
(ii) The Harmful Wastes Decree of 1988 which made the transportation, dumping or trading of harmful waste within Nigeria or its exclusive economic zone illegal if it does not have permit of the Ministry of Environment.
(iii) The National Environmental Protection Agency Act of (1991) which requires that every industry installs abatement equipment, restricts release of toxic waste, and obtain permit from Ministry of Environment for storage, treatment, and transportation of toxic waste.
(iv) The Guidelines and Standards for Environmental Pollution Control in Nigeria issued by FEPA (1991) and containing guidelines and standards, for industrial effluent, gaseous emissions and noise limitation, management of solid and hazardous/dangerous chemicals and VOCs.
(v) The National EIA Decree No. 86 of 1992 which requires that EIA report be prepared for all new major development activities, as well as, the accompanying EIA procedural and technical guidelines.
(vi) The National Environmental Standards and Regulations Enforcement Agency Act 2007 (NESREA Act). After repealing the Federal Environmental Protection Act of 1988, the NESREA Act of 2007 became the major statutory regulatory institution to guide and enforce on environmental matters in Nigeria.

1.6.1.1 The Environmental Impact Assessment (EIA) Act CAP E12 LFN, 2004

The EIA Act makes it mandatory for any person, authority, corporate body private or public, to conduct EIA before the commencement of any new major development or expansion that may likely have a significant effect on the environment. The Act sets the EIA objectives and the procedures for consideration of EIA of certain public or private projects. The proposed project fits the description of a major project which shall impact on the environment and the livelihood of the people who shall be directly affected by the project. Full compliance with the guidelines of the EIA Act is required for the success of the project.

1.6.1.2 The Nigerian Urban and Regional Planning Law.

The need for development and development control in Nigeria came about to curb haphazard development and the outbreak of the bubonic plague which ravaged the city of Lagos in 1928. Prior to this period, the building and regulation laws of the country were based on the Great Britain town and country planning law of 1932. By 1946, an indigenous town and country planning law was carved of this. This continued to be operative until in 1992 when a new Urban and Regional Planning Law was promulgated backed by the Decree 88 of 1992.

It is the section 27(1) of this law that concerns development control, stating that the Control Department, at the Federal level shall have over the Federal land. The State's Control Departments shall in turn have control power over the State lands. While at the Local Government level the power of development control shall be within the jurisdiction of the Local Government. The Control Departments should be a multi-disciplinary department charged with responsibility of matters relating to development control and implementation of physical development plans. All land development should require the approval of the relevant control department. Also, a developer should submit a development plan for approval to the Development Control Department as stated in section 28.

Section 31, sub section c of the Nigerian Urban and Regional Planning Decree No 88 states that "*… an applicant for a development permit may be rejected, if in the opinion of the control department, the development is likely to have major impact upon the environment, facilities or inhabitants of the community …*"

Further, section 33 of the decree provides that "*… a developer shall submit application for the development to the Development Control Department together with a detailed EIA for an application to develop his proposed project …*"

Section 33, of the Nigerian Urban and Regional Planning Decree No. 88 states that, "*… a developer shall submit application for the development to the Development Control Department together with a detailed EIA for an application to development his proposed project of the following magnitude.*

i. Residential land more than 2 hectares.

ii. Permission to build or expand a factory or for the construction of an office building more than four floors or 5,000 square meters of lettable space; or,

iii. *Permission for a major recreational development.*

1.6.1.3 The Land use Act.

The Land use Act No. 6 of 1978 (Cap L5, LFN 2004) vests all land comprised in the territory of each state in the Federation in the Governor of the state and requires that such land shall be held in trust and administered for the use and common benefit of all Nigerians in accordance with the provisions of the Act. It protects the rights of all Nigerians to use and enjoy land in Nigeria which must be protected and preserved. Land acquisition must follow all the due process of law.

The law also allows the compulsory acquisition of land in the public interest or for a public purpose, the legislation enables the State to acquire land (more precisely, to abrogate leases and other authorizations to occupy land). The Act also specifies the procedures the State must follow to take possession, and defines the compensatory measures the State must implement to compensate the people affected.

Other laws and policy instruments are summarized in the Table below.

Table 1.1: National Laws and Policy Instruments

S/N	Policy Instrument	Year	Provisions
1	National Policy on the Environment	1989 revised 1991	Describes the conceptual framework and strategies for achieving the overall goal of sustainable development in Nigeria.
Legal/Regulatory Instrument			
2	Forestry Act	1994	Provides for the preservation of forests and the setting up of forest reserves.
3	Endangered Species Act	1985	Provides for the conservation and management of Nigeria's wildlife and the protection of some of her endangered species in danger of extinction as a result of over-exploitation
4	FEPA/FMEnv EIA Procedural Guidelines	1995	The Procedural Guidelines indicate the steps to be followed in the EIA process from project conception to commissioning in order to ensure that the project is implemented with maximum consideration for the environment.

5	National Guideline and Standard for Environmental Pollution Control	1991	Provide guidelines for management of pollution control measures
6	S.I.15 National Environmental Protection (Management of Solid and Hazardous Wastes) Regulations	1991	Regulates the legal framework for the effective control of the disposal of toxic and hazardous waste into any environment within the confines of Nigeria.
7	Workmen Compensation Act	1987 reviewed 2010	Occupational Health and Safety
8	Child Rights Act	Act No. 26 of 2003	Best interests of a child are to be paramount in all actions and clearly states the rights of the child.
9	The Endangered Species Act	CAP E9, LFN 2004	Focuses on the protection and management of Nigeria's wildlife and some other species in danger of extinction as a result of overexploitation

Table 1.2: Policies, Legislation and Regulations

Policy/ Legislation	Objective/Purpose
Constitution of the Federal Republic of Nigeria (1999)	Recognizes the importance of improving and protecting the environment and makes provision for it.
National Water Resources Act (draft in 2017)	The National Water Resources Act defines the powers and functions of water management institutions, the approach to water resource management and strategy development and definition of the mechanisms and procedures for implementation as well as promoting good governance in the water sector. As of June 2018, the draft Water Resources Bill is still under consideration by the National Assembly. Draft regulations on water user associations (WUAs) and irrigation scheme management prepared with support from TRIMING are to be issued once the Bill has been enacted.
National Water Policy 2004 (superseded by a new Water Policy in 2016	The National Water Policy states that all water infrastructures shall respect the environmental requirements as laid down in the general principles. Besides, this policy states that the regulations to be established must guarantee the achievement of conservation and protect the environment from degradation, pollution and overexploitation; prevent uncontrolled exploitation of water as a natural resource and; ensure sustainable access to water through good environmental management practices. The Policy also presents main strategies in order to comply with the environmental regulations, preparation of Environmental Impact Assessment and Environmental Audit for all water resources programmes and projects and to impose sanctions to control environmental degradation.
Nigeria Water Resources Decree 101, 1993	By this Decree, the FG has the right to use and control all surface and groundwater and of all water in any water course affecting more than one State.
The Water Resources Act of 2004 (to be superseded by a new Water Resources Act – draft in 2017	This act is the highest existing legislation governing water resources management in Nigeria. It confers on the Federal Ministry of Water Resources (FMWR) the responsibility for controlling the use of trans-state surface and groundwater resources throughout Nigeria. The Act represents the contemporary approach on water resources development, conservation, allocation and use that aims to optimize and sustain social, economic

	and environmental needs based on the IWRM approach.
National Water Supply and Sanitation Policy, 2000	The objective of this Policy, which was issued in 2000 by FMWR, is the provision of sufficient potable water and adequate sanitation to all Nigerians in an affordable and sustainable way through participatory investment by the three tiers of government, the private sector and the beneficiary.
National Environmental Policy (2016	The major objective of the national environmental policy is to encourage measures which sustain a balance between population and environment.
Federal Environmental Protection Agency Act, 1988 (Decree No 58) and amendment Decree No 59 of 1992	By this Decree, FEPA was strengthened and transferred to the Presidency and expanded its mandate to include the conservation of biodiversity and sustainable use of Nigeria's natural resources.
Environmental Impact Assessment Decree Number 86 of 1992.	Decree 86 empowers FEPA and its custodian, to ensure that all major developments including the utilization of water resources are undertaken in a manner that does not result in unacceptable environmental impacts.
National Environmental Sanitation Policy, 2004	This Policy was issued in 2004 by the Federal Ministry of Environment to serve as an instrument for securing quality environment for good health and social well-being of present and future generations. Its purpose is to ensure a clean and healthy environment by adopting efficient, sustainable and cost-effective strategies, so as to safeguard public health and wellbeing in line with the national development objectives.
Water Resources Act, 1993 (soon to be superseded by a new Water Resources Act (draft in 2017)	Defines the place from which water may be taken; fix the amount taken in times of shortage, prohibit the taking if water is dangerous to public health; prohibit the use of water or the operation and management of any borehole or hydraulic works; prohibit any act which could interfere with the quality or quantity of water; supply or sell raw water to any person, on terms and conditions determined by the minister.
Vision 2020 released in 2010	Sets the overarching long-term development framework for Nigeria. It is designed to push the country to achieve socio-economic development status of the top 20 countries in the world thus enabling the country to attain a high standard of living for its citizens. The Vision envisages increased investment in agriculture, industry and manufacturing and expansion of the infrastructure base for production. The Federal Government has the overall responsibility for providing secure water

	resources needed for the economic and social development and creating the enabling environment for sustainable water resources management.
Agricultural Policy (2016)	This policy requires that Nigeria should strive to be self-sufficient in agricultural products. It is this policy which gave rise to the construction of dams and large-scale irrigation schemes as a means of reducing dependence on rain fed agriculture. This policy also gave rise to the ADPs and the National Fadama Development Programme (NFDP) which have popularized small-holder irrigation in the basin, through the use of water pumps.
National Irrigation Policy (2015)	The National Irrigation Policy is based on the premise that boosting domestic agricultural production will require irrigation to produce the quality and quantity of output where rain-fed production alone cannot meet the demand. The policy recognizes that whilst irrigated agriculture can contribute to poverty reduction through improved food security, along with job creation and income generation, the overall policy goal is to improve the economic and environmental performance of irrigation. The National Irrigation Policy has a primary purpose to improve the performance of irrigation services within the mandate of the Federal Ministry of Water Resources (FMWR).
National Environmental Standard and Regulation Enforcement Agency (NESREA) Act, 2007	By this Act, NERSREA was established as a parastatal of the Federal Ministry of Environment, Housing and Urban Development. By the NESREA Act, the FEPA Act has been repealed.
The Nigerian Minerals and Mining Act, 2007	This act gives provisions for regulating the exploration and exploitation of solid materials in Nigeria. The Act also gives provision on environmental management aspects including prohibition of pollution of water courses.
Minerals and Mining Act, 1999	Give provisions for obtaining and convey such volume of water as may be required for the purpose of its mining operations; construct any works necessary for the collection, storage or conveyance of the water occupy such land as may be required for a dam, reservoir of pumping station and for the conveyance of water to the area of the lease by means of pipes, ducts, flumes, furrows or otherwise.
Nigeria Industrial Standards 554, 2007	Provide standards for drinking water quality.

National Effluent Limitation regulation, S.I.8 of 1991, FEPA	This regulation makes it mandatory for industrial facilities to install antipollution equipment, make provision for effluent treatment and prescribes maximum limits for effluent discharging.
Pollution Abatement in Industries and Facilities Generating Wastes Regulations, 1991, FEPA	Among other thing, this Regulation imposes restrictions on the release of toxic substances and stipulates requirements for monitoring the pollution and gives directions on how to proceed before unusual or accidental discharges
National Environmental Protection Management of Solid and Hazardous Wastes Regulations 1991, FEPA	Give provisions for the appropriate management of solid and hazardous wastes not to pollute the environment with special emphasis to groundwater protection
River Basin Development Authority Act, 1987	Give provisions for developing of surface and underground water resources for multipurpose use; construction, operation and maintenance of dams, dykes, wells, boreholes, irrigation and drainage systems, polders, etc.; supply of water from storage scheme to all users for fee; preparation of water resources master plans; management of irrigation scheme and regulation of water, if approved by the National Council of Ministers.
EPA National Biodiversity Strategy and Action Plan, 1997	Managing and conserving the country's biodiversity.
Policy on Forestry, Wildlife and Protected areas (1999)	The main goal of this policy is to achieve sustainable development in the country with particular emphasis on maintaining environmental quality of the nation; conserving the environment and natural resources; restoring, maintaining and enhancing the ecological processes which are necessary for proper functioning of the environment; raising public awareness and public understanding of the important linkages between the environment and development; cooperating with other countries and international organizations to preserve the environment; encourage "rational exploitation" of forest resources to satisfy local consumption and attain a significant export level in the long term; regulation of forestry activities to ensure "conservation and environmentally sound management practices; strengthening of forest protection activities in marginal areas to prevent harmful changes in such areas; encouraging afforestation and reforestation

	programmes with the aim of reversing the effects of deforestation; supporting (NGOs) and tree planting programmes of local communities; reforestation programmes with the aim of reversing the effects of deforestation.
National Environmental (Permitting and Licensing Systems) Regulations, 2009, NESREA	The purpose of these Regulations is among others, to enable consistent application of environmental laws, regulations and standards in all sectors of the economy and geographical regions.
National Environmental (Sanitation and Waste Control) Regulations, 2009,	These Regulations seek to minimize pollution through sustainable and environmentally friendly practices in environmental sanitation and waste management
National Environmental (Textile, Wearing Apparel, Leather and Footwear Industry) Regulations, 2009, NESREA	These Regulations are to prevent and minimize pollution from all operations and ancillary activities of the Sector to the environment. It also provides standards for effluents, air pollutants, soil quality and noise
Environmental (Mining and Processing of Coal, Ores and Industrial Minerals) Regulations, 2009, NESREA	The purpose of these Regulations is to minimize pollution from the Sector. It provides standards for effluents, air pollutants and noise.
National Environmental (Noise Standard and Control) Regulations, 2009, NESREA	These regulations ensure maintenance of a healthy environment through limiting noise levels
National Environmental (Ozone Layer Protection) Regulations, 2009, NESREA	This Regulation is to control the management of Ozone-depleting substances
National Environmental (Access to Genetic Resources and Benefit Sharing) Regulations, 2009, NESREA	The Regulations intend to prevent and control the depletion of biodiversity of Nigeria.
National Environmental (Wetlands, River Banks and Lake Shores Protection) Regulations, 2009, NESREA	This Regulation is for conservation and wise use of wetlands and for sustainable utilization and conservation of resources on river banks and lake shores.
National Environmental (Watershed, Mountainous, Hilly and	This Regulation gives provisions for the well use and conservation of watershed, mountainous, hilly and catchment areas

Catchment Areas) Regulations, 2009, NESREA	
National Environmental (Coastal and Marine Area Protection) Regulations, 2011, NESREA	This Regulation's intent to preserve the natural ecological conditions of the estuarine system, the barrier islands system and the beaches through a sustainable use of resources and control of activities that could degrade the coastal and marine environment
Protection of Endangered Species in International Trade 2011, NESREA	This Regulation is to controls the international trade of wildlife species listed in the Convention on International Trade in Endangered Species (CITES).
National Environmental (Soil Erosion and Flood Control) Regulations, 2011, NESREA	Gives standards and procedures to abate soil erosion and the sustainable protection and enhancement of the ecological integrity of flood plains as well as vulnerable lands and waters from significant adverse effects.
National Environmental (Desertification Control and Drought Mitigation) Regulations, 2011, NESREA	A regulatory framework for the sustainable use of all areas already affected by desertification and the protection of vulnerable lands.
National Environmental (Surface and Groundwater Quality Control) Regulation, 2011 by NESREA	This Regulation intent to restore, enhance and preserve the water quality of surface waters and its existing water uses by regulating pollutants discharges. Also, to protect groundwater sources by regulating the discharge and underground injection of hazardous wastes, fluids used for extraction of minerals, fossil fuels energy, etc.
National Environmental (Control of Bush, Forest Fire and Open Burning) Regulations, 2011, NESREA	The main objective of these regulations is to prevent/minimize the destruction of ecosystem through fire outbreak and burning of any material that may affect the health of the ecosystem due to the emission of hazardous air pollutants.
National Environmental (Electrical/Electronic Sector) Regulations, 2011, NESREA	To prevent and minimize pollution from all operations and ancillary activities of the Sector to the environment. It also provides standards for effluents and air pollutants.
National Environmental (Construction Sector) Regulations, 2011, NESREA	This Regulation is to prevent and minimize pollution from construction, decommissioning and demolition activities to the environment. The Regulations requires the minimization of dust and prohibition of open burning of solid waste and also provides standards for noise and illumination intensity.

National Environmental (Control of Vehicular Emission from Petrol and Diesel Engines) Regulations, 2011, NESREA	This Regulation is to restore, preserve and improve the quality of air. Standards are given for the protection of the air from pollutants coming from vehicular emissions.
The Lake Chad Water Charter adopted in 2012	The Lake Chad Water Charter is the legal instrument for the collaboration between the countries under the LCBC.
Groundwater Quality Control) Regulation, 2011	According to this Regulation, a person shall not release any substance into, or conduct any activity which will likely cause or contribute to pollution or adversely affect species of the water of the nation (surface water and groundwater); without having obtained all required approvals and permits from NESREA.
Ramsar, Iran,1971	Convention on Wetland of International Importance, especially as Water Fowl Habitat, Ramsar, Iran 1971. This provision came into force in Nigeria on 2nd February 2001 with the objective to stem the progressive encroachment on and loss of wetlands now and in the future, recognizing the fundamental ecological functions of wetlands and their economic, cultural, scientific, and recreational value.
Other international conventions related to nature and environment conservation	International conventions ratified to sustain the nature and environment in collaboration with other nations of the world include: African Convention on the Conservation of Nature and Natural Resources (1968); Convention to Combat Desertification (1994); Convention on International Trade in Endangered Species of Fauna and Flora (CITES, 1973);
	Conservation of Migratory Species of Wild Animals (1973) and Framework Convention on Climate Change (1992).
National Inland Water Ways (NIWA)	

1.6.2 Yobe State Legislation

1.6.2.1 Yobe State Ministry of Environment/Yobe State Environmental Protection Agency

Due to the necessity of protecting public health and safety while restoring and enhancing environmental quality and sustaining economic vitality through effective and efficient implementation of environmental programmes, a Ministry that takes charge of Environment affairs in Yobe State was established.

The Ministry is charged with the responsibility of providing decent, orderly and reasonable conducive environment for habitable society, as contained in the assignments of Ministerial responsibilities. Largely, the federal legislation serves as the benchmark in the execution of standards in the State.

In pursuance to its environmental goals, the State established the Ministry/State Environmental Protection Agency which is empowered to give direction to environmental concerns, monitor and control pollution and the disposal of solid, gaseous and liquid wastes generated by various facilities in the states.

1.6.2.2 Yobe State Environmental Protection Agency Law

The functions of the agency are:

i. Collection and disposal of both wet and dry refuse (solid and liquid) including human waste.
ii. Control of industrial waste (liquid emission) and air pollution.
iii. In consultation with FEPA ensure implementation and enforcement of FEPA's regulations in the state where applicable.
iv. Collaborate with the FEPA in conducting public investigation of measure environmental pollution.
v. Cooperate with federal and state ministries, local government council's statutory bodies, research and educational institutions on matters related to environmental protection.
vi. In collaboration with FEPA, conduct public investigation and pollution.

1.6.4 Bursari Local Government By-Laws

The activities of waste management and environmental management within Bursari Local Government are guided by Yobe State Laws

1.6.3 International Conventions

United Nations Guiding Principles and Rio Declaration on environment and development, 1992 are key. Nigeria is signatory to these guiding principles and declarations:

Table 1.3: International Treaties and Conventions

S/N	Treaties and Conventions	Year	Agreement
1.	The United Nations Environmental Guidance Principles	1972	Provide guidelines for protecting the integrity of the global environment and the development system
2.	Montreal Protocol on Substances that deplete the Ozone Layer	1987	An international treaty to eliminate Ozone depleting chemical production and consumption.
3.	United Nations Convention on Biological Diversity	1992	Places general obligations on countries to observe sustainable use and equitably share the plants and animals of the earth
4.	United Nations Framework Convention on Climate Change	1994	It calls on developed countries and economies to limit her emissions of the greenhouse gases which cause global warming
5.	Convention on International Trade in Endangered Species of Wild Fauna and Flora	1973	Restricts the trade of fauna and flora species termed as endangered Species
6.	Convention on Conservation of Migratory species of Wild animals (Bonn Convention)	1979	Stipulates actions for the conservation and management of migratory species including habitat conservation

7.	Vienna Convention for the Protection of the Ozone Layer	1985	Places general obligation on countries to make appropriate measures to protect human health and the environment against adverse effects resulting from human activities, which tend to modify the ozone layer.
8.	Paris Agreement	2016	An agreement with a goal to keep the rise in global average temperature to well below 2°C above the pre-industrial levels, and to pursue efforts to limit the increase to 1.5°C recognizing that this would substantially reduce the risks and impacts of climate change.

Table presents an overview of the policies and legal instruments of relevance to water resources management and environmental protection and regulation in Nigeria and in particular the KYB. The most important policies and legal instruments are discussed in more detail in the Institutional Thematic report.

Table 1.4: International Bodies and Conventions Applicable to the Gashua Irrigation Scheme and which Nigeria is Signatory

Organization/Agreement	Description
The Nigeria-Niger Joint Commission (NNJC)	A bilateral body between Nigeria and Niger established in 1971 to monitor and guide development in their common river basins including the KYB.
Lake Chad Basin Commission (LCBC)	Established in 1964 by the Fort Lamy Convention and signed by the Heads of State of Cameroon, Niger, Nigeria and Chad. The LCBC's mandate is to promote:

	• Sustainable and equitable management of Lake Chad and other transboundary water resources of the Lake Chad basin • Preservation and protection of ecosystems in the catchment area; • Integration and preservation of peace and security in the Lake Chad Basin.
Strategic Action Programme (SAP) for the Lake Chad Basin	An output of the UNDP-World Bank-GEF project; Reversal of Land and Water Degradation Trends in the Lake Chad Basin Ecosystem, resulting from a consultation process which involved the Member States of the Lake Chad Basin Convention, the Lake Chad Basin Commission and International Development Partners, with contributions from academics and NGOs in the region.
Joint Environmental Audit on the Drying up of Lake Chad	Undertaken in 2015 by the governments of Nigeria, Niger, Cameroon and Chad with support from the EU and GIZ.
UN Convention on Climate Change	Nigeria is a signatory of the United Nations Framework Convention on Climate Change. Nigeria's Second National Communication under the United Nations Framework Convention on Climate Change in 2014.
Hadejia Nguru Wetlands RAMSAR Site1	The Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat (1971) is an international treaty for the conservation and sustainable use of wetlands, also known as the Convention on Wetlands.
The Lake Chad Wetlands RAMSAR Site	Nigeria has designated the Lake Chad Wetlands (607,354 hectares) for the Ramsar List of Wetlands of International Importance, effective in April 2008.
Convention on Biodiversity	Nigeria signed the Convention on Biological Diversity (CBD) in 1992 and ratified it in 1994, committing itself to promoting sustainable development and recognizing that biological diversity is composed not just of flora and fauna, but that human actors also play an active role in conserving the environment in which they live.

	Nigeria also has a National Biodiversity Strategy and Action Plan.

1.6.4 The EIA Process in Nigeria

The Federal Ministry of Environment (FMEnv) developed guidelines to be used in conducting EIA in compliance with the EIA Act. This EIA process as illustrated in Figure 1. below shall form the step-by-step procedural guideline for this report.

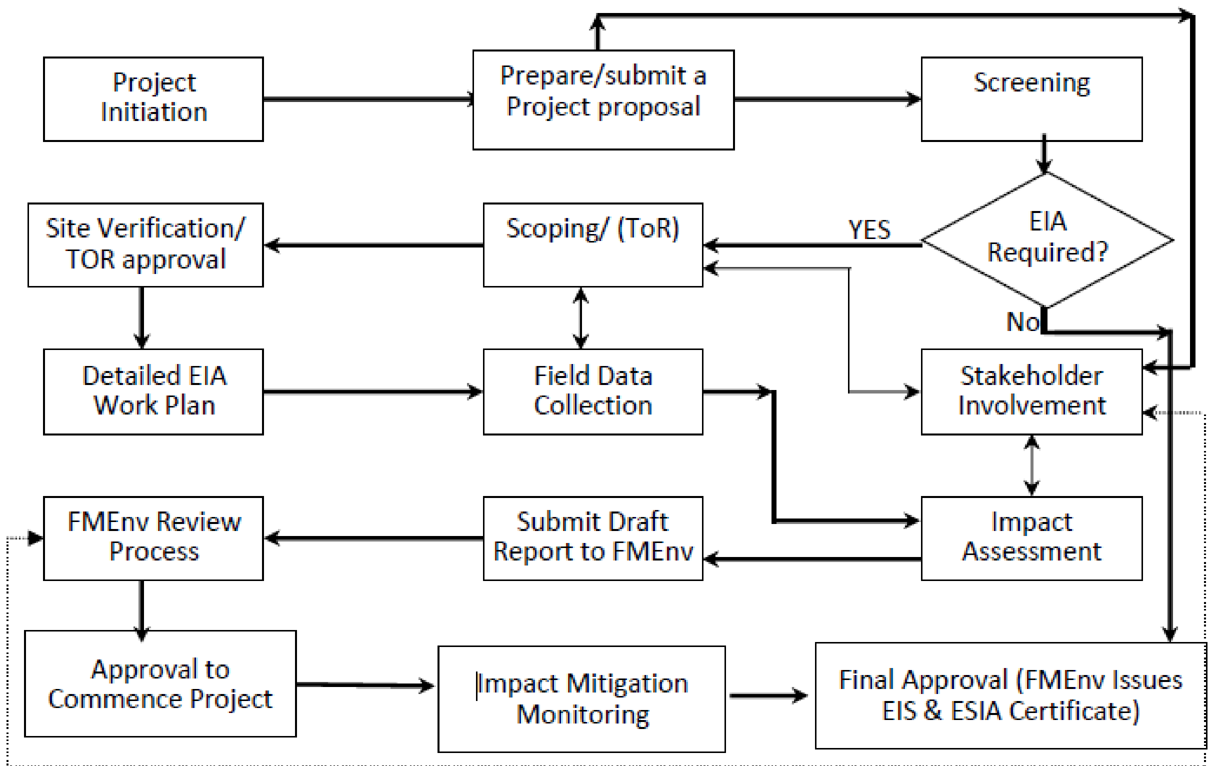

Figure 1.2: The EIA Process

Source: Federal Ministry of Environment

1.6.5 African Development Bank's (AfDB) Environmental and Social Policies

AfDB is a multilateral development bank and in keeping with global best practices as other international financial institutions such as the World Bank, Japan International Development Agency (JICA), Department of International Development (DFID), etc., has adopted environmental and social policies, guidelines and procedures to ensure that its operations avoid adverse impacts on people and the environment.

Its safeguard policies and processes cover three Global Environmental Facilities (GEF) Minimum Standards namely:

i. Environmental and Social Impact Assessment

ii. Involuntary Resettlement, and

iii. Accountability and Grievance Systems.

The Bank has adopted various environmental and social policies and procedures to ensure its projects to meet these minimum standards to prevent, minimize or mitigate any potential adverse impacts on people, communities and the environment.

CHAPTER TWO

2.0 Description of Project and Justification

2.1 Need for the Project

Agriculture remains the base of the Nigerian economy, providing a major source of livelihood for the majority of its people. The sector is faced with a plethora of challenges, notably an outdated land tenure system that constrains access to land, a very low level of irrigation development (less than 1 percent of cropped land under irrigation), limited adoption of research findings and technologies, high cost of farm inputs, poor access to markets have all combined to keep agricultural productivity low with high postharvest losses and waste (FAO, 2020). Although agriculture still remains the largest sector of the Nigerian economy, employing two-thirds of labour force, the production hurdles have significantly stifled the performance of the sector. As a result, food (crop) production increases have not kept pace with population growth, resulting in rising food imports and declining levels of national food self-sufficiency (FMARD, 2008).

The main factors undermining production includes reliance on rain fed agriculture, smallholder land holding, and low productivity due to poor planting material, low fertilizer application, a weak agricultural extension system amongst others. The Federal and the Yobe State Government has given the highest and urgent priority to increasing food supply by improving and strengthening agricultural production system in the country and State respectively.

Thus, the main objective of the proposed 2000 hectares Gashua irrigation project is to increase soil moisture where it is insufficient to permit satisfactory growth of crop leading to improved agricultural crop production and to curb existing food insecurity in the country in general and that of the specific project area in particular coupled with the employment potential of irrigated lands, development of allied activities, increase in the income of farmers and a sense of security and stability in agriculture, the scheme shall be of immense benefits to all stakeholders.

The project shall rehabilitate the existing 100 ha and develop new 2,000 ha irrigation land on the banks of Yobe River. Both the existing and proposed command areas are found on flat terrain at the right-side bank of Yobe River. There is an existing irrigation system which covers 100 ha; the existing system receives water from Yobe River with two surface pumps. The pumps are stationed at the river bank without an appropriate pump house and delivery pool (sump) and exposed to direct sunlight and rainfall. The pumps deliver water to the main canal that runs inside the 100 ha of field supplying the distributor canals. After the pump station, the entire system runs with gravity irrigation. The irrigation system is provided only with earthen canals without any irrigation and hydraulic structures. The presented project comprises rehabilitation of the existing scheme and development of new irrigation land. The project comprises of construction of proposed six (6) pumping stations, drilling of sixty (60) boreholes and developing irrigation farm on a total of about 2,000 ha of land.

In order to ensure that the proposed irrigation development scheme is sustainable, it is essential to study the socio-environmental impacts of the proposed project. Hence, this Environmental Impact Assessment (EIA) study is prepared with the objective to point out potential environmental impacts of the proposed project and recommend appropriate mitigation measures for the possible adverse impacts.

2.2 Value of the Project

Food security is a critical concern for any nation, the ability to cultivate land all year only increases the chance of providing this basic necessity, the Gashua Irrigation Scheme provides this advantage to beneficiaries of the project and to Yobe State and Nigeria at large. Income generation for the local farming community, especially women farmers shall have a cascading economic effect on household income and the local economy of the Project Affected Communities and the surrounding Gashua area.

According to the design report by CBDA (May, 2021), the implementation of the project is estimated to cost Ten Billion, Two Hundred and Forty-Nine Thousand, Nine Hundred and Twenty-Eight thousand, One Hundred and Sixty-Seven Naira, Fifty Kobo (N10,249,928,167.50) only.

2.3 Envisaged Sustainability of the Project.

Given the success of the 100 Ha pilot project and the existing Gashua Irrigation Scheme Management Organisation Structure domiciled with CBDA, which has proven efficient given the benefits of the project to the local economy and crop production in the area. Coupled with the buy-in of the first phase by the project affected communities and local farmers. The project proponent has great passion for innovative work systems and processes resulting from a commitment to learn and improve continuously embrace new ideas. The Project Proponent works professionally to maximize results through an interactive combination of high-quality human and material resources, efficient and effective strategic planning, dynamic project organization, reliable health, safety and environmental policy. These, added to the exceptional quality assurance bias, represent the pivot upon which their corporate credibility has relied over the years. There is indeed good assurance of the sustainability of the project.

2.4 Project Alternative

The main environmental advantages and disadvantages of the proposed project shall be subsequently discussed and outlined, and the reasons for the chosen scale, route, design and method of construction shall be proffered. Alternative scale, route, designs, and operating conditions shall also be considered and their environmental implications outlined.

2.4.1 No Project Option

In the event that the no project option is decided, there would be no adverse impact on the biophysical environment, noise level would be maintained, there would be no displacement of terrestrial and aquatic ecosystems within the area as environmental dignity would be maintained. There also would be no disruption in water flow and water quantity and quality would be maintained. The susceptibility of stakeholder communities to diseases such as malaria would have been abated.

Conversely, the no project decision would also mean that there would be no improvement on the farming yield of the local farmers which could translate to the risk of food insecurity. The neighbouring communities could also be susceptible to drought and reduced opportunities to Climate change Adaptation in Agriculture. The Knowledge of modern irrigation and advanced farming methods to boost agricultural production would have been missed. The stakeholder communities might be susceptible to famine which will result in hunger therefore reducing the chances of achieving the SDG 2 of the sustainable development goal which is zero hunger.

However, given the success of the first phase of this project as observed from feedbacks from beneficiary communities and persons during the scoping workshop who noted the beneficial impact of the project, this proposed expansion is a much anticipated and welcome development for the scheme.

Alternatives Considered

Provide information on feasible alternatives to the Gashua Irrigation Scheme e.g. piping water from upstream to downstream which will also allow for irrigation of farms? Outline also the implications of “without project” option.

Comparison the various alternatives on the basis of technical competency to implement the Gashua Irrigation Scheme, economic and social benefits, environmental and social adverse and beneficial effects, public opinions and perceptions.

Results of the Comparison of the Alternatives

The environmental and social impacts of the alternatives should be included in the report. The locations of the alternatives, possibility of applying available technology, the potential environmental and social impacts and the mitigation measures should be briefly provided and compared among the alternatives.

The selected alternative shall be the most technologically, economically, environmentally and socially sustainable.

CHAPTER THREE

3.0 Project Description

3.1 Background of the Project

The Gashua Irrigation Scheme Rehabilitation and Expansion Project is one of four selected priority projects of the SAP and approved by the Hadejia Jama'are Komadugu Yobe Trust Fund (HJKY_TF) for implementation in Kodamadugu Yobe (KY) basin over the coming 25 years as shown in Table . The project is intended for the development of about 2,100 Ha gross command area, on the right side of River Yobe using water pumping from the river. The preliminary designs for the project offer a surface irrigation system with pumping head work, mainly based on 12-hours per day surface irrigation, bringing the maximum net area under irrigation.

Table 3.1: List of Priority Projects

S/N	Project Name
1	Challawa Gorge Dam Watershed Management Project
2	Gashua Irrigation Scheme Rehabilitation and Expansion Project
3	Harnessing of Water for Community Fisheries Development in Plateau State
4	Jama'are River Regulation

Source: HJKY_TF and The SMEC Group, 2019

3.2 Project Site Characteristics

The project site is characterised by different agro-climatic physical features and socio-economical contexts. These are climate, hydrology, topography, soil and land use, land suitability and agricultural practice. These factors are the main determinant factors for the success of irrigation development. Accordingly, this section briefly discusses these issues in relation to the Gashua Irrigation Project area.

3.2.1 Project Location

The project site falls within the Nigerian sector of the Chad Basin and is located in Yobe State in the North-Eastern zone of Nigeria. The State shares an international boundary with Niger Republic at the north and local boundaries with Jigawa and Bauchi to the West, Gombe to the South, and Borno to the East as shown in Figure 2.

Figure 2.1: Map of Nigeria showing Yobe State

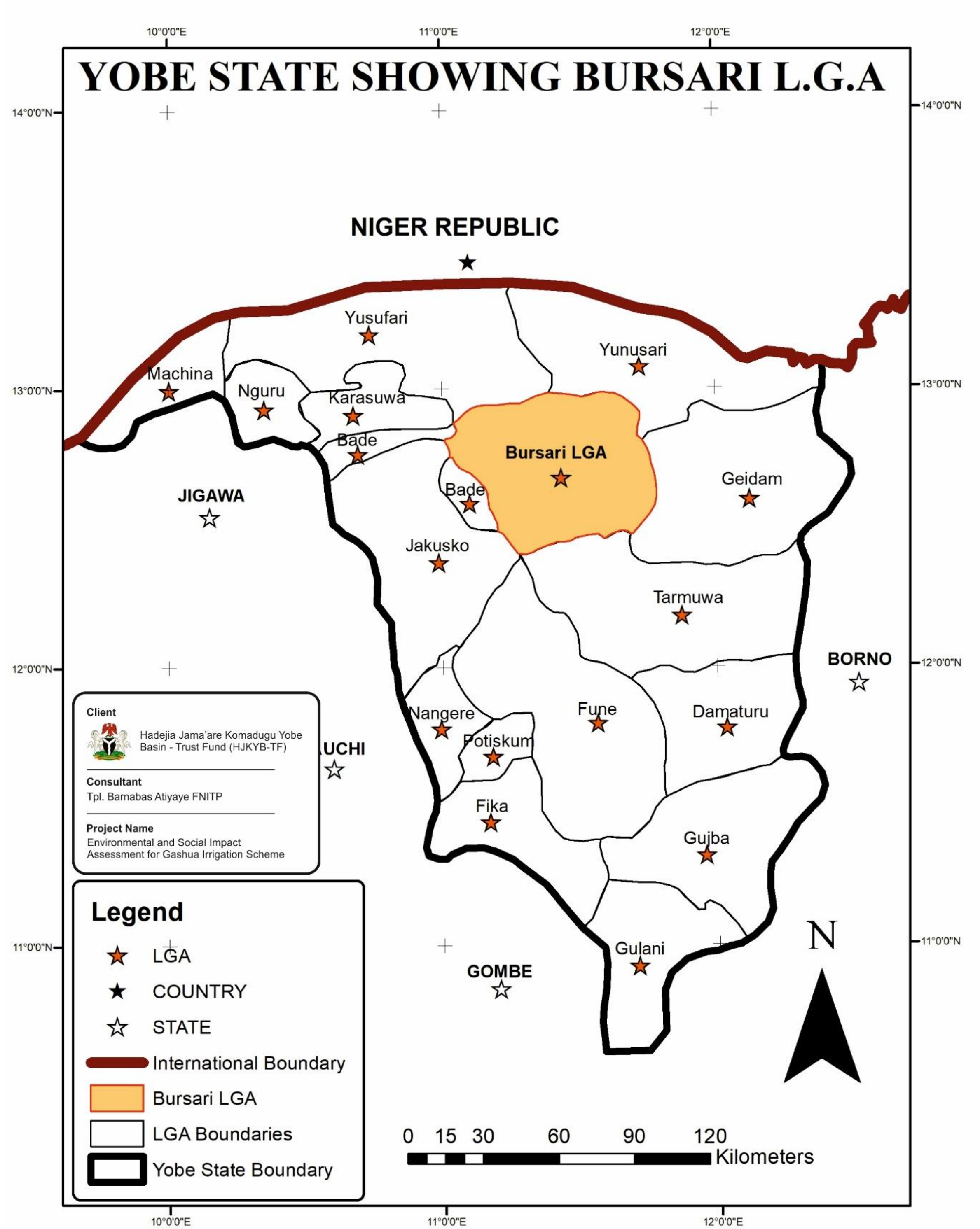

Figure 3.2: Map of Yobe State showing Bursari Local Government Area

The Gashua Irrigation Project (GIP) area is located in the South Eastern HJKY Basin of Yobe State, Nigeria. It lies south of Yobe River and north of Gashua-Damaturu road. The geographical coordinates of the site are 11.2092 E and 12.8252 N. The proposed Gashua irrigation development project is located in Garin Alkali/Laba communities of Bursari Local Government Area of Yobe State as shown in Figure 3. and Figure . The site is 189 km southeast of Damaturu, the state capital, 350 km northwest of the city of Kano, 159 km north of Potiskum town, and 65 km west of Nguru town. The irrigation area lies in the lowlands 176km Hadejia-Nguru Wetlands, with an average elevation above sea level 337 metres.

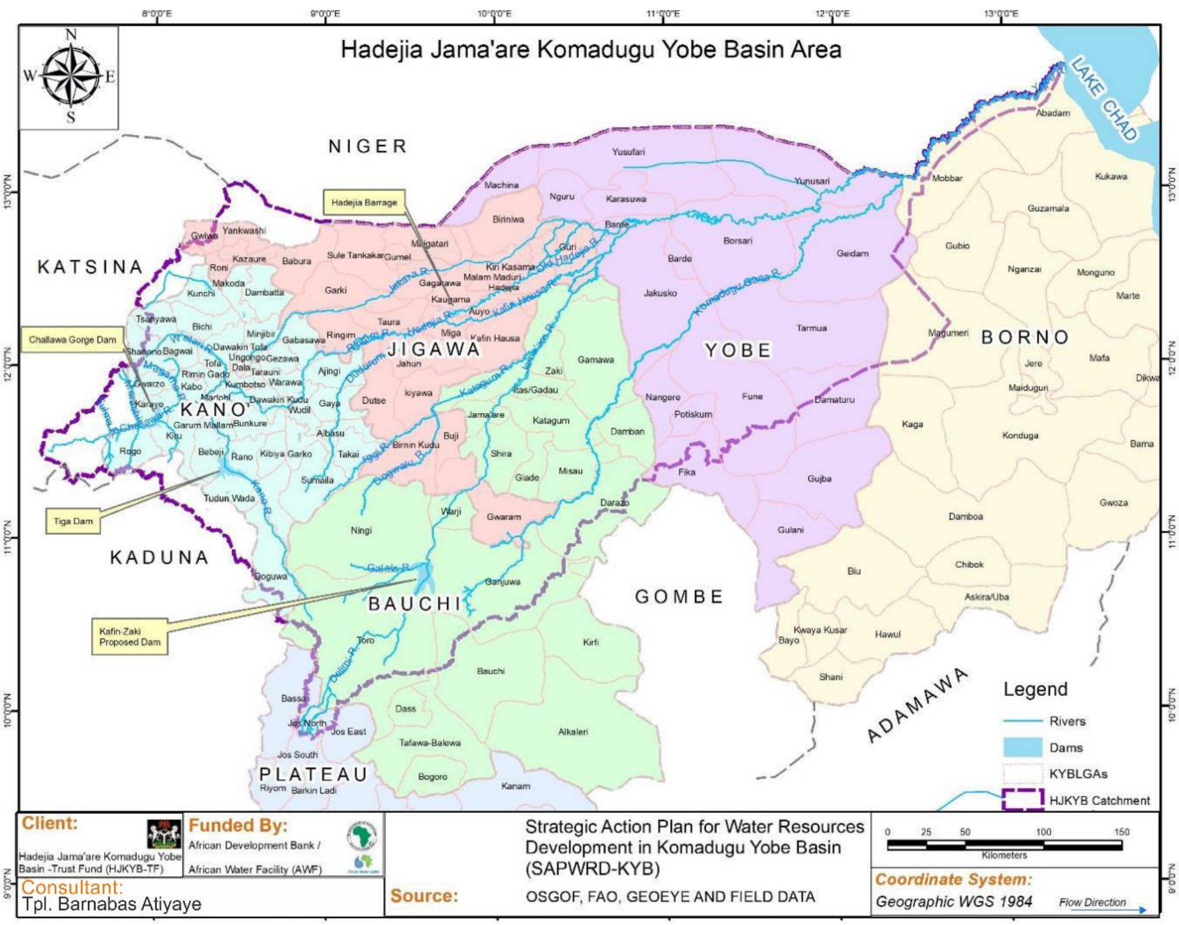

Figure 3.3: Map of Hadejia Jama'are Komadugu Yobe Basin
Source: OSGOF, FAO, GEOEYE and SMEC, 2019

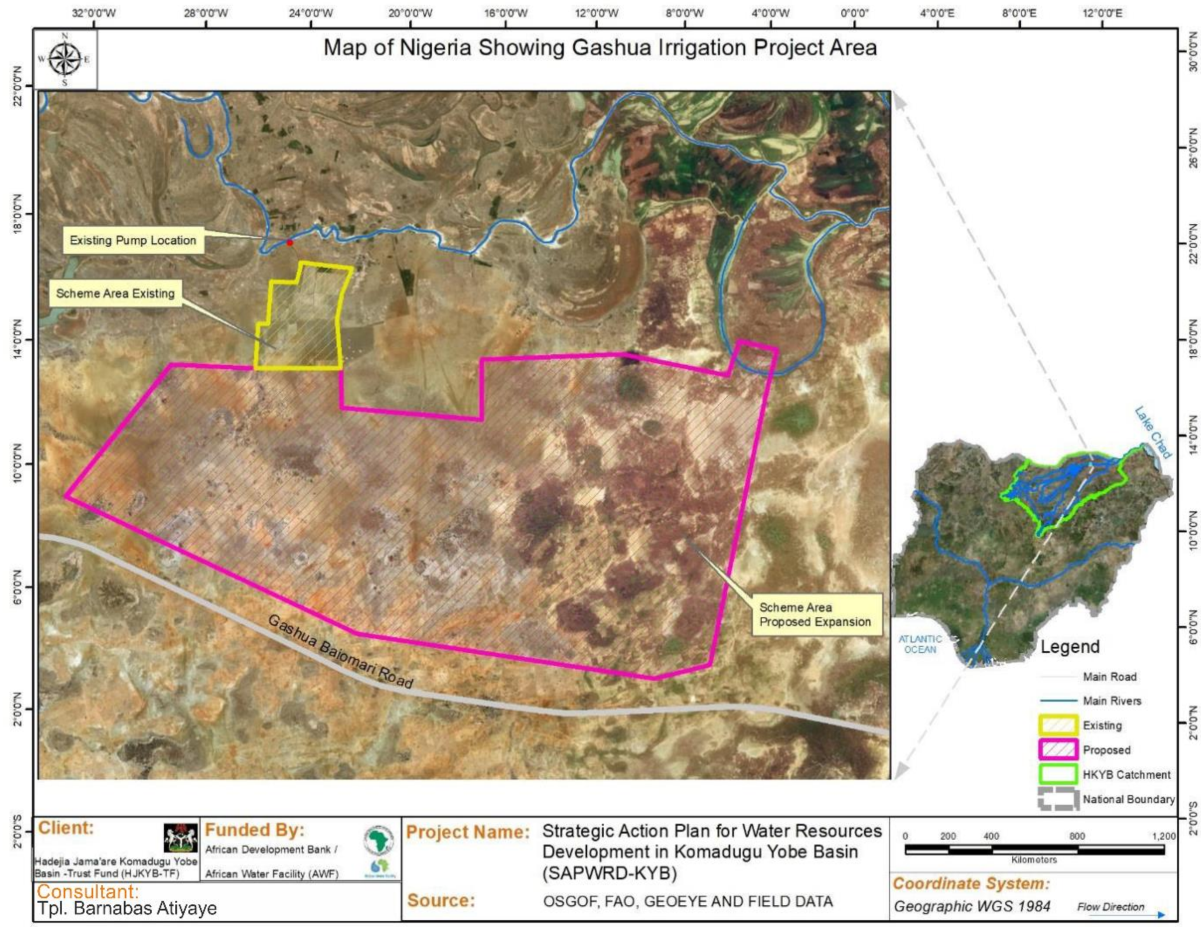

Figure 3.4: Location Map of Gashua Irrigation Project
Source: OSGOF, FAO, GEOEYE and SMEC, 2019

3.2.2 Climate

Gashua has the semi-arid climate prevailing. It is warm to hot all year round and devoid of trees because of the drought (occurs 7 out of 48 years). It consists mainly of sand with grasses and sometimes shrubs. The average annual temperature for Gashua is 35°C and there is about 502 mm of rain in a year. The short-wet season (June to September) is hot, harsh, and mostly cloudy and the dry season (which is about 205 days) is sweltering, windy, and partly cloudy. Over the course of the year, the temperature typically varies from 15°C to 41°C and is rarely below 12°C or above 43°C.

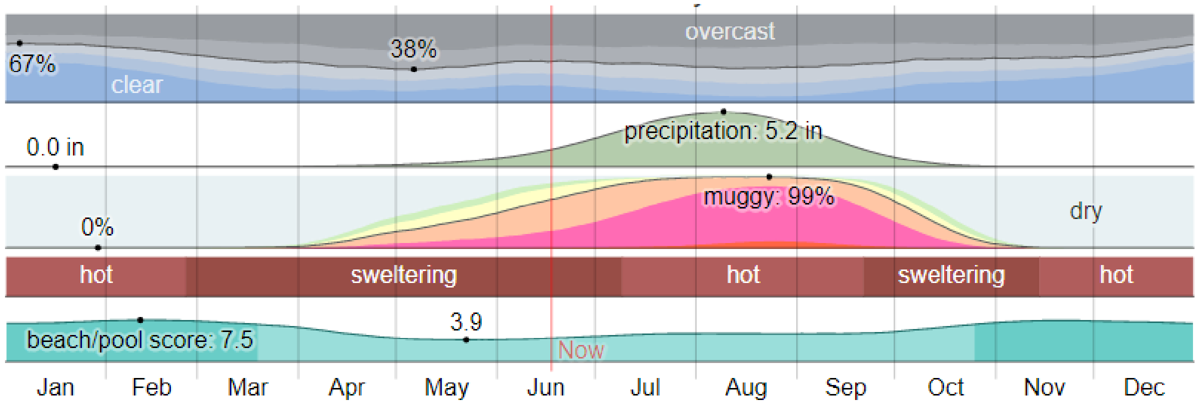

Figure 3.5: Climatic Summary of Gashua

3.2.3 Long Term Average Climatic data

The seasonal pattern of rainfall determines the annual variation of all climatic parameters. Linked to Harmattan, from December to February, both low maximum and low minimum monthly temperatures are observed, reduced cloud cover has been observed, relative humidity is at its minimum and sunshine hours' duration at its minimum. From March to April, average temperature reaches a maximum because of high day maxima and limited night cold, wind speed is also at a maximum. In July/August, the daily variation of temperature is low, relative humidity is high, sunshine duration is high and wind speed is low.

Monthly and long-term average estimates of temperature for Gashua project area were calculated using the gridded data set available from University of Princeton. Long term average monthly values for this climate data are shown in Table . Temperatures are highest from March through to June and are the lowest in January when Harmattan weather persists through the dry season. A maximum monthly temperature of 40.1°C occurs mid-dry season in April with a low temperature of 14.2°C in January at the height of the Harmattan season. Monthly average minimum temperatures vary from 22.8°C in January to 33.2°C in May. The humidity is highest in August at 68% in the wet season, and lowest in February at 11.9% during the dry season under clear sky conditions. The dry season humidity is assumed to increase from current lower levels due to the micro-climate effect of irrigated crops transpiring water, based on advice from FAO 56 (1998).

Wind speed varies from 1.73 m/s – 2.95m/s and averages 2.35m/s with high wind speeds from November through to a peak in February. Sunshine hours vary from just 11.26 hours in January to 12.6 hours in June.

Table 3.2: Climatic data and reference evapotranspiration for command area

Month	Min. Temp. (°C)	Max. Temp. (°C)	Humidity (%)	Wind Speed (m/s)	Sunshine Hrs (hr)	ET_0 (mm/day)
January	31.3	31.3	31.3	31.3	31.3	31.3
February	34.1	17.3	11.9	2.95	11.42	7.78
March	37.8	22.1	12.8	2.75	12.02	8.57
April	40.1	25.7	22.4	2.23	12.24	8.37
May	39.9	26.5	31.9	2.09	12.41	8.15
June	37.7	25.7	48.0	2.33	12.5	7.76
July	34.5	23.7	60.0	2.58	12.46	7.06
Aug	33.0	22.9	67.7	2.16	12.31	6.33
Sep.	34.9	23.3	59.6	1.73	12.11	6.36
Oct.	37.5	23.1	36.1	1.60	11.49	6.42
Nov.	35.3	19.5	21.2	2.29	11.31	6.82
Dec	32.3	15.5	19.5	2.64	12.06	6.66

Source: HJKY_TF and The SMEC Group, 2019

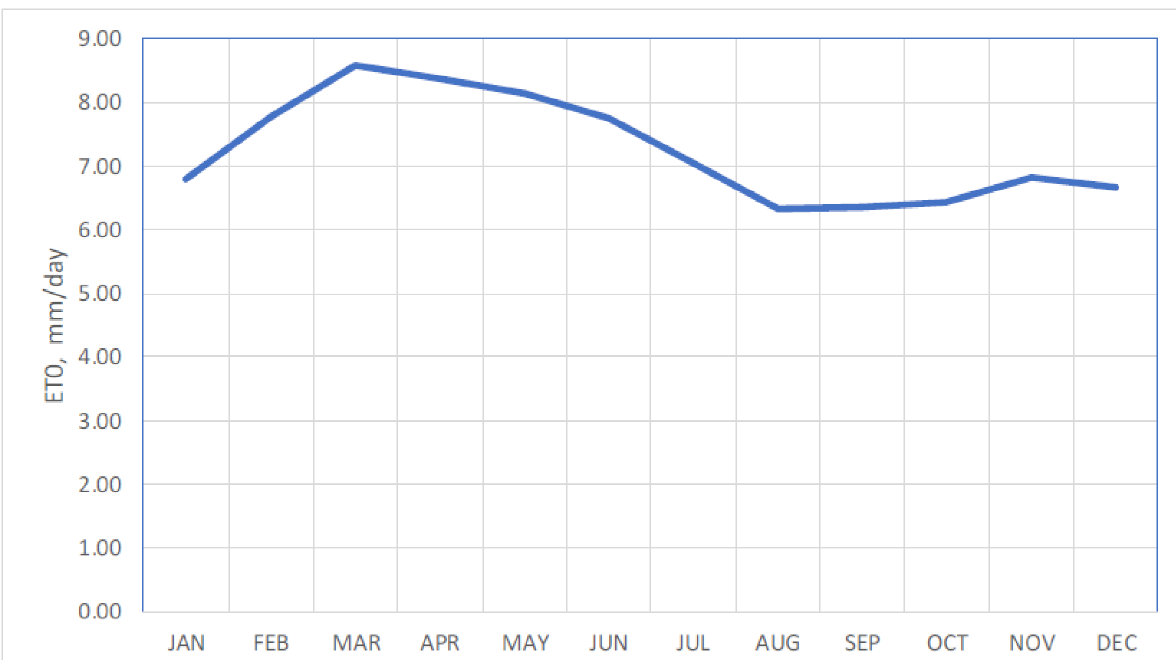

Figure 3.6: Monthly ET_0 at Gashua Irrigation Command area

Source: HJKY_TF and The SMEC Group, 2019

The long-term average climate data is used to estimate the reference evaporation ET_0 for the Gashua command area for estimating crop water requirements. The ET_0 is calculated using the Penman-Monteith formula, as recommended by FAO 56 (1998) using the CropWat (version 8) software. The monthly ET_0 is presented in Table . The ET_0 ranges from 6.33 mm/day in August to 8.57 mm/day in March, the seasonal variation in ET_0 is shown in Figure . The maximum ET_0 occurs in months from March to May. Overall, the average annual value is 7.26 mm/day with an annual total of ET_0 of 2649 mm.

3.2.4 Geology

The project area is located on the alluvia deposit of Chad Basin Formation towards the western fringes of the Chad Basin and has some rocks of the Chad Formation underlying it (see Figure). The Chad Basin is the largest area of inland drainage in Africa (Barber, 1965) occupying about 230,000 km2 in the Central Sahara and the southern Sudan. About one-tenth of the basin is situated in the northern part of Nigeria. The stratigraphy and composition of the various formations are as discussed by Barber and Jones (1960), Carter et al. (1963), Reyment (1956), and Cratchley (1960). The Chad Formation is a sequence of lacustrine and fluviatile deposits of clays and sands of Pleistocene age.

These sedimentary rocks dip gently and thicken eastwards towards the centre of the Chad Basin (Matheis, 1989). The Chad Formation consists of three water-bearing horizons namely: The Upper, the Middle, and the Lower Zone (Matheis, 1989). The alluvial deposits are superficial deposits lying on the Chad Formation. The longitudinal dunes or seif occur as parallel ridges trending northeast-southwest up to 10m to 15m in height and extending for tens of kilometres without interruption. The river alluvium deposits consist of sands, silts and clays.

Coarse sands and gravel occur along the present-day river channel. Less extensive alluvial deposits, mainly clay and silt, occur locally in interdunal depressions and semi-permanent ponds. Clays and silts also occur in oxbow lakes, abandoned channels and river floodplains.

The project area is directly underlain by the rocks of the Upper Member of the formation. Lithologically, the upper member is composed of layers of clayey grits and sands or sandstones of varying thickness. The rocks are largely concealed beneath a mantle of deposits. Artesian and sub artesian conditions are present over wide areas of the basin having profound effect on the economy of this area (Matheis, 1989). The Upper Zone of geological structure provides water for numerous dug wells throughout the rural areas.

The Chad Formation tends to thicken towards Maiduguri axis and thins out towards Potiskum where the Kerri-Kerri Formation is exposed. The topsoil was sandy with silt but in some areas, clay was observed at the surface. The Kerri-Kerri Formation in the north-east is part of the Tertiary deposits. The Chad Formation over lies Kerri-Kerri Formation and is composed of basal sands and gravels with greenish clays above, the latter containing some minor bands of sands.

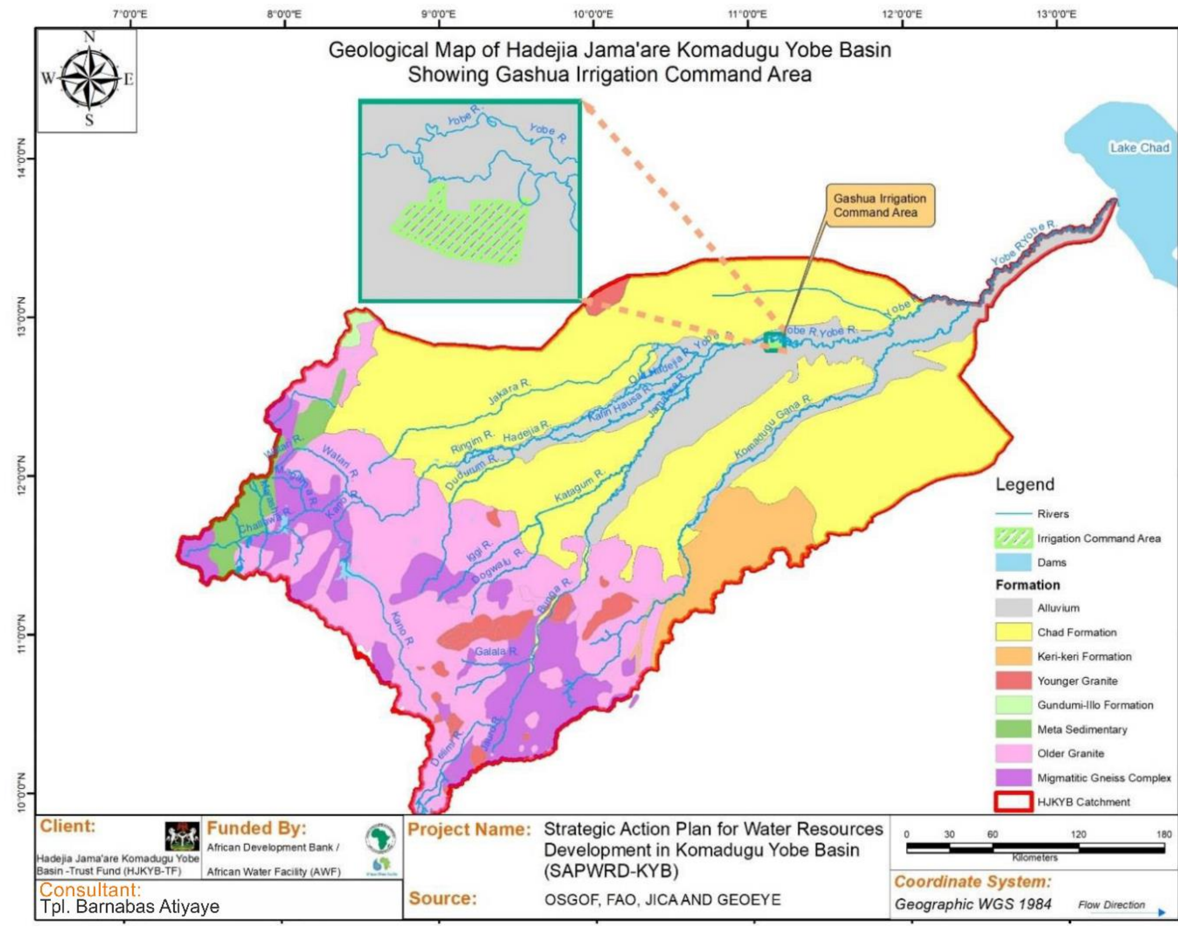

Figure 3.7: Geology map of the project and basin area
Source: OSGOF, FAO, GEOEYE and SMEC, 2019

3.2.5 Topography

The topography of the entire area has a slope of less than 5% and free from discontinuation such as gullies. The entire gross and existing command areas have been found to be less than 2% slope. Thus, the land suitability based on topography of the area is not a binding issue for the development of surface irrigation in the area. However, further suitability factors such as soil type is also assessed and the results presented in the following section.

3.2.6 Soil type and land use

The soil suitability survey of the PCA is carried out following the FAO framework for land evaluation for irrigated agriculture and land capability classification. According to the site visit the soils are deep and the texture is predominantly light clay. A large part of the area is generally well drained, with relatively moderate infiltration and permeability. The soil structure is such that it allows the moisture to be retained for a long period. As it is expected that canals will not remain closed for a long period, there will not be a problem of leakage depending soil type. Therefore, earthen unlined canals are being used in the existing Gashua irrigation command area and the same are proposed to be adopted for the expansion area.

The root zone in these soils is generally fertile and highly conducive to cropping. However, slow drainage, associated with clay texture, flat topography, and a shallow groundwater table and flooding might cause possible salinity and sodicity hazards below the root zone. These are the major limitations restricting irrigation suitability. Therefore, though the project boundary encloses an area of about 2,100ha, only a gross command area to the tune of not more than 1,767ha is available for surface irrigation development due to limitations caused by soil texture and drainage.

3.2.7 Land Classification and Suitability

A detailed soil study and land suitability maps were prepared for HJKY_TF by SMEC (2019), for the complete project area and these have been used to select the areas which are considered suitable for surface irrigated agriculture as shown in3.8.

Table 3.3: Rating of land units for gravity irrigation

Suitability class	Suitability index	Gravity irrigation		
		Land units	Area (ha)	Area (%)
S2	68	GSH 1	1,146.7	53.0
S3	47-50	GSH 3 & 4	621.2	28.7
N2	22	GSH 2	396.6	18.3

Source: HJKY_TF and The SMEC Group, 2019

The results presented in 3.3 are based on the analysis of soil characteristics and slope percentages. The analysis of the parametric evaluation system for gravity irrigation gave the results that are presented in Figure 3.8. The results of the evaluation showed that up to 1,146.7 ha, representing about 53% of the total land area is moderately suitable (S2) for surface/gravity irrigation.

This land unit (GSH 1) stretches from the north-western end of study area to the north-eastern end. Land mapping units 3 (GSH 3) and 4 (GSH 4) with a combined area of about 621.2 ha, representing about 28.7% of the total area was found to marginally suitable (S3) for surface irrigation under existing conditions. Mapping unit 2 (GSH 2) with only a small land area measuring about 396.6 ha was found to be currently not suitable (N2) for surface irrigation. The limiting factor to this kind of land is mainly the soil drainage status and texture that is mostly sandy, while surface irrigation requires heavier soil textures. Soil sample analyses were conducted by the University of Ibadan, Soil Department Laboratory and the University of Maiduguri, Soil Department Laboratory.

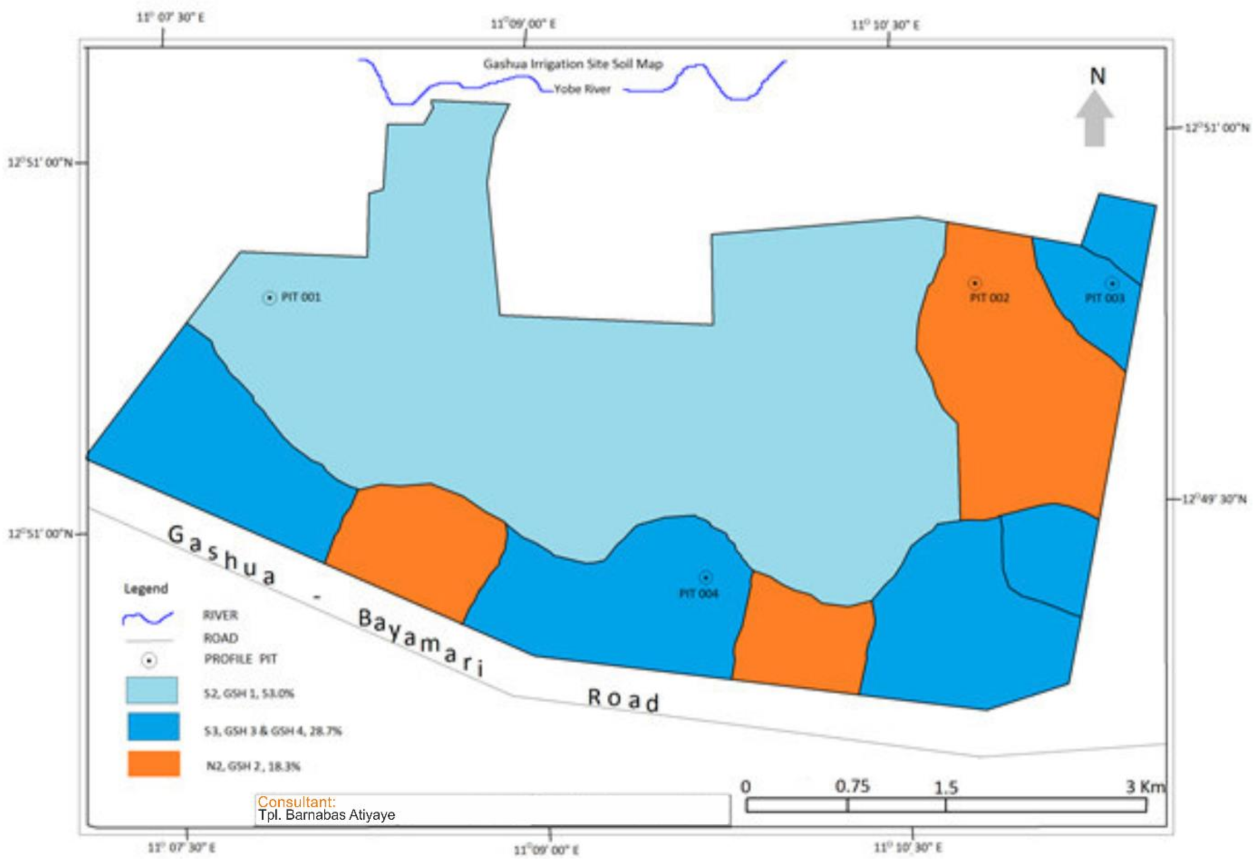

Figure 3.8: Irrigation suitability map of the site

Although the project boundary encloses an area of about 2,100ha, only a gross command area to the tune of not more than 1,767ha is available for surface irrigation development due to limitations caused by soil textural class and drainage status. Thus, after a detailed layout of fields and network of canals, a net command of 1,591 ha was found for the proposed Irrigation Project excluding the areas lost due to network of canals, drains and project roads which constitutes about 10% of area available for surface irrigation development.

3.2.8 Rainfall

3.2.8.1 Annual Rainfall

The annual rainfall varied from a minimum of 254 mm in 1987 to 969 in 2012. A slight increasing trend in annual rainfall prevails in the data as shown in Figure3.9 Drought occurred for seven years out of 48 years averaging one in every seven years. However, no drought has occurred in the last 27 years as all annual rainfalls are above normal annual rainfall less the standard deviation.

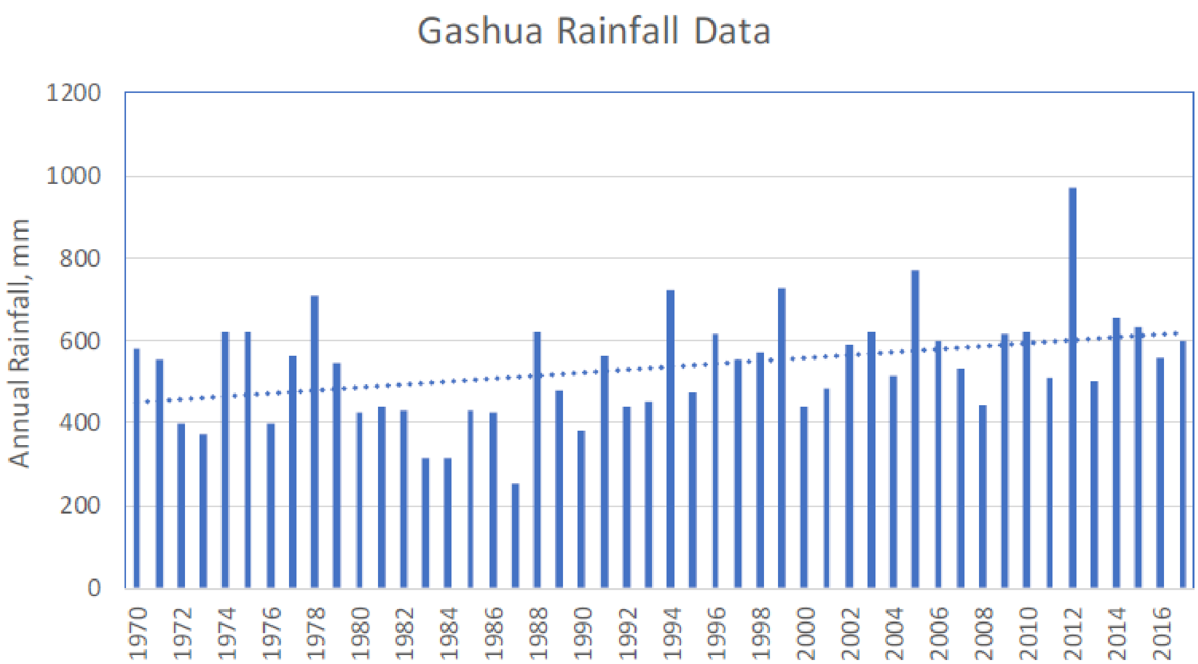

Figure 3.9: Annual Rainfall Data at Gashua Grid point

Source: HJKY_TF and The SMEC Group, 2019

3.2.8.2 *Monthly Rainfall*

The seasonal rainfall of Gashua is characterised by a single wet season from June to September displaying a mono-modal pattern whereby monthly rainfall varies from 76 mm in June, 177 mm in August declining through to 85 mm in September. The annual rainfall for the Gashua command area is 534 mm with annual dependable rainfall of 429 mm. On average 92% of the annual total rainfall falls during the wet season. The dependable rainfall varies from 44mm in June, peaking to 224mm in August, and declining to 119mm/month in September and is less than 20mm during the dry season; often with no rainfall from December through to March.

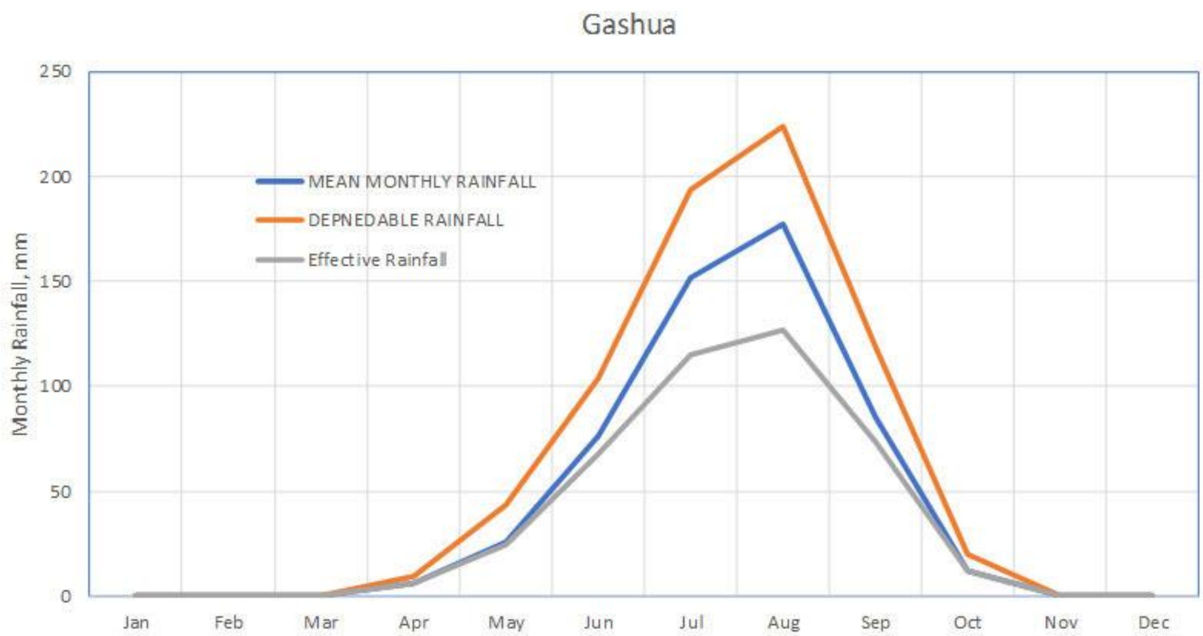

Figure 310: LTA Monthly Rainfall (mm) at Gashua Irrigation Site
Source: HJKY_TF and The SMEC Group, 2019

3.2.8 Annual maximum (AMAX) Rainfall Data

Design flood of return periods up to a 1:100-year events are required to determine the flood flows in the water course intersecting the project area, when designing flood defences and cross drainage culverts and siphons beneath the main irrigation canal. Rainfall frequency analysis is used to estimate the design rainfall depths for return period floods from 1:2 year up to a 1:100-year return period. Rainfall frequency analysis is performed using maximum annual daily rainfall from the gridded data set provided by University of Princeton.

Table 3.4: AMAX daily rainfall data

	Year	AMAX daily (mm)	AMAX Daily (NGURU) (mm)
	1970	41.29	
	1971	44.72	
	1972	36.76	
	1973	30.64	
	1974	42.26	
	1975	42.77	
	1976	32.41	
	1977	75.29	
	1978	58.22	
	1979	42.16	
	1980	54.76	
	1981	24.94	
	1982	86.46	
	1983	31.94	
	1984	27.04	
	1985	71.28	
	1986	55.54	
	1987	67.4	
	1988	50.4	
	1989	35.97	
	1990	29.31	
	1991	55.38	
	1992	26.99	
	1993	44.32	
	1994	48.85	
	1995	36.89	57.0
	1996	43.23	62.7
	1997	88.4	91.7
	1998	63.85	47.2
	1999	85.28	81.0
	2000	44.65	46.0
	2001	40.45	35.0
	2002	82.59	56.6
	2003	62.46	42.3
	2004	88.57	32.4
	2005	102.11	43.6
	2006	54.31	47.0
	2007	34.93	102.5
	2008	41.4	32.6

	2009	88.57	36.4
	2010	71.06	50.2
	2011	40.45	36.0
	2012	102.11	63.0
	2013	28.71	52.7
	2014	50.29	57.8
	2015	92.11	65.0
	2016	26.84	
	2017	97.68	
N		48	21
MAX		102.1	102.5
AVG		54.7	54.2
MIN		25	32.4
SD		23	18.5

Source: HJKY_TF and The SMEC Group, 2019

The Gumbel distribution with MoM parameter estimation have been applied for the AMAX series at the grid point at Gashua irrigation site. The KS goodness-of-fit indicates that Gumbel/MoM is the robust probability distribution to apply for the dataset. The frequency plot is shown in Figure11. A comparison has been made with Gumbel distribution but applying L-Moments at the parameter estimation method (

Table). The results are more or less similar.

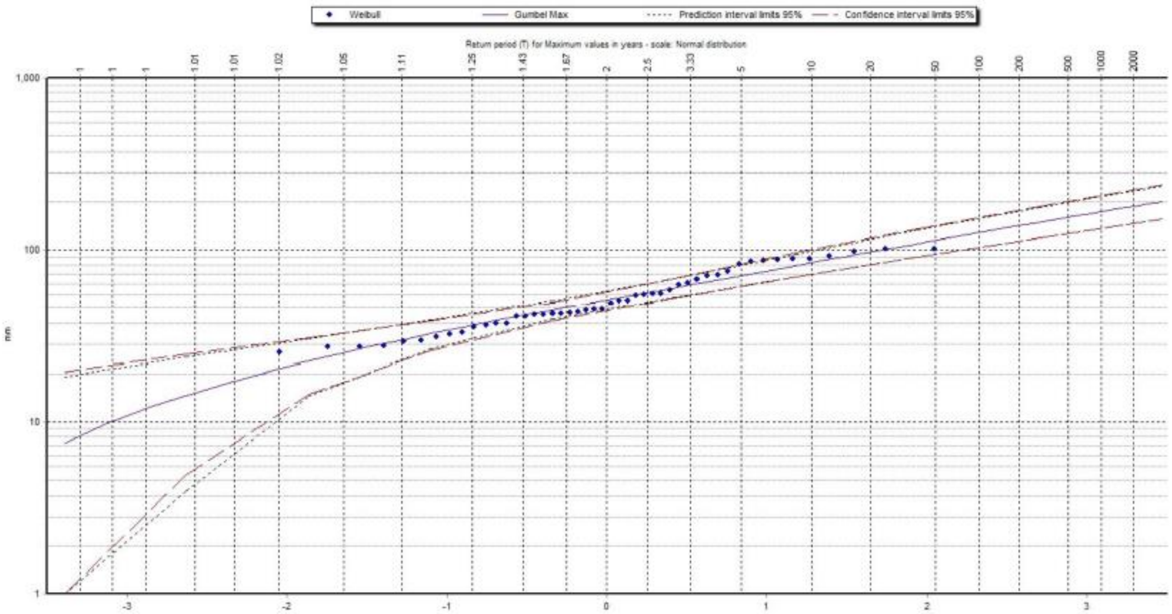

Figure 3.11: Rainfall Frequency Analysis (Gashua Grid point)

Source: HJKY_TF and The SMEC Group, 2019

The design rainfalls of various frequencies are reproduced in *Table* . These are rainfalls of 24-hr rainfall duration which could be rescaled to other durations to compute design rainfalls for shorter durations.

Table 3.5: **Design Rainfall Depths for Gashua**

Grid Point	Distribution	Return Period					
		2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Gashua	Gumbel	50.9	71.1	84.4	101.0	113.0	126.0
	Gumbel (L-Moment)	50.8	71.8	85.7	103.0	116.0	127.0

Source: HJKY_TF and The SMEC Group, 2019

2.4.5.1 *Intensity-Duration-Frequency curve*

An Ombros IDF curve has been prepared using the AMAX data discussed previously. The AMAX data is available only for storms of 24-hr duration. However, storm intensities might be required for durations less than 24-hrs. Hence, the IDF curve for 24-hr duration storms could be scaled to generate IDF curves for shorter duration. This was achieved through an application of Hydrogomon 4 software which implements the Ombros technique to scale down the 240hr storms. The IDF curve is plotted in Figure 43.12.

Table 3.6: 24-hr Rainfall Depths

	Return Period					
Return Period	2	5	10	25	50	100
Rainfall Depth, mm	50.9	71.1	84.4	101	113	126

Table 3.7: 24-hr Rainfall Intensity

	Return Period					
Return Period	2	5	10	25	50	100
Rainfall Intensity, mm/hr	2.12	2.96	3.52	4.21	4.71	5.25

Table 3.8: Rainfall intensity for a range of storm durations

Heading	Return Period						
Duration (hr)	Duration (min)	2	5	10	25	50	100
0.1	5	75.97	108.1	134.3	167.8	197.3	229.8
0.2	10	64.47	91.7	113.9	142.4	167.4	195.0
0.3	20	56.12	79.9	99.2	123.9	145.7	169.8
0.5	30	44.76	63.7	79.1	98.8	116.2	135.4
1	60	30.07	42.8	53.2	66.4	78.1	91.0
2	120	18.51	26.3	32.7	40.9	48.1	56.0
3	180	13.53	19.3	23.9	29.9	35.1	40.9
4	240	10.73	15.3	19.0	23.7	27.9	32.5
5	300	8.92	12.7	15.8	19.7	23.2	27.0
6	360	7.66	10.9	13.5	16.9	19.9	23.2
12	720	4.22	6.0	7.5	9.3	11.0	12.8
24	1440	2.30	3.3	4.1	5.1	6.0	6.9

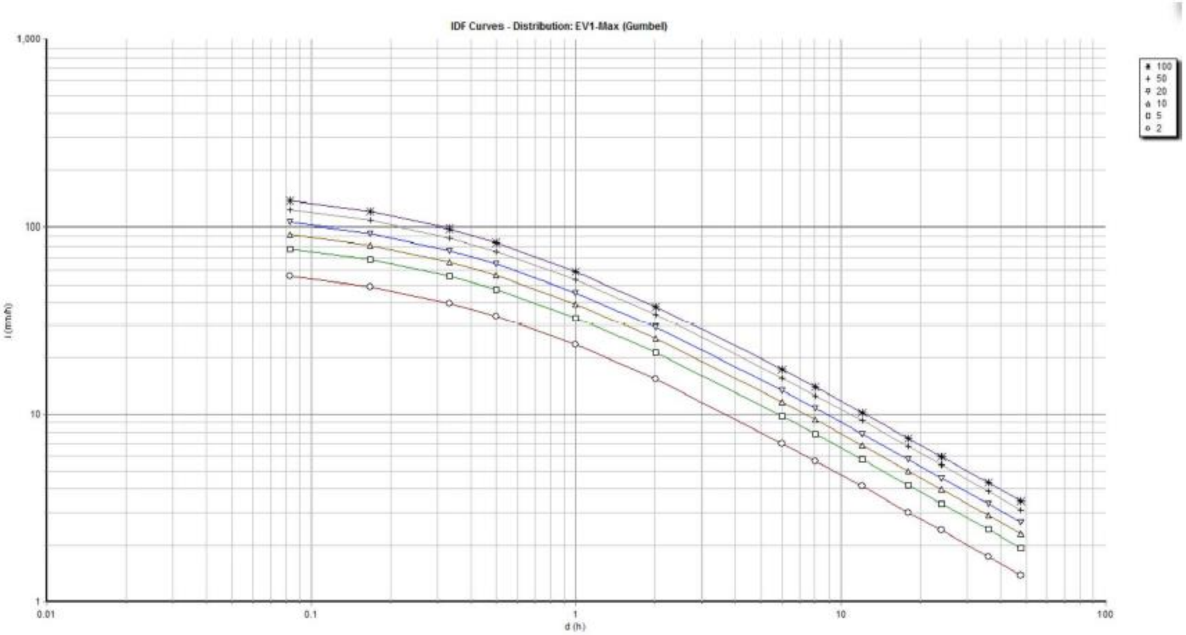

Figure 4: **IDF curve for Gashua Irrigation site**

Source: HJKY_TF and The SMEC Group, 2019

The analytical form of the IDF equation is shown in *Figure 3.135*3.13. The parameters of the theoretical distribution which nest fits the data are stated. Moreover, the parameters of the intensity-duration curve are also shown in the same figure.

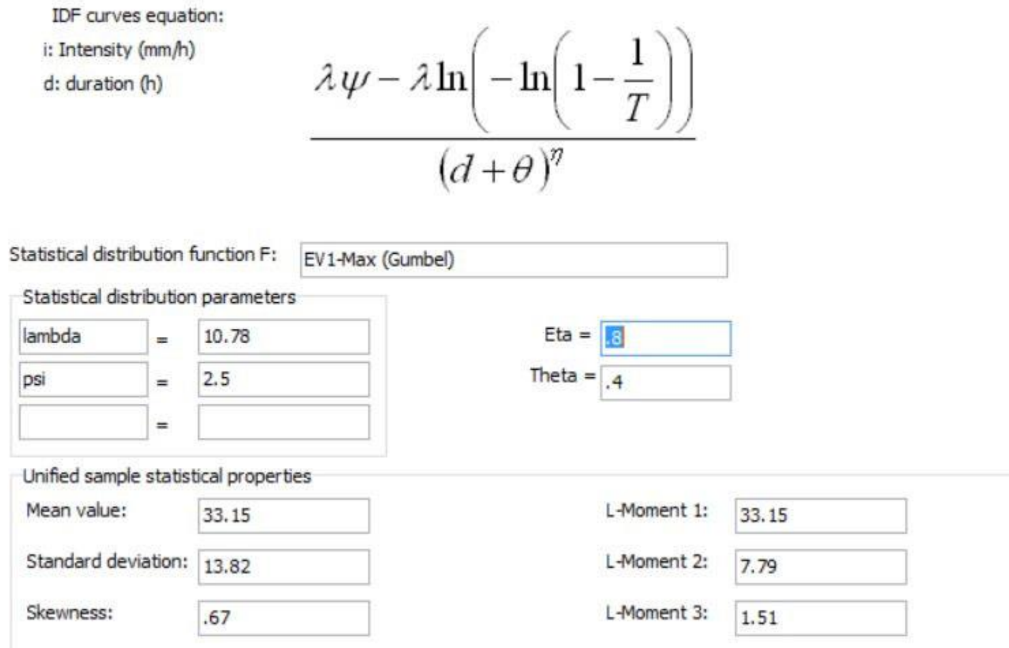

***Figure 3.135:* IDF Equation for Gashua Irrigation site**
Source: HJKY_TF and The SMEC Group, 2019

3.2.9 Flora

The data was collected by conducting a forest inventory, sample plots were established at different locations. Given the homogeneous vegetation of the project site, twenty plots were therefore randomly selected (using a sampling intensity of 20%) for data collection, one hectare (100m x 100m) lots were marked out. All the trees, shrubs, and bushes in each of the plots in the site were enumerated. Identification of tree species was carried out with the help of Trees, Shrubs and Lianas of West Africa dry zones and Nigerian Trees by (Arbonnier, 2004 and Keay *et al*., 1964). Species diversities indices as used in ecology such as Shannon (1948) and Simpson (1949) (Gorelick, 2006) were calculated using the Past 326b software. The project site is covered with tree, shrubs, and scattered bushy grasses and there are no major high canopy trees in the project area (

Table 4.9). Diversity analysis in which 300 individuals were recorded are shown in Table 3.10, with a dominance of 0.3035 reflecting complete dominance of a few species.

Table 4.9: Plant diversity in the area

Scientific Name	Common Name	Local Name	Frequency
Acacia nilotica	*Egyptian mimosa*	*Bagaruwa*	*33*
Acacia neberana	*White thorn*	*Farar kaya*	*2*
Acacia Senegal	*Gum Arabic*	*Dakwara*	*9*
Adansoma digitate	*Baobab*	*Kuka*	*1*
Anogeisus lerocarpus	*Chewstick tree*	*Marke*	*26*
Balanites aegyptiaca	*Desert date*	*Aduuwa*	*156*
Calotropis procera	*Sodom apple*	*Tunfafiya*	*12*
Combretina glutinosum		*Kantakara*	*1*
Diospyros mespiliformus	*West African ebony*	*kanya*	*9*
Guiera senegalensis		*Sabara*	*5*
Hyphaene thebaica	*Young doum palm*	*Kaba*	*2*
Piliostigma thoinmigu		*Kalgo*	*1*
Tamarindus indica	*Tamarind*	*Tsamiya*	*3*
Bauhuna rufesceus		*Tsattsaagii*	*4*
Ziziplus abyssunca	*Catch thorn*	*Magarya*	*11*

Source: Field Survey, 8th July, 2021

Table 3.10: Diversity indices of the surveyed area

Indices	Values
Taxa	12
Genera	15
Individuals	300
Dominance	0.3035
Simpson	0.6965
Shannon	1.734
Evenness	0.3776
Bullouin	1.651
Menhinick	0.866
Margalef	2.455
Equitability	0.6404
Fisher_alpha	3.323
Berger-Parker	0.52
Chao-1	16.5

Plate 3.1: Plant Species at the Gashua Irrigation Scheme

Plate 3.2: Plant Species at the Gashua Irrigation Scheme

Plate 3.3: Plant Species at the Gashua Irrigation Scheme

Plate 3.4: Plant Species at the Gashua Irrigation Scheme

3.2.10 Fauna

The presence of fauna was determined using several techniques including visual observation, sweep net, interviews with local residents and with local wildlife experts. Based on the field observation, sweep net collections, local residents and information from agriculture officers of the project area, the bird species that dwell in area are listed in

Table 3.11. However, none of them are endemic or endangered.

These birds are species to which the Agreement on Conservation of African-Eurasian Migratory Waterbirds (AEWA) applies.

Table 3.11: List of bird species that dwell in the project area

Scientific Name	Common Name	Local Name
Dendrocygna viduata	*White-faced whistling duck*	*Kirinjijiya*
Sarkidiornis melanotos	*Knob-billed duck*	*Kwarwa*
Plectropterus gambensis	*Spur-winged goose*	*Dinya*
Ardea melanocephala	*Black-headed heron*	*Zalbe*
Burhinus senegalensis	*Senegal thick-knee*	*Shaara hwagee*
Ploceus intermedius	*Village weaver*	*Kabaree*
Lamprotornis chalybaeus	*Great blue-eared starling*	*Shaya*
Bubulcus ibis	*Cattle egret*	
Streptopelia senegalensis	*Laughing dove*	*Kurciya*
Polyboroides typus	*African harrier hawk*	*Hura kogo*
Columbia guinea	*Speckled pigeon*	*Hasbiya*

Based on field collections and identification using insect morphological keys, the insect species found in the project area are listed in Table 3.125. Other macro fauna found in the project area is the Giant land snail (*Achatina spp),* locally known as Dodo kodi.

Table 3.125: Insect diversity in the project area

Order	Family	Genus/species	Freq
Orthoptera	Pyrgomorhidae	*Pyrgomorpha spp*	6
Orthoptera	Acrididae	*Brachycrotaphus spp*	4
Orthoptera	Pyrgomorhidae	*Atractomorhpa spp*	4
Orthoptera	Gryllidae	*Pteronemobius spp*	2
Orthoptera	Acrididae	*Mesopsis abbreviates Beauv.*	3
Orthoptera	Acrididae	*Trilophidia centurbata Walker*	1
Orthoptera	Tettigoniidae	*Thyridorhoptrum senegalensis*	2
Orthoptera	Gryllidae	*Gryllodes spp*	1
Coleoptera	Coccinellidae	*Scymnus spp*	3
Coleoptera	Chrysomelidae	*Pagria saturalis Lef.*	2
Coleoptera	Bruchidae	*Careyedon pallidus Olivier*	1
Coleoptera	Curculionidae	*Nematocerus acerbus Fst.*	1
Coleoptera	Coccinellidae	*Scymnus spp*	5
Coleoptera	Chrysomelidae	*Podagrica uniforma*	1
Coleoptera	Bruchidae	*Bruchidius spp*	2

Coleoptera	Bruchidae	*Bruchidius spp*	1
Coleoptera	Curculionidae	*Gasteroclisus rhomboilis Boh*.	4
Coleoptera	Coccinellidae	*Exochomus flavipes Thumb*.	3
Coleoptera	Bruchidae	*Caryedon pallidus Olivier*.	1
Coleoptera	Curculionidae	*Cylas cyanescenes Boh*.	1
Coleoptera	Coccinellidae	*Exochomus flavies*	*1*
Coleoptera	Curculionidae	*Trigonocolus punticollis Hust*.	1
Coleoptera	Scarabaeidae	*Goliathus spp*	1
Coleoptera	Scarabaeidae	*Holiocopris spp*	2
Diptera	Drosophilidae	*Mycodrosophilia nigerrima*	1
Diptera	Chloropidae	*Pachylophus spp*	2
Diptera	Drosophilidae	*Erima spp*	1
Hymenoptera	Ichneumonidae	*Angitia spp*	1
Hymenoptera	Formicidae	*Acantholepis spp*	1
Dermaptera	Hymennopodidae	*Pseudoharpex virescens Serv*.	1
Heteroptera	Pentatomidae	*Callidea duodecimpuntata*	4
Heteroptera	Pentatomidae	*Piezodorus spp*	2
Heteroptera	Lygaeidae	*Oxycarenus congoensis Samy*.	1
Heteroptera	Lygaeidae	*Oxycarenus congoensis Samy*.	2
Heteroptera	Lygaeidae	*Dinomachus spp*	2
Homoptera	Achilidae	*Cnidus spp*	1
Zygoptera	Coenagriidae	*Ceriagrion glabrum Burn.*	1

3.3 Irrigation in the HJKY Basin

In Nigeria, agriculture plays a pivotal role in the country's food security and socio-economic arena. The northern part of the country, as a whole, and Hadejia-Jama'are Komadugu Yobe Basin (HJKYB), in particular, are prone to unevenly distributed rainfall and suffer from drought spells. Irrigation is carried out both in the rainy season and dry season when cultivated land drops to a small area. Paddy, maize, sorghum, and millet are the main food crops, while crops such as wheat, soybean and different vegetables such as tomato, watermelon, and onion are considered to be cash crops. Public irrigation schemes use surface water as major water sources. Fadama farming and some small-scale private irrigation systems in floodplains mainly use sub-surface flows, which occur after flood recession. The other small-scale private irrigation systems outside floodplains obtain irrigation water mainly by extracting groundwater.

The Basin has about 49 existing and proposed irrigation schemes located in three of the four sub-basins, namely: Hadejia, Jama'are and Yobe. The potential irrigable area identified in these schemes is about 192,082 ha, of which about 55,348 ha is developed and 31,523 ha is being irrigated. Additionally, there is an estimated informal irrigation of about 90,000 ha within the Basin.

A map of the Basin showing the locations and classification of the formal government schemes by status (existing, under construction, not functional, proposed and unknown) is given in Figure 3.14.

The main crops under irrigation in the Basin include paddy rice (mainly supplemental irrigation), maize, sorghum, tomato, and onions. The actual mix varies depending on topography, soils, temperature, water availability, cultural practices, and markets. Rice is by far the most important irrigated crop in the Basin and even at national level. A main policy of the Federal Government is self-sufficiency in rice production.

The cropping pattern in the Basin is dynamic with a lot of temporal and spatial variations. The Consultant made field trips to different parts of the Basin and collected data from different sources to obtain a reasonable assessment of the "average" cropping pattern in the Basin.

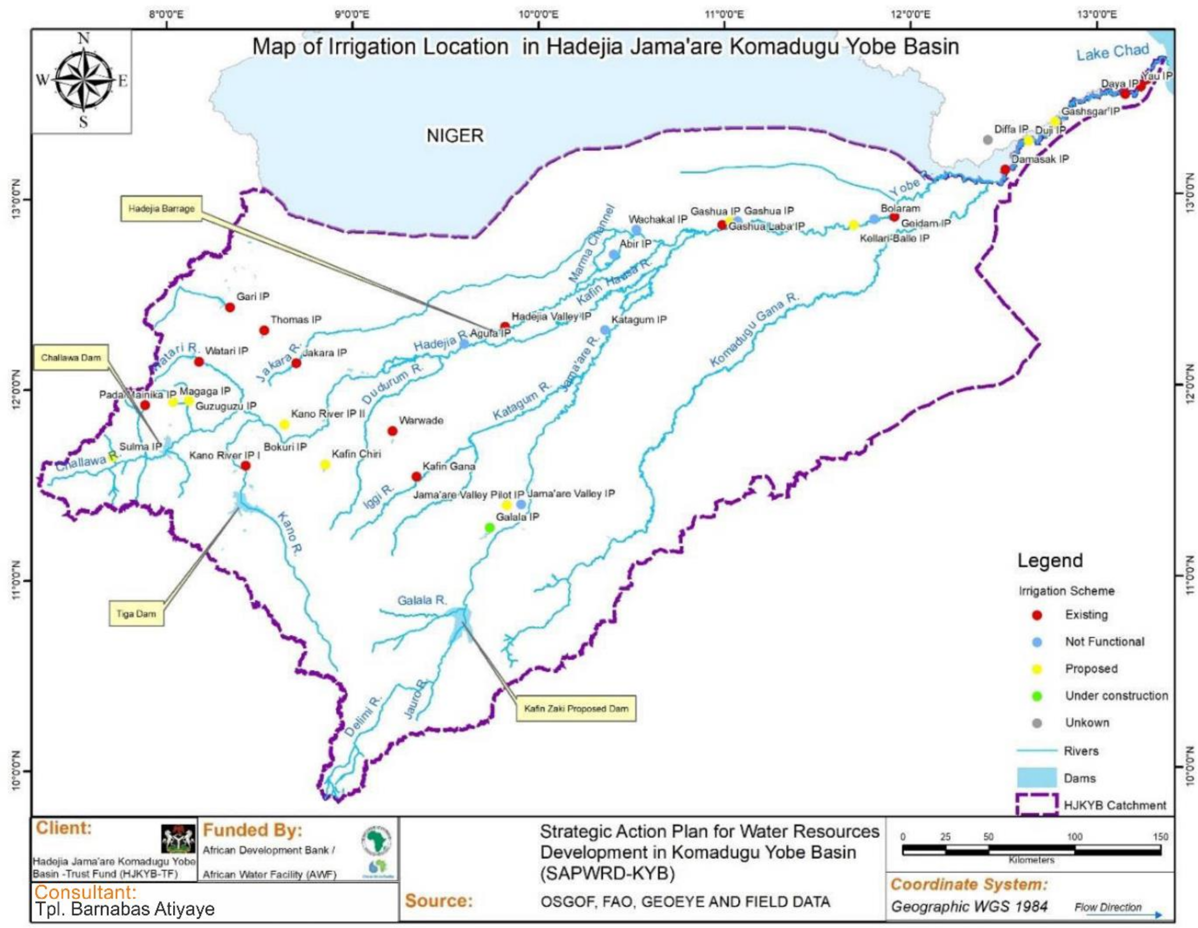

Figure 3.14: Map of Irrigation Location in Hadejia Jama'are Komadugu Yobe Basin
Source: HJKY_TF and The SMEC Group, 2019

3.4 Description of Surface Irrigation Method

3.4.1 General description

The Gashua irrigation command area is bounded by the main canal which runs from the off taking points up to the end of the command area on the Southern part of the command area and Yobe River on North side. The project area is divided into 7 blocks bounded by collector drainage lines. Each of these will be one irrigation secondary block forming a ridge to the direction of the dissecting river.

The design provides the irrigation and drainage networks which are aimed at ensuring an equitable supply of the irrigation water supplies. The essential components of the system are the hydraulic and control structures, which are the components of the system which allow the water distribution network to operate efficiently. The design provides for the location of various crossings and design of structures which are provided in the project. Gashua Irrigation Project is proposed to comprise of the following main components:

Main canal off-taking from the Pumping site at FSL 359.10, extending about 10.5km to the end of the command area to enable gravity irrigation of about 1,760ha. The main canal is proposed to have 2 gated cross regulator structures and 7 secondary structures.

An irrigation network comprising Secondary, Tertiary, Quaternary and Field channels throughout the command area, all canals being unlined. The network has total length of 21km of secondary canals, 35km tertiary and quaternary canals with associated drop structures, cross regulators and offtakes for a representative block.

A drainage network comprises Main, Collector, Tertiary and Field drain channels throughout the representative block command area. A total of 84km of Main, collector and tertiary drain and associated structures including service and access roads.

3.4.2 Proposed irrigation methods

Surface irrigation methods are most commonly used in the world. It is best suited for soils having infiltration rates less than 150 mm per hour and land slope less than 3% along flow in the field. These limitations are unavoidable and can be exceeded in some special situations. Most commonly used methods are: Field Flooding, Basin Irrigation, Furrow Irrigation and Corrugation.

Out of all the surface irrigation methods, basin and furrow irrigation methods are the most widely used in Nigeria and, therefore, proposed to be adopted in this project. This method is the cheapest and does not require any imported materials as required in case of a pressurised irrigation system. Given the wide range of slopes and the low degree of mechanisation, basin and furrow irrigation are the preferred method for efficient distribution of water to the fields.

3.4.3 Irrigation System Definitions

3.4.3.1 Main Canal

The Main canal is the principal channel of a canal system off-taking from the pump station and delivering the required amount of flow to all the project command areas. The starting point for the main canal alignment at pumping site would be fixed by considering the optimum command full supply level (FSL) at 357.85 masl. They are contour canals running at slopes of 1:3,500 to 1:3,000.

Structure losses are provided at gully/river crossings. They are designed for 12hr continuous supply when irrigation is required and is unlined for the entire length.

3.6.3.2 Secondary Canals
Secondary canals (SCs) off-take from main canal and deliver water to the individual blocks. There are seven secondary canals as the topographic situation dictates and these are designed for 12hr irrigation supply. They are generally unlined canals in a balanced cut and fill approach.

3.6.3.3 Tertiary Canals
Tertiary canals (TCs) off-take from secondary canals. Tertiary canals are designed for 12hr irrigation supply on a continuous basis. Tertiary canals are generally unlined contour canals.

3.6.3.4 Quaternary Canals
The quaternary canals will be unlined canals that off-take from tertiary canals. In most cases the area served by a quaternary canal is an irrigation unit of maximum 4 ha in one way and 8 ha in two-way irrigation. These canals normally run down the major slope.

3.6.3.5 Irrigation Stream
A flow of 15 - 23l/s is provided to each field unit.

3.6.3.6 Ridge and contour canal
A ridge canal is a section that runs down the contours (with a comparatively steep gradient), whereas a contour canal is a section of a canal running approximately parallel to the contours (with a comparatively shallow gradient).

3.4.4 Drain System Definition
3.4.4.1 Quaternary Drain
Quaternary drains run parallel to quaternary canals and collect escape water from field channel escapes and runoff from in-field furrows and basins. Disposal can be into a higher order drain or into main drain on the border of the command area.

3.4.4.2 Tertiary Drain
Tertiary drains collect water from lower order drains. Disposal can be into a collector drain or into main drain on the border of the command area.

3.4.4.3 Collector and Main Drain

The main drain is a drain running adjacent to the command area collecting water from collector and tertiary drains. This collects all the drain water and conveys it to Yobe River.

3.4.5 Area Definition

3.4.5.1 Field unit/Quaternary unit

The field is the smallest unit considered in the design of the project; generally, 4ha. It is the area that is irrigated using furrows and basins every 8 days, at maximum crop demand, by a field channel in 12hr per day intervals with a proportional irrigation stream.

3.4.5.2 Tertiary Block

These are groups of fields, ideally 32 ha but also in multiples of 4 ha. All fields within a unit will be irrigated during one rotation cycle. Where there are less than 30ha in a unit, the irrigation cycle will be reduced and the irrigation stream might be diverted elsewhere in the block.

3.5 Field (On Farm) Irrigation System

3.5.1 General Description

The planned water delivery system includes pumping of water directly from River Yobe and delivery of the water by main canal running along the contour in the East and South border of the project. From the main canal, secondary canals (SCs) are planned to take off perpendicularly to the main canal, running down the prevailing slope about 8 m along a distance of 10 km. Tertiary canals (TCs) are planned to take off from the SCs, running along the contours and serving the irrigated fields by field drains (FDs). The FDs serve several rectangular plots standard size of 2.0 ha – 100 m wide and 200 m long.

On-farm irrigation refers to water distribution and application over the irrigated area. Consequently, it refers to the irrigation system and operating practices. The objectives of on-farm irrigation planning are to:

- Select irrigation methods suited to the soil conditions and the irrigated crops and having high water application efficiencies.
- Design the irrigation system and determine an operation program that is simple and reliable, while enabling equitable water distribution to all users.
- Achieve high yields and returns to the farmers based on proper irrigation systems and operation.
- Establish extension service and water users' groups that will provide the farmers with the necessary training in irrigated crops and organize the users to operate the system and maintain it at the farm level.

3.5.2 Layout of Irrigation Plots (On farm Irrigation)

The sizing of the field unit is based on the stream size, which is based on crop water requirements. The field channel must be sized to meet the peak requirement for the crop for highest demand period. The smallest irrigation unit size is the area irrigated at a time by a quaternary canal during an irrigation turn. The irrigation unit size depends on several factors. Most importantly the following are the basic criteria used in Gashua Irrigation Scheme to fix the size of the smallest irrigation unit:

- The flow rate of the field canal is in the range of 15 – 30 l/s/ha (Albinson and Perry, 2002), 15 – 40 l/s (Ankum, 1992), 20 – 40 l/s (MacDonald, 1990).
- The depth of irrigation water is sufficient enough to wet the root zone until the next irrigation turn (interval of irrigation), and the irrigation water delivery time adopted.
- The irrigation interval is in agreement with the number of farms in the irrigation rotation period. As a rule of thumb, the nominal irrigation interval is set as a multiple of weeks i.e., 7, 14, 21, 28, etc days.

3.5.2.1 Basic Irrigation Unit (BIU)

BIU selection

The selected basic irrigation unit is planned to be symmetrical, with the selection of the BIU as a symmetric and uniform 2 ha plot. The area served by a TC can be described as follows:

- The cultivated plots are defined as a BIU, each BIU is of an area of 2 ha with a rectangular shape of 100 x 200 m.
- All BIUs are of the same size and dimensions except in some areas where the layout does not allow it. The 100 m side is the direction of the irrigation run (length of the furrows and basin) and is parallel to the TC and the 200 m side is perpendicular to the TC.
- The BIUs of 2 ha size are distributed along the TCs with each 2 ha BIU divided into eight sub-BIUs of 0.25 ha each with dimensions of 100 x 25m.
- Each sub-BIU of 0.25 ha is cultivated by a different user. The layout of the BIUs and the supply canal are presented schematically in Figure 6.

Supply System for the BIU

The 2 ha BIUs are supplied by TCs. From the TCs water is delivered to the BIU by field drains. The TC run along the contours and the FD run perpendicular to the contours. The furrows or basins are perpendicular to the FD. The FD runs along the BIU upper boundary and the basins runs in the middle of the BIU with a length of 200 m. The furrows and basins run along the full width of the BIU, being 100 m and 50 m, respectively.

Serving Both Sides

The typical layout of the 32-ha area which is served by a TC includes 4 FDs that run between two BIU and furrows to both sides of the FD. At the end of the furrows there is a field drain (irrigation drain). Operation is such that the flow of the TC is diverted to all the FDs that operate simultaneously during 12-hour each day during the 8-day irrigation interval. The field drain is located between two BIUs so that there are only five field drains. The advantage of this layout is the need to have only four FDs and five field drains.

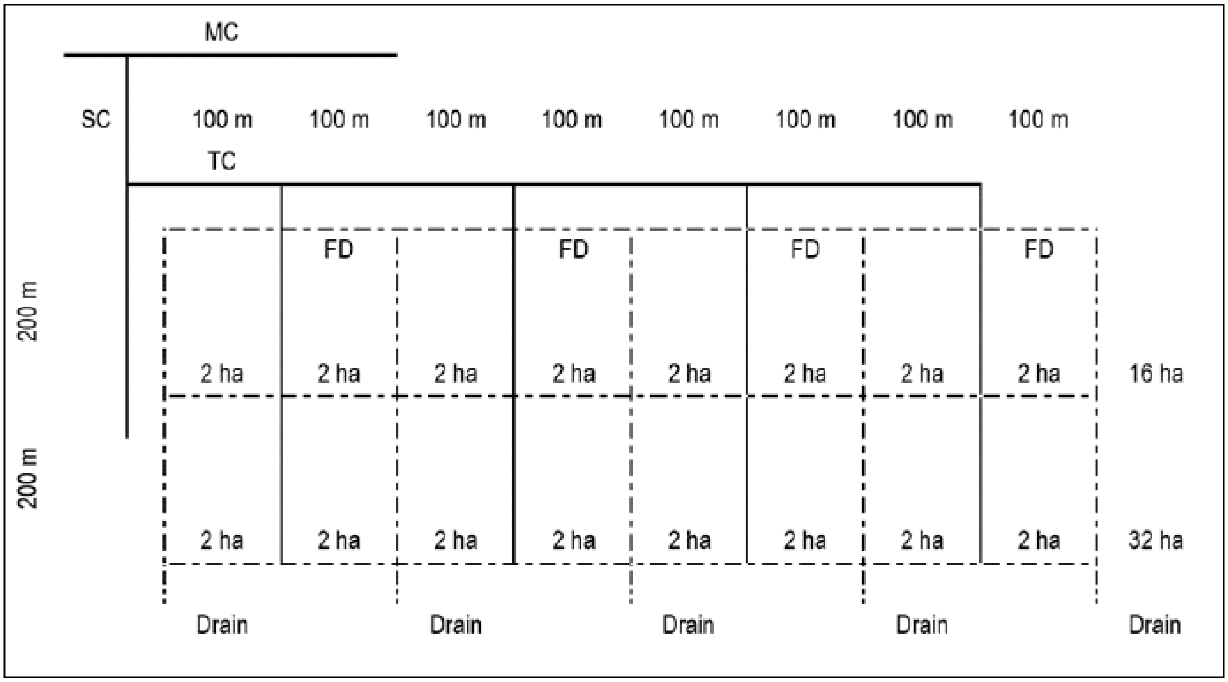

Figure 6: Schematic water delivery and distribution system for the Gashua Irrigation Project

Source: HJKY_TF and The SMEC Group, 2019

Rotational Water Supply

Water is delivered to the BIU either by rotating the irrigated area along the FD or rotating the FDs along the TCs. It is easy and simple to perform with the symmetrical layout (SL) alternative. With the SL alternative, with all plots having a uniform length of run of 100 m it is possible to apply planned furrow irrigation. Where the plots are of varying lengths, widths and directions, the only possible irrigation type is unplanned flooding of the plots, which are usually arranged as a group of basins. This type of irrigation is associated with excessive deep percolation and increased risk of waterlogging.

Irrigation Drainage System

With the symmetrical layout of BI, it is simple to construct the irrigation drainage system and collect the runoff in the fields (furrows) and FDs. Drainage is symmetric, composed of straight canals. Also, the collecting drains are simple to make with straight canals.

3.5.3 Irrigation Hours and intervals

3.5.3.1 Irrigation hours

Irrigation hours is one of the major factors affecting the project construction cost, especially on the size of canals and associated structures and operation cost including efficient utilization of the irrigation system. In most cases two options, 12 and 24 hrs irrigation time, are in practice. To fix irrigation hours many factors are analysed below and actual practice in the country is to be considered. In this case, 12hr irrigation hour has been adopted.

a. Cost implication

The major difference is cost of the irrigation infrastructure. If the system is design for 24 hr irrigation the irrigation duty will be less by half compared to 12 hr irrigation. Therefore, the canal capacity/size and associated structure will be bigger and subsequently the project cost will increase. The cost effect is significant in a large-scale irrigation project. However, in the case of Gashua irrigation project with a 12-hr irrigation hour the cost increment will be minimal compared to the efficiency to be attained for day time irrigation.

b. Efficiency

Regardless of the skill of irrigators, a system designed for a 24-hr irrigation period will have very low efficiency compare to a 12hr operated system, since irrigating during the night, especially for surface method, is very difficult. At night, high water loss occurs due to improper operation of gates, managing of flow in furrows and basins, which creates bad uniformity of irrigation etc. Further, overtopping of flows in the canal creates breaching of canal embankments etc.

c. Local experience

In Nigeria, the irrigation practice can be divided in two; state owned mechanized irrigation schemes and other small-scale irrigation schemes, among which many of them are traditional schemes, run by farmers. The actual practice in these schemes shows that the irrigation is for 12 hr even if the schemes have been originally designed for 24hr irrigation. This is due to various reasons such as lack of infrastructure, lack of experience and poor farming planning, requirement for 24 hr operation lighting (electricity) during the night, at key infrastructure locations all over the project area. For the development of an irrigation scheme, skilled manpower is essential to run the operation of the system. In Gashua irrigation project area there are none or little modern irrigation practices. It will be difficult for farmers to attain the irrigation practices soon unless extensive training and support is given by concerned agencies. Considering the above points, the irrigation scheme shall be designed and operated for 12hr per day, in order to increase efficiency.

3.5.3.2 Irrigation Interval

The maximum interval between successive irrigations is applied for the purpose of operating on-farm irrigation. If necessary, a shorter interval is possible without damaging crop production. However, a longer interval between irrigations should be avoided since it affects the yields. The maximum interval between successive irrigations is determined by total available water in the soil profile, effective root zone, which is the soil profile used by the crops, crop water requirement and critical point, which is the minimum soil moisture content for good yields. Considering these factors, the interval between successive irrigations is calculated by:

$$TAW (m) = [(FC – WP)/100] \times BD \times 1000$$

Where:

TAW (m) = Total available water for one metre soil profile [mm/m]
FC = Moisture content at field capacity [% by weight]
WP = Moisture content at wilting point [% by weight]
BD = Bulk density [gr/cm3]
RZ = Effective root zone depth [m]
TAW = TAW (m) x RZ

Where:

TAW = Total available water for the soil depth of the effective root zone [mm]
RZ = Effective root zone [m]
MWD = TAW – TAW x CP/100 = TAW (1 – CP/100)

Where:

MWD = Maximum water deficiency [mm]
CP = Critical point percent of TAW above the wilting point [%]
T = MWD/NIWR

Where:

T = Interval between irrigations [days]
NIWR = Irrigation water requirement [mm/day]

a. Irrigation Interval for Gashua Irrigation Scheme

Calculation of the interval between successive irrigations for the project was carried out with the following considerations in mind:

- The soil survey provides information on the soil moisture content. For most of the area the TAW (m) is in the range of 100-360 mm/m.
- The NIWR is taken for the proposed basket of crops which is a maximum of 5.8 mm/day.
- The effective root zone is taken for the relatively shallow root crops of vegetables, namely, 60 cm.
- The critical point is taken as most representative for the proposed crops as CP = 50%.

The maximum permitted irrigation interval during the peak irrigation season (February) is calculated
based on the following considerations:

- Total available water (TAW) for 1 m of soil profile is 190 mm/m.
- TAW for a 60 cm effective root zone is: TAW = 190 x 600/1,000 = 114 (mm/600 mm)
- The maximum water deficiency for a critical point of 50% is: MWD = 114 x 50/100 = 57 [mm/600mm].
- The maximum irrigation interval for a crop water requirement of 5.8 mm/day is: T = 48/5.8 = 8.2 days.

Since the irrigation interval is an integer, it is taken as 8 days. The maximum irrigation interval is, thus, 8 days.

3.5.4 Irrigation efficiency

For Gashua Irrigation Project 70%, 86% and 80% are used for application efficiency, operational efficiency and conveyance efficiency, respectively given in

Table3.13. The overall efficiency of the system (product of all the three above, expressed in percentage), assuming the system is constructed according to the design and assuming intensive training to irrigators and proper operation and maintenance is to be carried out, is 48%. The overall project efficiency is the irrigation efficiency multiplied by the delivery efficiencies of all the canals up to the main canal. For surface irrigation, the overall project water efficiency is presented below.

Table 3.13: Water Losses, Efficiencies and Duty for Surface Irrigation

Type of Efficiency	Main Canal	Secondary Canal	Tertiary Canal	Quaternary Canal	Net
Conveyance	0.94	0.94	0.95	0.95	0.80
Operational		0.95	0.95	0.95	0.86
Field Application					0.70
Overall Efficiency	0.94	0.89	0.90	0.90	0.48

Source: HJKY_TF and The SMEC Group, 2019

3.6 Water Delivery System (Conveyance System)

The gross command area has a flat topography. There are also some isolated areas which are slightly rising above the average level of the plain, which actually require land levelling and will require more detail in the detail design phase. The main system is supplied by pumping water from River Yobe to the Main Canal, from the main canal to distributary networks, by gravity, to the smallest end of the network to field canal. The topography feature in most of the command area allows the field canals to deliver in two directions. Aligning quaternary canal across the contour in this topographical feature type is advantageous in terms of reducing the canal density of the area and, subsequently, reducing the infrastructure. The general conveyance system is described in the following sections.

3.6.1 Pumping Station

The water abstraction system for the Irrigation scheme is through the pumping head work directly from River Yobe. The technical feasibility of other alternatives such as a diversion weir were also studied. The most feasible and economical abstraction system is found to be a pumping head work. The peak scheme demand estimated from irrigation duty for 1,767ha of land is 2.11m3/s. An irrigation raw water pumping station is proposed. The standard type of centrifugal pumps and suction pool arrangements are proposed for Gashua irrigation scheme. Abstracting raw water from River Yobe and delivering it via two parallel DN 600 and 1,000 mm raw water main (rising main). The DN 600 delivery pipe is connected to one pump while the DN 1,000 mm pipe is connected to three merged pumps.

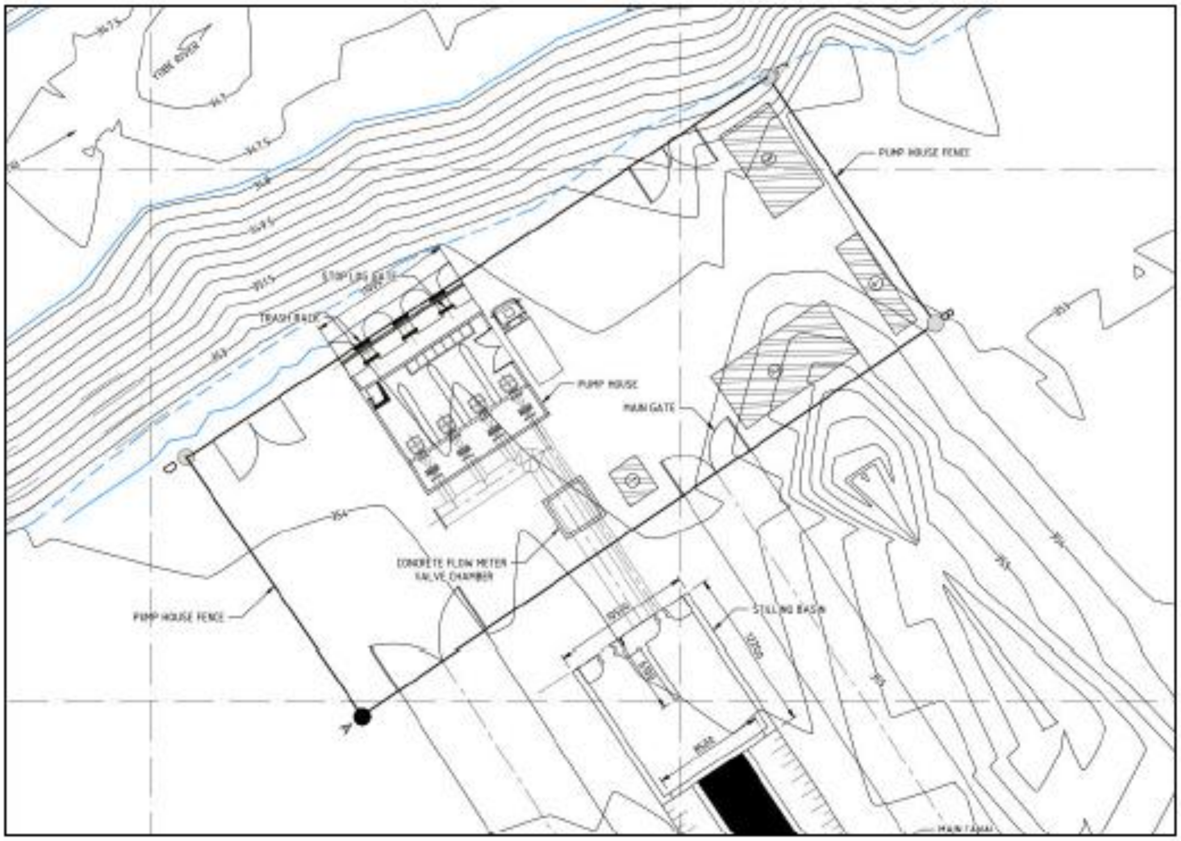

Figure 3.167: Gashua Proposed Pump House Layout
Source: HJKY_TF and The SMEC Group, 2019

The pumping station will be equipped with vertical deep well centrifugal pumps installed in a wet well; the pumping units will be housed in a pump house. A dedicated crane will be provided. Electricity supply will be ensured from the local grid interconnected with the national grid or, alternatively, from a locally installed, dedicated diesel generating set (optional). The rising main will be a delivery pipeline for all the pumping station units, from the discharge manifold to the main delivery canal.

3.6.1.1 Pump House Layout and Location
The pump house is proposed to be located at the banks of River Yobe where the existing pump is located. Selection of the site for the pumping station was done considering various factors, as outlined below:

- The river has straight reaches along the banks and it will protect the approach channel and pump sump from being eroded and deposition caused by the river flow.

- The area selected is downstream of an ox bow lake, where periodic flooding is avoided at the pump location due to relief effect of the oxbow lake. The ox bow lake helps as a bypass channel in reducing the peak flood.
- The selected location has a good consolidated soil foundation and river bank, which is adequate to support the pumping station, rising pipe and stilling basin.
- The topography of the selected location is best suited to the overall arrangements of the canal head works.

3.6.1.2 Pumping station and delivery pool design

The location of the pumping station selected just upstream of where the existing pump is erected. The approach channel is shorter and free of obstacles for guiding the water towards the sump. Also, the pressurized pipeline towards the delivery pool will be aligned straight. The main components in the mode of water delivery are: Approach channel; pumping station which consists of pumps & accessories, generator set, and shade; dry vertical shaft (long pump shaft), suction and delivery pipes design; and pumping capacity.

a. Approach channel

The geometry and size of the approach channel were determined based on the topographical survey and river bank cross section. The approach channel is designed to carry the required flow with sufficient reserve to allow for additional capacity. Rock fill banks on both sides are proposed for cleaning the channel and periodic maintenance. The maximum water level of Yobe River and minimum operating level are given below. The approach channel is designed for a discharge of 2.11 m3/s. The following parameters have been used in the design:

Invert level of the stream = 346.813masl
Channel bed gradient =1/1,000 m/m
Approach channel bottom width =14.0m
Side slope of the canal =1.5

b. Pumping Station

To facilitate demand fluctuations during irrigation season, four pumps are proposed after computing velocities and head loss. The pumps' operation will depend on irrigation season and growth stage of plants. All four pumps will operate during peak season demand while a single pump will be sufficient in low demand season:

- Two rising mains from these four pumps will be aligned in parallel towards the delivery pool. One of the rising mains is to be directly connected to the single pump and laid in parallel up to the delivery pool/ sump.
- The delivery pipes from three pumps are to be merged into one pipe and laid in parallel up to the delivery pool/ sump.

i. Wet water suction well

The criteria for design of the well are recommended in terms of suction pipe diameter, D as follows:

Minimum water level above the foot valve = 1.5D

Foot valve height above the invert of the sump ≥ 1.5D

Flare angle between approach channel to the sump = 200

Minimum length of transition to the sump = 10D

Minimum distance between pumps = 2D

Accordingly, the suction pool dimension is determined as 14 x 6.6m for a predetermined suction pipe diameter of 600mm. The preliminary drawings and dimensions.

ii. Suction pipes

The suction pipe design is based on the operational objectives of irrigation scheme as stated above. The main design criterion is limiting the velocity within the section pipe. The velocity in the pipe should be maintained not to exceed 3.0m/s and should not be less than 1.0m/s to manage the flow in the delivery pool (sump) and to give sustainable serviceability for future use.

Table 3.146: Pump number selection with respect to velocity (four pumps)

Diameter of Pipe, D (mm)	Discharge in the pipe, Q (m3 /s)				Velocity, V(m /s)			
	One pump	Two pumps	Three pumps	Four pumps	One pump	Two pumps	Three pumps	Four pumps
500	2.11	1.06	0.70	0.53	10.75	5.38	3.58	2.69
600	2.11	1.06	0.70	0.53	7.47	3.73	2.49	1.87
700	2.11	1.06	0.70	0.53	5.49	2.74	1.83	1.37
800	2.11	1.06	0.70	0.53	4.20	2.10	1.40	1.05
900	2.11	1.06	0.70	0.53	3.32	1.66	1.11	0.83
1000	2.11	1.06	0.70	0.53	2.69	1.34	0.90	0.67

Source: HJKY_TF and The SMEC Group, 2019

Table 3.1463.14 shows the composition of pumps. Cells shaded in red are acceptable ranges of velocities for different pump arrangements. Cells shaded in green are the selected diameter of suction pipe and associated design discharge capacity and velocity. For this project, a four-parallel pump arrangement has been selected. The selected case is when the individual pumps are operating and the flow velocity is 1.87m/s, for design discharge of 0.53m3/s for each pump. If all the pumps are working at the same time the total discharge will be 2.11m3/s. For these four sets of pumps, a suction pipe of 600mm and suction head of 5.95 m has been determined.

iii. Delivery pipes

Two rising mains are proposed to deliver water from delivery pipes to the delivery pool. Out of the four pumps, three of the delivery pipes are proposed to be merged and run parallel to the one from the remaining one pump. The merged pipes operations and its impact on the head are assessed for the following two scenarios. These are: Operating the delivery pipe flow from three pumps through the merged pipe towards the delivery pool; and operating the delivery pipe for one pump flow through the single pipe. The critical scenario is when two pumps are operating and the pipes after the pumps are merging

Table 3.157: Delivery pipe analysis and selection

Diameter of Pipe, D (mm)	Discharge in the pipe, Q (m3 /s)				Velocity, V(m /s)			
	One pump	Two pumps	Three pumps	Four pumps	One pump	Two pumps	Three pumps	Four pumps
500	1.58	0.79	0.53	0.40	8.05	4.03	2.68	2.01
600	1.58	0.79	0.53	0.40	5.59	2.80	1.86	1.40
700	1.58	0.79	0.53	0.40	4.11	2.05	1.37	1.03
800	1.58	0.79	0.53	0.40	3.14	1.57	1.05	0.79
900	1.58	0.79	0.53	0.40	2.48	1.24	0.83	0.62
1000	1.58	0.79	0.53	0.40	2.01	1.01	0.67	0.50
1200	1.58	0.79	0.53	0.40	1.40	0.70	0.47	0.35

Source: HJKY_TF and The SMEC Group, 2019

Delivery pipes decisions

The analysis has concluded that PN 10, uPVC pipes are proposed with diameter of 600mm and 1,000mm a length of 0.075km. These pipes will deliver the pumped water from the river to main canal lifting over 12m head.

Pumps capacity

From the analysis above, the pumps characteristics are summarized in

Table 3.1683.16. According to the analysis, four set of pumps which run in parallel with rate of 527l/s over a total head of 17m area are proposed.

Table 3.168: Proposed Pump Capacity for Gashua Irrigation Project

Pump parameters	Qty	Unit
Pump units	4	No
Flow rate	527	l/s
Pump head with 20% efficiency	17.0	m
Suction Head	5.95	m
Suction head diameter	600	mm
Delivery pipe in parallel	2	No
Delivery pipe diameter in parallel	600 and 1,000	Dia (mm)

Source: HJKY_TF and The SMEC Group, 2019

3.6.2 Layout of Main Canal system

The layout of the main canal is the most important and vital component of the entire planning work. It calls for most careful consideration of all the factors governing the alignment (topography, natural drainage pattern, etc.) especially at the head reach. Therefore, considering the topography of the site and command area, the canal is aligned as a contour canal with gentle slope of 1:2,000 to 1:2,500 and with structure head losses at regulating and cross drainage locations.

The headwork for this project is a pumping station installed at the bank of River Yobe and delivering water to the main canal. The starting point for main canal alignment is at the delivery pool structure and UTM coordinate of 732,418.174 latitude and 1,422,366.977 longitude. The canal has a total length of 10.94km. The FSL fixed at the main canal inlet (359.10 above mean sea level) is sufficient enough to irrigate the maximum level in the command area.

After fixing the FSL of the Main canal, initially they are aligned as independent of the offtake canal to maximize the command area for the given outlet levels. Later they have been modified, based on off-taking canal FSL's and as much as possible shortening of the canal length in order to reduce the selected type material embankment fill, until the optimum alternative type obtained. In general, the Main canal is aligned as contour canal. The following main factors are considered in the alignment of the Main Canal:

- As much as possible the canal should get the required head to supply to the secondary/tertiary off-take points without and/or acceptable earth fill works.
- Keeping in mind that the flow induced tractive forces at the bottom and sides of the canal have to be below the permissible material tractive forces.

- Since the properties of soil along the main canal has not been analysed at this stage, canal lining is not considered (this shall be treated at detail design stage).
- Though, in general, the canal follows contour canal alignment, in certain reaches alternative routes due to economic consideration such as minimum head loss, smaller investment and/or maintenance cost in the form of canal fill or possible cross drainage works are considered.

Hence, in order to reach an optimum solution for the above stated factors but having inverse relations, the following gradients mentioned in Table 3.1793.17 are used for layout of the canal:

Table 3.179: Gradients used in the alignment of Main Canal

Main Canal in Km	0.00 to 5.96	5.96 to 10.94	Remark
Bed Slope	0.20	0.25	Main Canal

In some reaches of the Main Canal (MC), a road system is usually provided for the operation and maintenance of the canals and structures. Therefore, parallel to the MC alignment, in the direction of the command area, a service road at the right bank of the canal has been aligned as shown in Figure 3.1783.17.

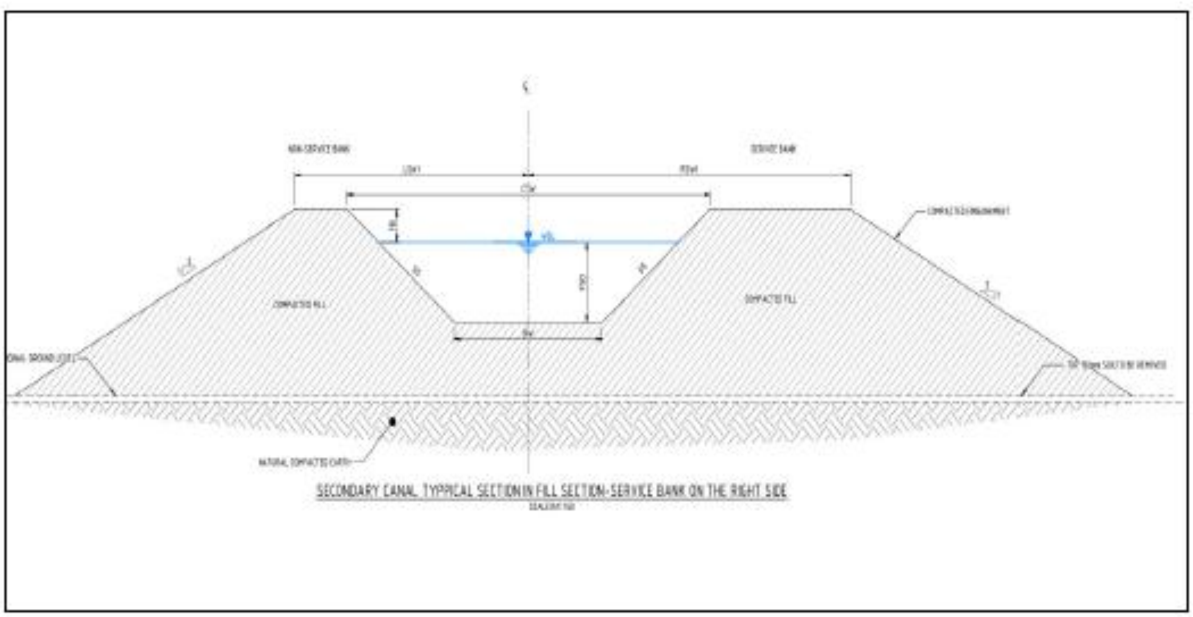

Figure 3.178: Typical Secondary Canal Cross Section
Source: HJKY_TF and The SMEC Group, 2019

3.6.3 Layout of Distribution irrigation & drainage system

The distribution system consists of quaternary, tertiary & secondary canals and quaternary, tertiary and collector drains with all their access roads. As a general principle, the following points are considered in the alignment of the distribution system:

- Irrigation and drainage water is to be supplied and evacuated by gravity and as much as possible crossing of drains and irrigation canals will be avoided.
- Irrigation and drainage canals are completely separated inside the tertiary unit, they first convey water to the farm plots and then later evacuate excess water from the field.
- Tapping water is possible only from quaternary (Field ditches) canals over the farm plots (to the basins and/or furrows).
- A general road network of the area shall be provided. Existing roads are considered. Service and inspection roads are aligned in secondary and tertiary levels respectively and farm roads are provided in the quaternary units.
- As much as possible, secondary canals should be projected halfway between the two natural drains, if topography allows, to provide optimal design conditions.

The prepared irrigation and drainage layout for the distribution system area is done considering the above criteria. However, if natural topographical features do not allow to follow the above conditions, deviations from the above points were also considered in the layout design. Initially all-natural drains, depressions and small gullies are located and off-take supply canals projected halfway between these drains folding ridges. There are some minor natural drainage patterns with in the command although they are not clearly defined. These natural drains are the governing factor in dividing the distribution system as blocks. Each distribution canal system has been bounded by these natural drains. The shape and area of the command area bounded by such natural drainages determine the type of distribution canal off-take from the Main Canal.

3.6.3.1 Secondary Canal Alignment

The layout of the secondary canal should satisfy to irrigate the command area or blocks that are bounded by two collector drains. It is generally aligned across the contour on natural ground slope of less than or equal to the slope of the command area. The lengths of secondary canals vary from one block to the other depending strictly on the topographic condition of the individual blocks. The number of secondary canals is limited to 7 with a total length of 18.5Km. Most secondary canals are aligned as much as possible along ridges, across contour and supply to tertiary canals. Those tertiary canals are aligned mostly as contour canals. The shape and size of those tertiary units in secondary canals are kept optimal per requirement.

3.6.3.2 Tertiary Canal Alignment

The entire command area of the project is planned to be irrigated using the tertiary canals that off take directly from the secondary canal and supplies irrigation water to quaternary/field canals. Tertiary canals are aligned along the contour with some exceptions where necessary. There are about 44 tertiary canals.

3.6.3.3 Quaternary Canal Alignment

Quaternary canals are the smallest canals which carry irrigation water to the farmer's outlet/connection point. These canals are laid across the contour and most of them are designed to supply water to the field in both directions making an 8ha quaternary units at times. Quaternary canals are aligned so as to irrigate units of 8 ha, 400 m to 200m long. According to the shape and lengths of tertiary units, the area of tertiary block will be a multiple of the quaternary unit area. Any size variation will be accommodated by sizing the quaternary canal for a lesser or a somewhat bigger quaternary canal.

3.6.3.4 Layout of Drainage system

The drainages system is designed so as to evacuate excess irrigation and storm water from the field. The main drainage alignment follows the natural depressions as per general topography of the area. The drainage network from lower order to higher order channel consists of the following canal system: Field drain, Tertiary drain, Collector drain, Main drain and catch drain in some reaches of the main canal.

Tertiary drains are aligned as contour canals whereas field drains are aligned as contour crossing or side slope canals. Collector Drains collect excess water from Tertiary drains and discharge to Main drains. The main drain will convey the drain water to River Yobe. The catch drains run parallel to the Main Canal as a contour canal. Catch drains intercept the overland (sheet) flow from the uplands above the Main Canal and will be aligned approximately 20m offset from the Main Canal centre line following the right side of the access road, running parallel to the main canal.

3.6.3.5 Layout of the System for Water Delivery to the Furrows

Quaternary canals are connected to the tertiary distribution network in the canal system. These are the last link in the water delivery system of an irrigation network.

The planning and design of quaternary canals are, therefore, key issues, which determine the success of an irrigation project. In the GIP water will be delivered from the tertiary canals to the furrows or basins via a quaternary canal that runs perpendicular to the tertiary canal. The furrows will be supplied by the quaternary canal using temporary field ditches supplied by simple turnouts from the quaternary canals. Shovels will be employed to facilitate. Water from the temporary field canals will flow into a manageable number of furrows or basins.

3.6.4 Design duty of canals

The peak requirement, in terms of duty in l/s/ha, for proposed crops and their intensities are given in the following tables. The figures in this table show that the peak duty is 1.37l/s/ha. Though the demand of irrigation water requirement varies in time and space the discharges of canals are designed based on the maximum capacity.

3.6.4.1 Flexibility factor and Peak design duty

The design of the system allows flexibility if any change in the future happens such as needs of irrigable area expansion and/or unforeseen events come during operation. Thus, a flexibility factor of 10% is considered for all the canals. Peak design duty of canals are then estimated and used for the design.

3.6.4.2 Canal Capacities and Cross Sections

The maximum discharge capacity in the irrigation system is based on the area to be irrigated, the peak irrigation water requirement at field level, the application efficiency at field level and the conveyance efficiencies at this discharge. It is proposed for 12 hr discharge in the Main, secondary and other lower order canals, such a system allows more efficient conveyance and application of water but does require larger canals where 12 hr discharge is maintained. Further details can be studied during detailed design for the use of 24 hr operation of main canal with the night-time flows in the Main Canal stored in the night storage reservoirs.

3.6.4.3 Main Canal Discharge Capacity

Based on the recommended maximum net irrigable area of 1,767ha and 1.37l/s/ha maximum irrigation duty (based on 48% overall efficiency) the Main Canal capacities are given in Table 3.18. The capacity of the Main Canal has been established on the basis of the possible irrigation of additional command area, in view of a possible increase in application efficiencies

Table 3.18: Design Discharges in Main Canal and Secondary Canal

Name of off-taking canal	Net Area(ha)	Offtake Chainage (m)	Peak Discharge (m3/s)

SC-Exi	100.00	0+220	0.137
SC-1	96.35	4+540	0.132
SC-2	64.23	4+940	0.088
SC-3	256.20	5+960	0.351
SC-4	319.71	7+520	0.438
SC-5	191.97	7+920	0.263
SC-6	224.09	8+540	0.307
MC	1,540.88	10+563	2.111

Source: HJKY_TF and The SMEC Group, 2019

Table 3.19: Main Canal Capacity and Cross section design

Station	Off take	Bed Slope (S)	Bed Width (B)	Full Supply Depth (D)	Side Slope	Manning's coefficient	Area of Flow (A)	Wetted Perimeter (P)	Hydraulic Mean Radius (R)	Velocity (V)	Critical Velocity (Vo)	C.V.R (V / Vo) (0.75 to 1.0)	Actual Section Capacity
0+020	SC-1 EXI	0.200	2.500	1.25	1.50	0.025	5.469	7.007	0.780	0.480	0.630	0.76	2.622
4+540	SC-1	0.200	2.300	1.15	1.50	0.025	4.629	6.446	0.718	0.454	0.597	0.76	2.100
4+940	SC-2	0.200	2.200	1.10	1.50	0.025	4.235	6.166	0.687	0.440	0.580	0.76	1.865
7+520	SC-4	0.250	1.900	0.95	1.50	0.025	3.159	5.325	0.593	0.446	0.528	0.85	1.410
7+920	SC-5	0.250	1.800	0.90	1.50	0.025	2.835	5.045	0.562	0.431	0.510	0.84	1.221
10+560	SC-7	0.250	1.200	0.60	1.50	0.025	1.260	3.363	0.375	0.329	0.394	0.83	0.414

Source: HJKY_TF and The SMEC Group, 2019

3.6.4.4 Distribution canal system design

A secondary block, SC-1 and SC-2, is selected as representative for the design of the distribution canal system. The net command area in the block is 157ha. The schematic layout of the block is presented in Figure 3.18.

Figure 3.18: Schematic layout of sample block-SC-1 and SC-2
Source: HJKY_TF and The SMEC Group, 2019

3.6.4.5 Secondary canals discharge Capacity

Based on the recommended maximum net irrigable area of secondary, canal (from pump station) blocks and 1.37 l/s/ha maximum irrigation duty (for 12 hr/day operation) the secondary Canal capacities are given in

Table 3.20

Table 3.20: Design Discharges in Secondary 1 and 2 canals off taking from Main canal

Station	Off take	Bed Slope (S)	Bed Width (B)	Full Supply Depth (D)	Side Slope	Manning's coefficient	Area of Flow (A)	Wetted Perimeter (P)	Hydraulic Mean Radius (R)	Velocity (V)	Critical Velocity (Vo)	C.V.R (V / Vo) (0.75 to 1.0)	Actual Section Capacity
SC-1													
0+020	TC-1-1	0.310	0.800	0.40	1.50	0.02	0.560	2.242	0.250	0.279	0.304	0.92	SC-4
0+840	TC-1-2	0.310	0.700	0.35	1.50	0.025	0.429	1.962	0.219	0.256	0.279	0.92	SC-5
1+660	TC-1-3	0.310	0.500	0.25	1.50	0.025	0.219	1.401	0.156	0.204	0.225	0.91	SC-7
SC-2													
0+020	TC-2-1	0.320	0.500	0.25	1.50	0.025	0.219	1.401	0.156	0.207	0.225	0.92	SC-4
0+820	TC-2-2	0.320	0.500	0.25	1.50	0.025	0.219	1.401	0.156	0.207	0.225	0.92	SC-5

Source: HJKY_TF and The SMEC Group, 2019

3.6.4.6 Quaternary canals discharge Capacity

The capacity of quaternary canal, assuming a continuous flow and expressed in l/s, is based upon the maximum quaternary turnout requirement (l/s/ha) multiplied by the size of tertiary unit (in ha). However, the operation and/or irrigation schedule and the minimum discharge requirement are also taken into account and either of the maximum of these has been considered as the design discharge. Therefore, based on these factors the required discharge and design discharge for each quaternary canal ranges between 15-23 l/s.

The Agriculture planning phase of the project suggests that 60% of the command area be covered with Rice crop. In actual practice, the selection of type of crops to be grown is mainly decided by farmers. It means that the optimal discharge amount should be designed in such a way that it satisfies flexibility for farmers' choice and overall construction cost. The justification also assures that when Rice (the peak demanding crop) is the choice crop the supply to the peak demand can be balanced either by adjusting irrigation delivery time and/or using the rotation method.

3.6.4.7 Secondary Canals Design

Generally, secondary canals flow for 12 hr/day and flow will be distributed down each off-taking tertiary canal in proportion to the area irrigated. The secondary canals generally run down the prevailing slope in sub-critical channels with frequent drop structures, with the FSL around ground level. As a consequence of balancing cut and fill the water level will be above ground level upstream of drop structures. In addition, the water level will be set to be at least 300 mm above ground level upstream of cross-regulators, so that off-taking tertiary canals can command their head reaches.

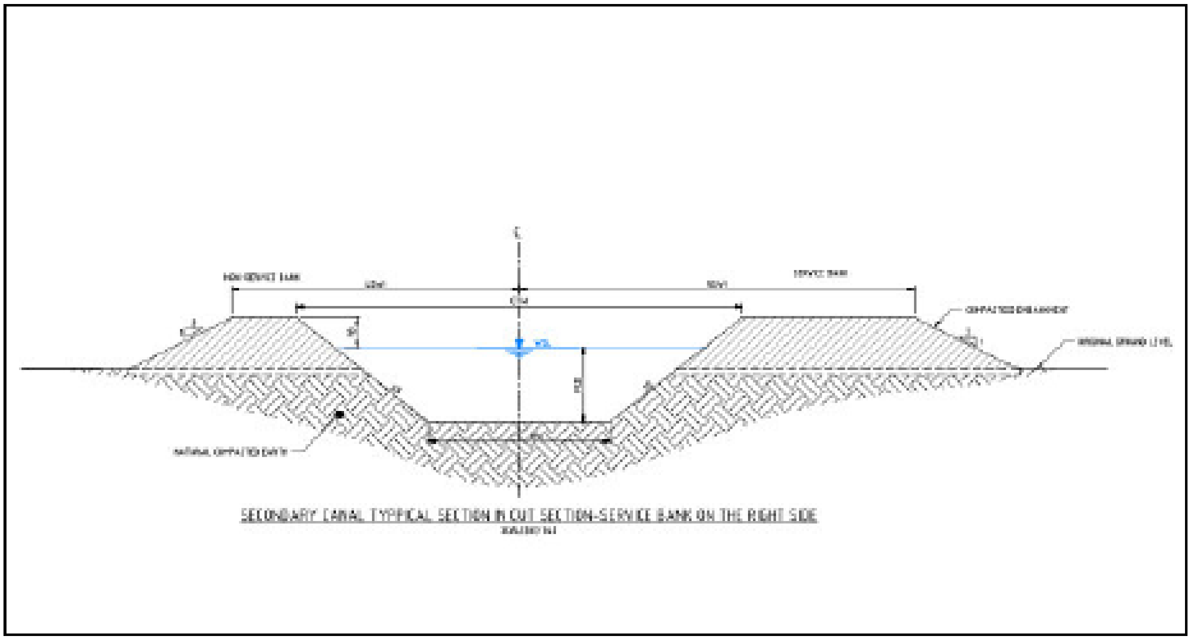

Figure 3.19: Typical Secondary Canal Section
Source: HJKY_TF and The SMEC Group, 2019

3.6.4.8 Tertiary Canals Design

Tertiary canals will flow for 12 hr/day and flow will be distributed down each off-taking quaternary canal in proportion to the area irrigated. The tertiary canals generally run down the prevailing slope in earth channels with sub-critical flow achieved by frequent drop structures, with the FSL at or a little above ground level. At off-take structure locations the FSL should be about 200 - 250 mm above ground level, so that off-taking quaternaries can command their head reaches. The tertiary canal will generally be unlined, with Manning's "n" = 0.0225 and side and embankment slopes of 1:1. Minimum embankment top width is set to 500 mm. A 4.0 m wide surfaced farm access track will be provided where necessary along the tertiary canal alignment.

3.6.4.9 Quaternary Canals Design

Each Quaternary canal will flow 12 hr/day for the crops with the highest consumptive use and either the irrigation duration or flow rate will be cut back if requirements are much lower. The Quaternary canals will serve an area of 8ha in case of two-way irrigation within the tertiary units on a rotational basis. Quaternary canals have been designed mostly as ridge canals and rarely as contour canals; in both cases are they unlined earth channels. Where they go down the major gradient, they will have frequent small check structures to control bed erosion. Where they go down the minor gradient, they will be designed to be non-erosive without drop structures. At the locations of the off-taking field channels water levels are to be minimum of 200 mm above ground level to provide command for the field channels. The channel section will have minimum bed width of 250 mm and side slopes of 1:1. A flow depth depends on the discharge. The bank top width is set to a minimum of 500 mm. The tail end of each Quaternary canal is to be flattened and widened in order to discharge surplus flow into the field drain, thus avoiding tail escape structures.

3.7 Drainage and Flood Protection Works

The Gashua Irrigation project area is generally flat and is susceptible to flooding from over bank river flow during the wet seasons particularly when wetland levels are high. The project area is dominated with medium to poorly draining soils whereby any rainfall in excess of soil infiltration rate is partly stored on the soil surface and partly infiltrates into the soil downstream. If rain continues for long periods, pools or ponding on the soil surface causes water logging and contributes to a prolonged high-water table. The principle causes of water logging and high-water table levels are identified as the following:

- A lack of an adequate and functional drainage system
- Regular overtopping and flooding from Yobe River

Flooding from Yobe river will be prevented by provision of semi-retired flood bunds along the river. The impact of raised wetland levels is particularly acute along the river (the buffer zone) and irrigation is not proposed in this area. To address poor land drainage within the irrigation command area, surface drainage is planned, comprising a network of main, collection and tertiary / field drains. Where possible these will be aligned along natural drainage channels, which will be straightened and remodelled to have an appropriate capacity. As well as removal of surface water, these surface drains will enable some control of the water table and prevent saline build up in the root zone. However, pumped outfalls are avoided and the depth of tertiary / field drains below ground level will be limited by (high) wetland levels particularly towards the Yobe River. In this Chapter, the general criteria affecting the drainage modulus, the appropriate method for its determination, and values of appropriate drainage modulus and general planning of drainage system are presented.

3.7.1 General criteria and methods to determine drainage modulus

The rate of water removal to be provided by the surface drainage system depends on several interrelated factors such as rainfall characteristics, soil properties and cropping patterns. As cropping in Yobe will (continue to) be dominated by row crops, with furrow irrigation proposed for most of the command area, removal of excess water from the soil surface within 24 hours after rainfall is required. The return period adopted for surface drainage depends on the level of protection desirable. For agricultural land five years is usual. There are several methods that may be used to determine the drainage modulus.

Two appropriate methods are outlined below, depending on land slope. Areas with slopes less than 0.2% are designated as "flat", while areas with slopes greater than 0.5% are sloping. Peak discharges are usually more pronounced and cause more damage on sloping land than on flat land. Therefore, design for sloping areas is usually based on peak discharge, while for flat areas design based on average high discharges usually suffices. For Yobe land slopes are mostly less than 0.5%, as tabulated below in Table 3.21, and design based on either method may be appropriate. It is therefore suggested that a comparison of the two methods be made in assessing which is appropriate:

Table 3.21: Land slope categories

Slope (%)	Slope Category	Area (ha)	% Area	Cumulative
0.1-0.2	Flat	280	14	280
0.2-0.5	Flat	1,080	54	1,360
0.5-1.5	Flat	640	32	2,000

Source: HJKY_TF and The SMEC Group, 2019

3.7.2 Drainage modulus for flat land

For flat areas (slope less than 0.5%) the average high drainage modulus is determined by the design storm divided by the evacuation time. For Gashua, a 24-hour storm with a return period of 5 years is adopted as the design storm, giving a rainfall depth of 71.1 mm. It is assumed that this design storm falls on wet land, and the total storm volume is to be drained off within 24 hours. This gives a drainage modulus of 8.23 l/s/ha. This modulus applies to drainage catchment areas up to 500 ha in size. For larger areas, the following area reduction factors should be applied:

Table 3.22: Areal Reduction factor

Nr.	Area (ha)	Reduction factor
1	Less than 500	1.0
2	500 – 1,000	0.90 – 0.95
3	1,000 – 1,500	0.75 – 0.90
4	1,500 – 2,500	0.65 – 0.85
5	2,500 – 5,000	0.60 – 0.80
6	5,000 – 10,000	0.55 – 0.75
7	More than 10,000	0.50 – 0.70

Source: Agricultural Compendium for Rural Development in the Tropics & Subtropics, Elsevier

3.7.3 Drainage system layout

The main natural drainage channels will form the core of the planned system to drain excess runoff during the rainy season and mitigate inundation and waterlogging in the PCA. The system will also serve as the outlet for the on-farm drainage system, designed to drain surplus irrigation water and evacuate excess runoff.

As the project's main objective is to develop and increase agricultural production in the area, the drainage system will be designed for a 10-year (10% probability) return period for the main drains and a 5-year (20% probability) return period for all other drains. The layout of the drainage system will be based on Main Natural drainage, incoming sources (watersheds upstream of the proposed main canal, direct rainfall over the Project command area and water level changes in Yobe River), Land use (crop types and layout, and field management) and Planned irrigation systems.

The main drains will be based on the two main existing natural drainage patterns and will later drain out to Yobe River. The internal drainage system is proposed as per the requirements and will follow the agricultural plot layout and irrigation systems as per the proposed layout explained in the previous section.
Additional drains will be constructed upstream of and parallel to the main canal, as interception drains, to reduce crossings on the main canal and protect it. These drains will divert floodwater as topography permits to the Main drain system entering the river.

3.7.4 Main drainage system

The main drainage system is provided to evacuate runoff from collector drains and later to River Yobe. The drain will collect water from the project command area created either by excess irrigation or by storm rainfall.

3.7.5 Internal drainage system

The preliminary need of a drainage system in an irrigation command area is to remove excess water from the ground surface as well as from the root zone in the sub-soil. The main source of excess water on the land surface is the rain falling over the catchment area. The surface drainage system is most effective in case of impermeable soils or where infiltration is impeded by an impermeable layer. Considering that the soils are heavy clay with a low hydraulic conductivity, a surface drainage system has been proposed.

The objectives of surface drainage measures are to empty the submerged agriculture lands from surface water over a certain period so that standing crops are not damaged; sufficiently lower the groundwater table to prevent waterlogging; and drain the irrigation surplus water during dry season. A surface drainage system serves a useful purpose at the time of heavy rainfall during storms by preventing prolonged submergence of agriculture fields. It quickly removes the water that collects on the ground from rainfall. It would act the same way during the period of normal and low intensity rainfalls, the incidence of whose occurrence is far more frequent than that of heavy rainfall. An efficient surface drainage system would significantly reduce the infiltration of water into the ground and increase the volume of runoff. This would be so during each and every event of rainfall, mild or heavy. It is not practically feasible to altogether prevent temporary submergence of all lands at all times. But drainage systems can be improved to minimize the damage due to waterlogging at affordable costs.

3.7.5.1 Internal drain layout

The excess water arising either from irrigation or from excessive rainfall over the irrigated land will be collected by a network of field drains, each serving an area of 2 ha, and located at the lower edge of the irrigation plots, perpendicular to the irrigation direction. The field drains will be connected to tertiary drains, the tertiary drains to collector drains, the collector drains to Main drains, the primary drains to outfall drains, and finally the outfall drains will convey the drained water to Yobe River. The existing natural drainage channels through the developed area are designed as collector or higher main drains.

3.7.6 Drainage Canal cross drainage structures

Whenever an irrigation canal intercepts natural streams or drainage channels in its passage, cross drainage works have to be constructed. Cross drainage works can be in the form of pipe culverts, slab culverts or level crossings, which pass drainage water either under or above or at the same level as the irrigation canal.

3.8 Preliminary Design

3.8.1 Primary Pumping Stations

3.8.1.1 General Description

The combined irrigation system according to irrigation requirement will require four pumping stations. Each pump will abstract water from Yobe River and discharge it via a short-pressurized pipeline system to the main canal.
The pumping station (PS) will be equipped with several vertical deep well turbine pumps installed in a wet well. The pumping units will be installed outdoors, on a concrete platform, above the canal/pond maximum water level and/or above the 100-year maximum (flood) water level. The rising main will be a common delivery pipeline for all the three PS units, from the PS discharge manifold to the water delivery heads.

3.8.1.2 PS Configuration and Elevation

As stated, the PS will be equipped with multiple deep well turbine pumps installed in a wet well, while the pumping units will be installed outdoors, on a concrete platform. The elevation of the platform is the higher of the following levels:

- 100-year flood level +1.5 m.
- Ground level +1.0 m.

3.8.1.3 Characteristics of the Pumping Equipment

Each installed pump will receive raw water directly from the approach channel connecting the main canal to the pumping station. The wet well of the pumping station will be isolated by means of stoplogs. Upstream of the stop-log, a trash-rack will be provided. The discharge pipes of the pumps will be connected to the rising main by means of non-return valves and gate valves.
Regardless of the number of pumps to be installed, a flowmeter will be installed between the PS manifold and the rising main. Downstream of the flowmeter, an isolation (flanged, manual, gate type) valve will be installed. The pump arrangement is such as to enable pumping even at minimum water level in the canal.

3.8.1.4 Characteristics of Auxiliary Equipment

a. Trash racks

The trash racks are provided to prevent the entry of floating debris into the pumping station. The trash rack is a welded steel single element structure installed inside embedded steel channels. The side guiding channels are extended up to the level of the pumps' concrete platform. A bottom embedded channel will be provided as supporting element.

b. Stop logs

Stop log elements are provided for the complete isolation of the pumping station wet well or for dismantling of any of the trash racks. The stop logs consist of a steel skin plate reinforced with horizontal steel T-section supports. They are guided by embedded rails provided with stainless steel strips. Sealing sides will be fitted to three sides of the stop log: the lateral two sides will be of musical note type and seal due to hydrostatic pressure; the bottom seal will be of rectangular section and will seal due to the weight of the stop log element. There will be no upper support (embedded thimble). Unlined and Lined Irrigation Canals

Design of unlined canals should be based on criteria that allow them to be non-silting when conveying sediment laden water, and to be non-scouring when carrying silt free water. Unlined trapezoidal shaped canals are the most common and economic solution in most irrigation schemes in all situation of terrain. The canal sections should be chosen ideal for construction and maintenance enabling cost effective and economical.

3.8.1.5 Hydraulic Design

In the Gashua Irrigation Project the water has to be lifted from Yobe River and it will be silt free. The canal will be unlined except some reaches of the main canal where the soil is not suitable. The main canal will be a contour canal with slope in the order of 20 to 22 cm/km. The secondary canals will be unlined ridge canals with slope of about 25 to 30 cm/km. The tertiary canals will generally follow contour and will be unlined. The canals shall be designed using Manning's equation and for limiting non-silting, non-scouring velocities the canal sections shall be checked by Kennedy, Lacey's and Tractive force equations as required. In case of Gashua canals the slope shall be enough to transport incoming silt load. Recommended values of Manning's "n" as in "Guideline, Manuals and Standard Design of Small and Medium Scale Irrigation Projects are presented in Table 3.23 for unlined canals

Table 3.23: Manning's Coefficient "n" for Unlined Canals

Canal Location	Canal Type	Condition Values of Roughness	Coefficient "n"
On plain terrain	Primary	Well maintained Poorly maintained	0.025 0.028
	Secondary	Well maintained Poorly maintained	0.025 0.030
	Tertiary	Well maintained Poorly maintained	0.030 0.035

Source: HJKY_TF and The SMEC Group, 2019

3.8.1.6 Canal Cross Section

Shape and size, including the hydraulic section, service and feeder roads, tracks, bank widths, side drains, free board, side slopes, bank slopes, etc. are defined by cross-section of channel. The most economical section of unlined canals is semi-circular. In practice, trapezoidal canals are most often used for ease of construction. The ideal hydraulic shape for a trapezoidal canal leads to deep and narrow sections which are only possible for small capacities (up to 0.5m3/s). Canals with high discharges are generally wide and shallow with large bed width/depth ratios. It is also necessary to keep them within maximum allowable velocity limitation. Wider canals also facilitate better water distribution due to lower variations in water level with changing discharge. The main governing factors in the design of canal cross-sections are: Channel shape; Position of water level to ground level; Embankment size and shape; and Seepage gradient.

3.8.1.7 Canal Side Slope Selection

Canal side slope depends on the material in which it is cut and banks are made. Based on whether the canal is on cut or in fill and as per the soil types, the canals are to be designed as steep as possible in order to limit excavation volumes and expropriation of costs. For erodible soils, the slopes should be checked against criterion of the maximum allowable velocity or by the principle of tractive force. Other factors including the method of construction, depth of canal & the level of ground water table are among others to be considered in canal slope selection. Considering all these aspects for Gashua Irrigation project canals canal sides slope 1:1.5 (Vertical: Horizontal) has been proposed.

3.8.1.8 Freeboard

Free board is the margin left between full supply level (FSL) and top of embankment. It is intended to allow for: Water level being above design water level, Deterioration of the canal embankment and Prevention of fluctuations in water surface overflowing the sides. Recommended Free Board of the Canals as recommended in several guidelines are presented in Table 3.24

Table 3.24: Freeboard V/S Canal Discharge

Scale of the project	Canal Discharge Q (m3/s)	Free board (m)	Remark
Small Scale	<0.5	0.3	
Small Scale	0.5 to 1.0	0.4	
Small Scale	1.0 to 3.0	0.5	

3.8.1.9 Radii of Bends

The radius of curvature of a canal will be different in the hills and plains due to the topographical conditions and soil types. The minimum radius (of the canal centreline) for an unlined canal in the hills (except in rock, hard conglomerate or very stiff clay should be taken as seven times width of water surface. In rock, hard conglomerate or very stiff clay, the minimum radius may be reduced to three times the width of water surface. Recommended Radii of bends in the Canals are presented in Table 3.25

Table 3.25: Radii of Bends

Location	Soil type	Radius	Qmin m3/s	Qmax m3/s
On plain terrain	Alluvial, erodible cohesive	R = 25WS	5<10<15 1<5<10	>15 10-15
On steep terrain	Rock, conglomerate or stiff clay	R = 10WS	<1 2-5	1-2 >5<10
	Other soils	R = 3WS		

Source: HJKY_TF and The SMEC Group, 2019

Curve radii are required to be determined for roads and canals equally. Service roads are provided on the banks of primary and secondary canals and may determine canal radii. The radius of service roads depends upon the type of vehicles or equipment to be used the type of vehicles or equipment to be used on the roads.

3.8.1.10 Embankments

If a canal is in cut the size of the embankment is often determined by the amount of soil to be disposed of. The width of top of the bank depends on the type of soil from which the canal is to be constructed, flow capacity, canal type (earth, lined/or both) and the seepage gradient and the width of service road to be provided. Bank widths of 3 to 5m are required where service roads are provided for small and medium canals with surface roads. Where embankments are in fill with canal water level above the natural ground level, the seepage gradient needs to be considered for the stability of embankment. In such cases, the bank width should be sufficiently wide to retain the seepage gradient below the toe of the outer face of the bank. Recommended minimum widths for canal embankments are presented in Table 3.26.

Table 3.26: Minimum Width of Canal Embankment

Design discharge m3/s	without Inspection Road (m)		with Inspection Road (m)	
	On steep canals	On plain areas	Steep	Plain
0.0 <Q < 1.0	0.75	1.0	-	3.0
1.0 < Q < 5.0	1.50	1.5	-	4.0

Source: HJKY_TF and The SMEC Group, 2019

Bank back slopes should be provided according to the stability of the fill materials. The recommendations for side slopes for compacted fill can be applied to bank back slopes. Service roads should be provided on one side of the canal. For primary contour canals service road should be provided on the irrigated farm side to facilitate the inspection of structures, but for maintaining the catch drain a minimum 3.0m wide embankment is essential in left side. For secondary ridge canals, service roads might be provided on either side. As the terrain is gently sloping, side drains would be provided to prevent gullying of the slopes and would be connected to an inlet draining into the collecting drain or to nearby natural drains.

3.8.2 Regulating Structures (Cross Regulators)

Regulating structures are provided both on the main and secondary canal to maintain the full supply level of the canal and regulate discharge into the off taking system. Canals are to be operated on volume control concept, with a series of pools. The importance of regulating structures is vital.

3.8.2.1 Layout

The layout will depend on the type of the cross regulator and whether it is to be combined with other structures viz., fall, bridge etc. as per specific requirement. The main components are a Control structure with an operating platform for regulating the water elevation; upstream (U/S) & downstream (D/S) transition walls for smooth entry and exit; Energy dissipation arrangements; Impervious floor with U/S and D/S cut-offs to take care of uplift pressure and exit gradient; and Operating Gate System.

3.8.2.2 Hydraulic Design

a. Waterway

Linear waterway of the cross regulator without fall shall be so provided that the head loss does not exceed 5 cm, which is usually provided in overall planning of the cross regulator for canals. Head loss shall be calculated as 0.5 times the change in velocity head at cross regulator opening and in the canal on the downstream. Where the regulator is combined with a fall, the clear waterway would depend on the following conditions:

- For submerged falls, the ratio of tail water over crest to head of water over the crest should be greater than 0.8; and
- In case of free falls, the discharge per unit length over the crest should be equal to or greater than that required for available loss of head and the required value of the full supply depth downstream.

The ratio of clear waterway to designed bed width downstream should not be less than 0.5 although it has to be fixed keeping the requirements of setting the crest in accordance with total head loss available. The number of bays in canal may be kept odd from aesthetic reasons and to avoid a pier in the centre of the canal. This would help in better check over centre line of the canal because of direct visibility.

b. Crest Level and Width of Bays

Crest level and width of ways of the regulator shall be worked out using equation for free fall and submerged fall as per condition using the respective coefficient of discharge. The Crest should be kept at U/S canal bed level in case of lined canal and minimum 0.15m high to U/S bed level in case of unlined canal but not higher than 40% of U/S full supply depth. For discharges above 10 cumec, downstream glacis should have a slope of 2:1. The crest width shall be minimum 2/3*H, where H is the head over crest. The radius joining the crest with U/S glacis should be kept equal to H and for joining with D/S glacis should be 1.5H. For discharges lower than 10 cumec, the slope of d/s glacis shall be kept 2.5:1 The U/S glacis shall be entirely of a circular curve without any straight portion. Slope of U/S glacis should be in between 1:1 to 2:1.

c. Cistern and Cistern Level

Canals are to be operated on volume control concept, with a series of pools. Sufficient water depth will be available D/S of the gate. Hence for various gate openings available tail water depth would be much more than required for a perfect jump. Therefore, only submerged jumps will occur. However, during initial filling of canal, when there is no water D/S of gate, energy dissipation is required for a discharge up to which submerged jump will occur. Difference in total energy lines between U/S and D/S and unit discharge over the crest should dictate the sequent depths. The Stilling basin is designed according to USBR basin type based on the Froude's number of incoming flows. The basin appurtenances include chute blocks, basin blocks and dentated sill should be designed accordingly. The minimum cistern length should be provided as per hydraulic design considering jump formations and may extend in the D/S impervious floor.

3.8.2.3 Cut-off Walls

Cut offs should be provided at the end of U/S and D/S floors for safety against scour, undermining and exit gradient. U/S Cut-Off shall be provided at start of impervious concrete floor with a depth of maximum of the depth required for "R" scour depth consideration (1.25R) and "d" depth of flow (d/3+0.5 & 0.69√d).
D/S Cut-Off shall be provided at end of D/S impervious concrete floor. The depth of D/S cut-off wall should be the maximum of the depth required for "R" scour depth consideration (1.5R) and "d" depth of flow (d/2+0.5 and 0.69√d). Minimum depth of cut-off in U/S and D/S shall be kept 1.0m and 1.5 respectively below corresponding floor level. The minimum thickness of cut-off should be 0.3m & fillets of minimum 0.15 m X 0.15 m size at the junction of cut-off with the floor.

3.8.2.4 Exit Gradient

The structure should be checked for safe exit gradient in accordance with accepted theories and adequate length of floor and D/S cut-off wall should be provided for safe values of exit gradient. An exit gradient of 1 in 6 allowable for fine sand has been taken for safety considerations.

3.8.2.5 Length of Impervious Floor and Uplift Pressure

The total length of impervious floor is taken from U/S end to D/S end of floor. Optimum length of floor has been worked out considering different depth of D/S cut-off and quantities of concrete involved therein. Uplift pressures should be worked out according to Khosla's theory for permeable foundation and 100% uplift pressure should be allowed for working out the thickness of impervious floor. If rock is available in foundation, creep length shall be worked out and should be safe as per lane's weighted creep theory. Where considerable amount of seepage is probable, cross drains of selected graded gravel (inverted filter) with pressure relief valves should be provided in the concrete floor below the cistern. The benefit of release of uplift pressure due to this may however be not availed of in design of floor thickness. The D/S floor should be designed according to unbalanced head at particular section. The minimum thickness of U/S floor should be 0.3 m for discharge < 1.5 cumec and 0.6 m for >1.5 cumec.

3.8.2.6 Transitions

Transitions are used to provide a connection with the canal section both U/S and D/S of the structure. Straight warped transition walls should be provided with minimum splay of 2:1 in U/S and 3:1 in D/S at full supply level. Top of wing walls (U/S and D/S) shall be kept at respective top bank level. The warped transition walls should be designed from vertical to 1:1 slope. Figure 3.20 shows general features of a regulation structure

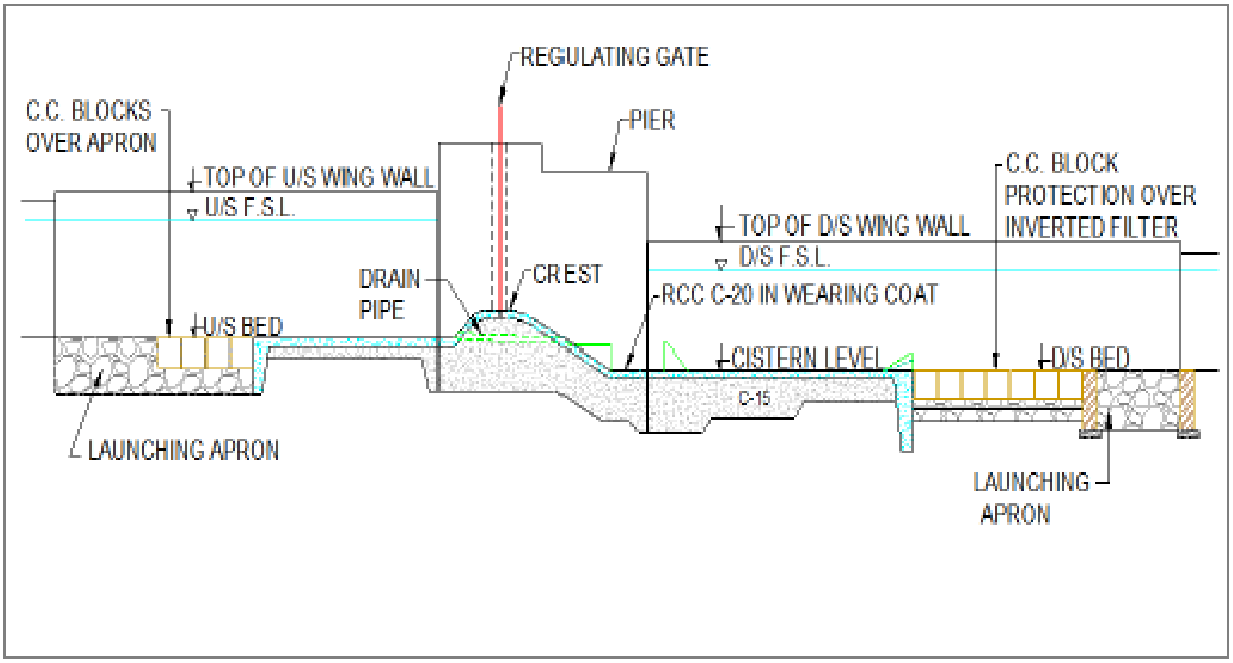

Figure 3.20: Regulating Structure (Cross Regulator)
Source: HJKY_TF and The SMEC Group, 2019

3.8.3 Canal/Drain Crossing (Culverts)

These are structures which convey a water course (a canal or a drain) underneath a road. Usually, the road crossings are planned to be provided at the crossing of the existing roads or cart tracks. The average distance between two road crossings should generally not be closer than 1.0 km. For the sake of economy, wherever possible, the Canal-Road crossings should be combined with irrigation structures like falls, cross regulators, cross drainage works etc, and in case of Drain-Road crossing it should be combined with fall.

3.8.3.1 Carriageway

Clear carriage width for all categories of classified road bridge on main, secondary and tertiary canals and drains shall be kept 4.2m for single lane culverts and 7.3m for double lane culverts as recommended in Nigerian road design manual.

3.8.3.2 Hydraulic Design

The hydraulic design of canal and drain crossing structures require the following basic requirements (principles) need to be met in the design of culverts.

- Culvert location in both plan and profile shall be investigated to avoid sediment build-up in culvert barrels.
- Culverts shall be designed to accommodate debris or proper provisions shall be made for debris maintenance.
- Material selection shall include consideration of materials availability, and the service life including abrasion and corrosion potentials.
- Culverts shall be located and designed to present a minimum hazard to traffic and people

The type of drainage structure specified for a particular location is often determined based on economic considerations. All the spans shall be usually kept equal, maximum span shall be generally not greater than 10 m.

3.8.3.3 Culvert Inlet and Outlet

The use of headwalls and/or wing walls with pipe culverts is generally dependent on factors such as the slope and stability of the channel. Pipe culverts can often be placed particularly on lower volume roads without headwalls or wing-walls.

a. Length and Slope

Fluming of the canal shall not be adopted at road crossings to avoid unnecessary head loss. In case of a multi span bridge, the clear water way shall be provided in such a manner that the flow velocity is maintained. The culvert length and slope should be chosen to assimilate the existing topography, and to the degree practicable. The culvert invert shall normally be aligned with the channel bottom and the skew angle and the culvert entrance shall match the geometry of the roadway. In practice, it has been found satisfactory to use a minimum slope of 0.005 and a maximum slope slightly steeper than the critical slope.

b. Culvert Alignment, Size and shape

As far as possible right-angle crossings shall be provided. However, the alignment of road crossing may not be changed when the road crosses the canal or drain at a skew angle of less than 30˚. The culvert skew shall not exceed 45° as measured from a line perpendicular to the centreline of a farm road. The culvert size and shape selected is to be based on engineering and economic criteria related to site conditions. 750 millimetres is the absolute minimum diameter that shall be used to avoid maintenance problems and clogging in case of pipe culvert.

c. Minimum and Maximum Velocities

When the approach velocity is supercritical, either a single barrel or special inlet-treatment is required to avoid adverse hydraulic jump formation. It is good practice to install one barrel at the flow line of the stream while other barrels are set slightly higher to reduce sedimentation.

Velocities used in the design of culverts depend on the amount of head loss available and the entrance and exit geometry. For design purposes, the maximum velocities should be taken as 1.5 m/s for culverts on irrigation canals and 3.0 m/s for culverts on drains. Maximum velocity at the culvert exit shall be consistent with the permissible velocity in the natural channel bed material.

d. Minimum Vertical Clearance

The lowest point of super structure may be kept at the top of bank level (TBL) of in case of canal crossing and top level of guide bunds of a drain. The minimum vertical clearance shall be equal to the free board as given in Table 3.27.

Table 3.27: Minimum Vertical Clearance

Discharge Q (m3/s)	**Vertical clearance (m)**	**Remark**
0 - 3.0	0.3	Gashua Irrigation
3.0 - 30.0	0.6	
30 to 300	0.9	
> 300	1.2	

Source: HJKY_TF and The SMEC Group, 2019

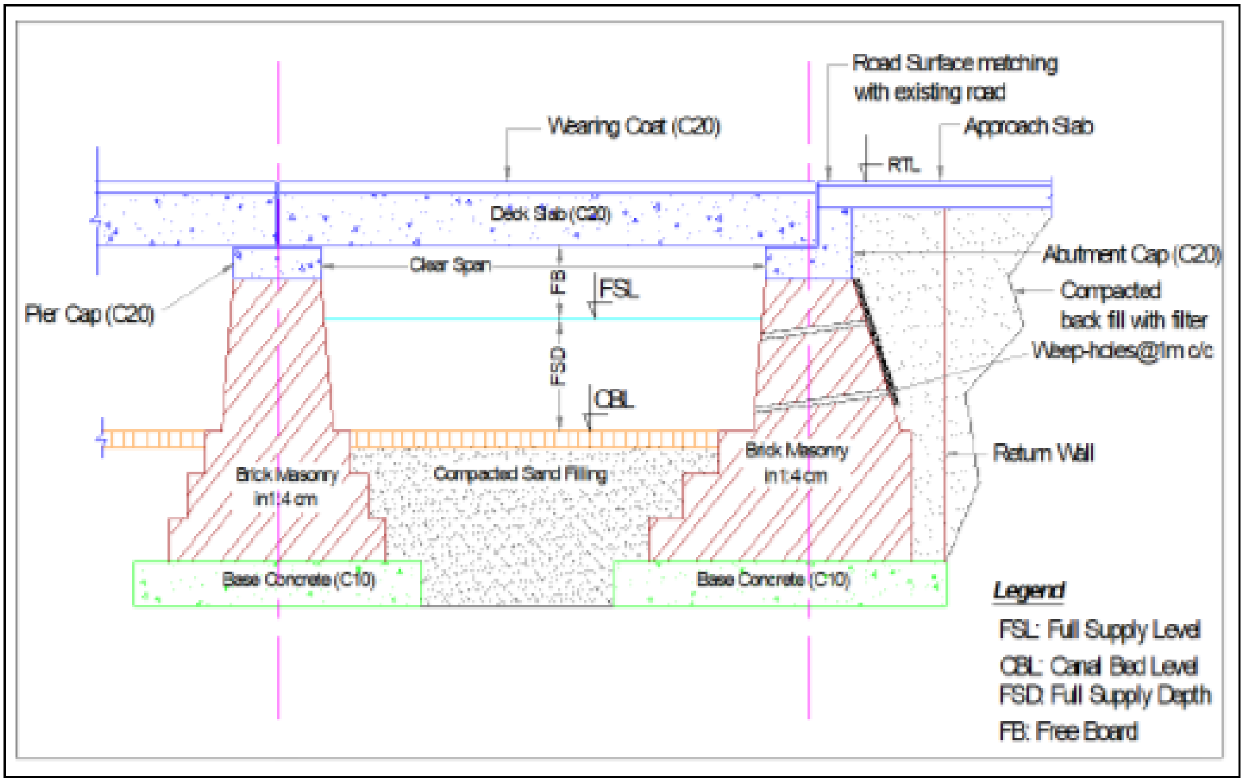

Figure 3.21: Main Canal Crossing structure
Source: HJKY_TF and The SMEC Group, 2019

3.8.4 Design of Drains

The drains are constructed with the objective to relieve excess water due to rainfall or irrigation from agricultural or other areas and thereby disposing the surplus water not required for agricultural or other operations. These drains may be artificial or natural, generally aligned along a valley lying between two ridges, except in some cases where ridges / watershed lines are cut to reduce the length of drains and/or to achieve the proper outfall conditions. The present practice of drain design has wide deviations, based on local conditions. The various parameters considered in design of drains are discussed in the below.

3.8.4.1 Alignment of Drains

Drains generally follow the drainage line that is the lowest valley line. As far as possible, the alignment of the main or outfall drain is in the centre of the area to be drained. If the alignment crosses any depressions, ponds or marshes, the drain should not pass through these, as apart from the difficulties in excavation, it affects the hydraulic performance of the drain. In such cases, it is preferable to

take the drain away from the depression or pond, and suitably connect it to the drain if it is required to drain the pond or depression.
In selecting alignments, care should be taken to see that as far as possible these do not pass-through village habitations. In the forced reaches, care should be taken to see that the embankments of the drains are not of an excessive height, in order to minimize the danger of flooding in the event of breaches in the embankments.
As far as possible, the alignment of the drain is such that the designed water level is below the natural surface level.

3.8.4.2 Design Frequency

The peak discharge values for 5-year and 10-year return period will be used for the design of the drainage of the agricultural lands and their drainage crossings, respectively. Therefore, a drainage duty in l/s / ha will be determined for 5-year and 10-year return period.

3.8.4.3 Design of Channel Section

For the design of channel section, the considerations for various parameters are given below:

a. Roughness Coefficient

Roughness in a channel mainly depends on the type of material and condition of channel. The values of roughness coefficient – *n* – for artificial and natural channels are as given in the ERA Drainage Design Manual (2002).

The value of n for field drains is adopted as 0.033 (maximum value of Type a.4 under excavated or dredged channels). For tertiary drains, secondary drains, primary drains and outfall drains the value of n is adopted as 0.030 (average of the normal and maximum value for Type a.4 under excavated or dredged channels).

b. Hydraulic Slope

The designed water level of the drain, as far as possible, is at or below the average ground level. Where it cannot be ensured, the designed water level is in no case more than 0.3 m above the average ground level at the starting point of the drain. The hydraulic slope is then determined adopting this stipulation and the criteria laid down for fixation of designed water level at outfall. The hydraulic slope is set so as to provide permissible velocities. The slope is calculated from the L-section, considering outfall conditions and the existing levels at various points of the drain. Other features, such as intercepting waterbodies, are also taken into account.

Variation in slope is done depending on the topographical requirements and critical velocity ratio.

c. *Velocity*

The drain is adequate to carry the designed discharge, and the velocity is non-silting and non-scouring, to be determined by Manning's formula. The maximum permissible velocity is determined by the soil type, the surface protection, the flow depth and the windings. Table 3.28 presents the maximum permissible velocities for different channel surfaces:

Table 3.28: Permissible Velocities based on Channel Surface Material

Channel Perimeter Cover	Permissible Velocity (m/s)
Bar clay	1.5–2.0
High natural vegetation cover	2.0–2.5
Planted vegetation cover	3.0–3.5
Small stones (25 mm)	1.5–2.0
Intermediate stones (40 mm)	1.6–1.8
Big stones (300 mm)	4.0–5.2
Big boulder (1,000 mm)	7.3–9.3

Source: HJKY_TF and The SMEC Group, 2019

d. *Side Slopes*

The side slopes are determined according to the soil type, the subsoil layer, and the surface and subsurface flow into the channel. For the PCA, in which the soil is a deep homogenous clay soil with low permeability values, the side slopes are not less than 1.5:1 (H:V).

e. *Cross-Sections*

Although deeper sections of the drain may be desirable, the width to depth ratio is selected such that the section is both hydraulically efficient as well as economical in excavation. In the case of drains with embankments, the berm width is equal to the depth of the drain, subject to a minimum of 1 m that is provided between the toe of the embankment and the section of the drain. The tops of the embankments are 0.50 m higher than the design water level. Wherever there is likelihood of a backing up effect because of floods in a river into which the drain outfalls, the top of the embankment is designed such that the flood levels because of back water conditions are accommodated within the section over which the minimum freeboard is provided. The section of drains is trapezoidal. Velocity and channel dimensions are worked out on the basis of Manning's equation:

ώ =1/ὲ 'Y2⁄3'Y21⁄2

Where:

V = velocity (m/s)
n = rugosity coefficient
S = slope (m/m)
R = hydraulic mean depth (A/P)

Where:

A = cross-sectional area (m2)
P = wetted perimeter (m)

The mean velocity (*V*) calculated with Manning's equation will be compared with the critical velocity (*V0*) calculated from Kennedy's equation given below. The Critical Velocity Ratio (*V/V0*) should be within the range of 1.0–1.2.

Where:

D = designed water depth (m)

f. Actual Discharge

In order to obtain the discharge of a drain, it is necessary to know the mean velocity of flow as obtained above, which when multiplied by the area of the cross-section of the drain in m^2 gives the actual discharge capacity in m^3/s.

3.10.4.4 Fixation of Water Level at Outfall

Whenever the drain is out-falling into a river, the designed water level is slightly higher than the dominant flood level. Where the topography permits, the designed water level can be above the highest flood level. However, if such a level results in flatter slopes or in designed water level becoming higher than the natural ground level, the designed water level at outfall is kept slightly above the dominant flood level. In such cases, there will be backing up in the drain when the river rises above the dominant flood level. Such occurrences, being infrequent and of short duration, can be tolerated. However, care is taken in determining the dominant flood discharge and the level.

3.8.5 Design of fall on Drains

Normally, no falls are provided in drains, except in rare cases where there is a sudden appreciable drop in the natural surface level or where the designed water level is likely to be more than natural surface level without provision of falls.

The length of crest is kept the same as the bed width of the drain. The crest is provided at u/s bed level of the drain. The u/s wing wall beyond crest is splayed at an angle of 30° from the axis of the drain and extended up to u/s line of the floor and then turned inside, up to a length equal to water depth or minimum of 1.0 m. The d/s wing wall is taken straight up to end of floor and then turned inside the bank by a distance 1.25 × water depth, with a minimum of 1.5 m.

3.8.5.1 Floor

The floor is designed for maximum water head, as obtained between crest and d/s bed levels of drain. The design of floor is done by Khosla theory, taking the value of safe exit gradient as 6. The u/s cut-off at the end of the floor is provided for maximum scour of 1.25 × *R*, where *R* is the normal scour depth calculated from the following formula:

Ὑ = 1.35 ή/Ὢ

Where:

q = discharge per m width for masonry work

f = silt factor, taken as 0.6

The minimum depth of u/s cut-off is kept as 0.8 m. The d/s cut-off is provided for scour of 1.5 × *R*, with a minimum of 1.2 m. The minimum thickness of floor on u/s is kept as 0.45 m, and, on d/s, as required by computation, with minimum of 0.5 m at the end.

3.8.5.2 Crest

The length of fall has been kept equal to bed width of drain and having its crest level same as of u/s bed of drain. The top width of crest *Bt* in meters has been kept as:

ὅ = 0.55√Ὀ1 ὂ

Where:

HL = drop (m)

D1 = depth of water on u/s (m)

The base width of crest at floor level is kept as *0.85* × *D*, where
D = drop + depth of cistern

3.8.5.3 Cistern

The length of the cistern is:

ὓ = 3.8Ὠῷ + 0.415 + Ὀὓ

Where:

dc = critical depth computed from

q = unit discharge per metre width

The depth of cistern is kept as *dc*/3. In drains having falls of more than 1.0 m and discharges greater than 3 m3/s, friction blocks are provided in two rows, staggered in plan. The dimensions are as follows:

Length of friction block = 2 × *dc*
Height and width = *dc*
Distance of first row from d/s face of crest = 1.5 × *dc*
Distance between blocks = 1.5 × *dc*

3.8.5.4 Protection

On u/s, cc blocks of 0.5 × 0.5 × 0.3 m are used at bed level of drain in a length of *d*, i.e., water depth with a minimum of 1 m beyond which toe wall is provided. On d/s of impervious floor, 0.5 × 0.5 × 0.3 m cc blocks, with 50 mm gaps between them, are laid over 300 mm thick graded filter. Further d/s of cc block / toe wall, loose protection is provided in a width of 1.5 × *df* for scour of 2 × *R* in accordance with standard design guidelines, where *df* is the scour below bed. The minimum size of apron is 2.0 m × 0.6 m, or as required.

3.8.5.5 Wing Walls

Wing walls are designed for earth pressure as per standard design guidelines. The testing is done under the following conditions:

- D.L. + dry earth pressure
- D.L. + saturated earth pressure

The wing walls are taken to the end of the floor on u/s and d/s side. Copper and PVC seals are provided in the construction joints between the floor and the wing walls.

3.8.6 Flood Protection Dikes

Flood protection dikes are provided to protect the irrigation area from inundations caused by over bank flooding of the Yobe River. The dikes are provided on the Gashua Irrigation side, as per the topography. The dikes are designed such that the failure of its embankment and foundation does not occur. The dike is designed to be safe and stable during construction and throughout its life. For safe design of the dike, the following basic design criteria are satisfied.

3.8.6.1 Alignment

There should be no opportunity for the free passage of water beyond the meander belt of the meandering rivers. As far as possible, curves in the alignment of the dikes are avoided. The location of the dike may be dictated by flood protection requirements, regardless of foundation conditions. A dike along the river is on an alignment at a suitable distance from the low water bed. If this is not possible erosion protection is placed along the dike to protect it against fast-flowing water.

3.8.6.2 Height and Freeboard

The design criteria for determination of the height of dikes include economic, engineering and social considerations, with the latter two prevailing, regardless of the economics. In practice, the greatest hazard involved in a dike system is that it provides full protection up to a certain flood stage, and no protection at all for higher stages.

The design height of the dike (*Hd*) is the sum of the design high water stage (*H*) and the freeboard (*Hf*). The constructed height includes an allowance for settlement (*Hs*), which depends on the foundation and materials used in construction. The actual design high water stage is based on the water surface profile. Based on the above criteria, the average design height of dike will be 1.5–2.0 m in the reaches along the farm area.

Adequate freeboard is provided such that the dike is not overtopped during occurrence of the worst floods and due to wave action. In addition, suitable allowance in the height of the dike is made to account for settlement. The minimum freeboard for dikes is 0.50 m.

3.8.6.3 Top and Bed width

The top width of the dike is governed by the requirements of the movement of maintenance equipment:

- A minimum top width of 1.5 m is planned for soil dikes designed to control water depths of 1.5 m or less, where there is no need for inspection and maintenance access.
- Top widths are at least 3.0 m where the dike is to be used for inspection and maintenance access
- Where the dike is designed to contain more than 1.5 m deep water, the minimum top width is 3.0 m.

The base width of the dike is determined by the seepage gradient. The phreatic line remains well within the downstream face of the dike, such that no seepage failure occurs. The normal value of the seepage gradient (or saturation line) for various types of soils is given in Table 3.29.

Table 3.29: Seepage Gradients for Various Types of Soil

Soil Type	Seepage Gradient (V:H)	Remark
Clay	1:3	Gashua Irrigation Project
Loams	1:4	
Coarse sands	1:6	
Fine sandy, silty materials	1:7	

Source: HJKY_TF and The SMEC Group, 2019

The flatter slopes are for coarse soils. The value of 1:3 (V:H) for clay is adopted in the design. The base width is such that there is a minimum cover of 0.60–1.0 m over the seepage gradient line. In addition, the dike embankment and foundation are designed to be safe against piping failure.

3.8.6.4 Side Slopes and Slope Stability Analysis

The dike is designed to have an economic section. As far as possible, the materials available at or near the location of the protection dike are used to reduce the cost. The section of the dike depends upon its height and the available materials. Generally, the preliminary dike section is selected by empirical formulae and compared to side slopes for homogeneous earthen embankments recommended by the USBR. For the type of local soil, a side slope of 2:1 (H:V) is adopted. Since the height of dike will be less than 5m no need of Checking for stability analysis.

3.8.6.5 Slope Protection

Proper slope protection is provided. If the dikes are likely to come in contact with high-velocity flowing water, either from rainfall or from the river, the waterside slope of the dike is protected against erosion, using grass cover, with due consideration to cost and suitability of effecting any of the options.
As much as possible, an adequate protective cover of grasses is established on all exposed surfaces of the dike where it is necessary to protect against erosion by rainfall and runoff on the dike. Thus, as the other types of protection are quite expensive, their use is restricted to short stretches against flowing water in a river or canal. The downstream slope and the top width (crest) are also protected against erosion due to rain and wind.

3.8.6.6 Design Procedure

It is standard practice to select a preliminary section of the protection dike and check whether it satisfies all the criteria mentioned in the preceding section. The preliminary section is selected based on experience considering various factors. If the section does not satisfy the safety criteria, it is modified and checked again. Generally, dike sections are selected by empirical formulae and appropriate theoretical considerations are applied in the design of the flood protection dikes. Fill for the dike, for reasons of economy, may be selected from nearby borrow pits, thus limiting the choice of materials. Earthen embankment sections recommended by the USBR are applied in the design of dikes.

Based on the above criteria, for a water depth of 2.5 m, the dike height is 3.0 m, considering a freeboard of 0.50 m. For this water depth, a top width of 3.0 m is provided and, considering side slopes of 2:1 (H:V) on both sides, the bottom width is 15.0 m. The seepage gradient line of 1:3 (V:H) is shown in Figure . Hence, there is a cover of 1.25 m over the seepage gradient line.

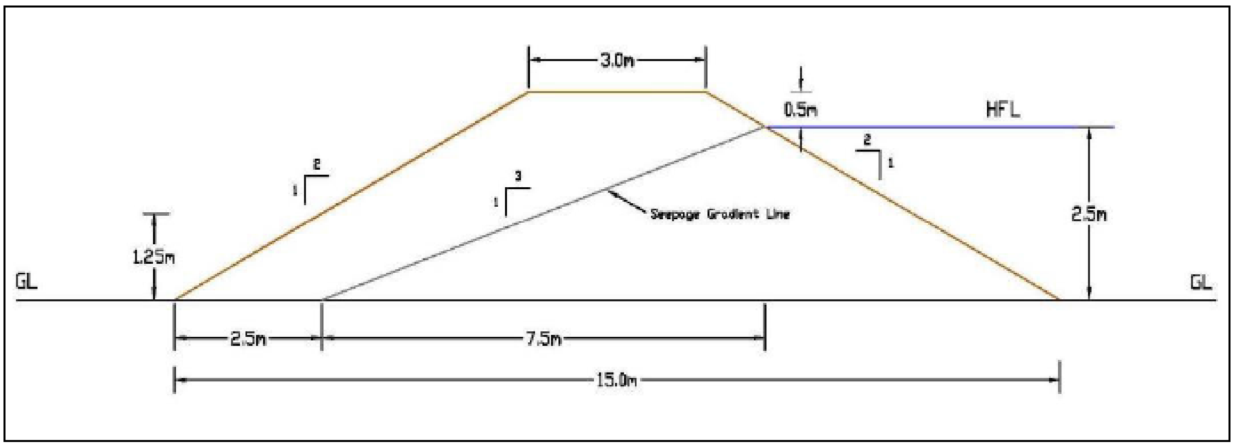

Figure 3.22: Typical design of a 3.0 m high flood protection dike

3.8.7 Profile of the Recommended Boreholes

The main water bearing strata in the basin are the sequence of continental sediments of lower Pliocene and quaternary sequences, three major aquifers are differentiated in the Chad basin i.e. the upper, the middle and lower. The upper aquifer consists of two overlying water bearing strata. The first is the phreatic Aquifer, contained within sand or clayey sand deposits it is mostly found around 50m in the Chad basin and is hydrologically connected to the Lake Chad, the second is the confined and often artesian Aquifer found at considerably deeper depth than the first. The second aquifer is the artesian type at a lower aquifer contain fossil and highly mineralized water. This lower aquifer consists of sediment deposits during the cretaceous period.

The Geophysical/Hydrogeological Report of the Site as prepared by CBDA (2021) recommended 60 borehole sites after profiling the site for suitable locations.

3.9 Characteristics of Yobe River

3.9.1 Hydrology of Yobe River

Yobe River is situated in a very flat ancient alluvial plain overlying the lake sediments of the Chad Formation. There are also sand dunes in the area which influence the path of the river. The drainage area to Gashua is 62150 km2 (Diyam, 1996a). The Yobe River flows into Lake Chad to which it contributed historically about 1% of the annual inflow (Mott Macdonald, 1993). Approximately, 43% of the water that flows into the wetlands (Hadejia, Katagum and Kafin Hausa) leaves the wetlands at Gashua.

The annual flow passing Gashua is characterized by the filling of the river channel and flooding of the adjacent Fadama land. The flood peak falls and with progressively greater lag time as it passes the gauge station at Geidam, Damasak, Gashagar and Yau.

a. Contribution from Jama'are, Hadejia and Komadugu Rivers to Yobe River

The historic (pre-Tiga Dam, 1974) ratio of contribution to the Yobe River at Gashua from the Jama'are and Hadejia Rivers was, and still is, a topic of debate in the basin. Schultz (1976) was the first to suggest a ratio of 45% from Hadejia River and 55% from the Jama'are River. The calculation was based on discharge at Foggo and Wudil, which are situated in the upstream part of the basin near the geological boundary between Basement Complex and the Chad formation. However, this computation was found to be simplistic by Diyam (1986 and 1996a). The Hadejia River system is different from Jama'are because it has non-returning, distributaries like the Marma channel.

Diyam (1996a) also estimated the annual contribution of the Hadejia River to the Yobe River in a situation where there are no dams. The calculation yielded an average contribution from Hadejia of 244 MCM, which is approximately 20% of the average annual runoff at Gashua. It is certain that there was a historic contribution and the people along the Yobe River are in need for additional water. The way forward is to determine how much water can be contributed by the Hadejia River to the Yobe River without jeopardizing other uses significantly. *The* SMEC Group (2019) *estimated a contribution under natural conditions of 13% by Hadejia and 87% by Jama'are to the flows at Gashua.*

Based on Diyam's estimates annual runoff at Hadejia of 850 MCM will lead to 238 MCM contributionto the Yobe River. In order to realise this, the current consultant found out that the annual losses at Hadejia Nguru Wetlands should reduce by 29%.

b. Comparison of Yobe River Flows at Gashua, Geidam, Damasak and Yau

There is a clear relation between the annual Gashua Discharge and the annual discharge downstream at Geidam, Damasak and Yau. If Gashua annual discharge is taken as 100% then roughly 70% arrives at Geidam, 45% at Damasak and 28% at Yau. This relation was valid from 1963 to at least 1985. It is not known if this relationship has changed since then. On average (1964-67, 1970-72, 1974, 1976-78 and 1984), 9.2% of the water that leaves the basement complex (Wudil and Foggo) reaches Yau. Presently, the Yobe River ends in a series of smaller pools and lakes which do not connect directly with the northern Lake Chad. Lake Chad has been receding since the early 1970s up to date. The impact of the Yobe River on this recession is probably limited because historically the Yobe River contributed only 1% of the total inflow into the Lake.

3.9.2 Anthropogenic Effects on the Yobe RIver

Anthropogenic effects are caused by human interventions in the river basin from large scale projects such as the construction of Tiga Dam and Challawa Gorge Dam but also local projects such as the irrigation schemes along the Hadejia, Jamaare and Yobe rivers and water extraction for local irrigation. Developments along the river system in the past largely affect the water distribution along the basin. The most important developments are:

i. Abstraction for drinking water is done through pumped systems. Kano City Water Supply installed 10
ii. intake stations along the Kano and Challawa rivers. At one of the locations a groyne has been constructed to raise the water levels to get sufficient head for the pumps. Downstream water intake for human consumption is often by groundwater abstraction by pumps or dug wells.
iii. Two irrigation schemes exist in the Hadejia basin, although both operate far below original design level. Thus, both water inflow and return drainage flow are higher than what is needed at the moment. Several small-scale irrigation systems, either formal or informal, are scattered over the river basins. Basically, everywhere where water becomes available new local initiatives pop-up. The so-called Fadama irrigation systems use either water by gravity, natural or manmade canals, flood recession farming, or small diesel pumps.
iv. Fishing ponds fill with the floods and are also used for water supply during dryer times.
v. Cattle grazing is seen throughout the wetlands, both in desert-like places and in irrigated areas. The latter is often a reason for tension between farmers and herdsmen.
vi. To date several dams have been built to store water: Watari Dam (100 MCM), Tiga Dam (1,200 MCM), Challawa Gorge Dam (900 MCM), Hadejia Barrage (11MCM), etc. The operation of the dams has resulted in much

reduced discharges during the wet season, and increased availability of water in the dry season; also, some 20% of the inflow into the reservoir is lost to net evaporation due to the high evaporation rates in the region. However, these dams did not impact the flows on Yobe River at Gashua significantly.

3.9.3 Effect of HNW on Yobe River Flows

The HNW (as shown in Figure 3.23) is one of the largest wetland in the basin. It covers an area of approximately 3500 km^2 including the floodplains of Jama'are and Hadejia rivers. The seasonal flooding of the wetland has an impact on the hydrographs along Yobe river (located downstream of HNW). 57% of the inflow is lost to evaporation and infiltration. This significantly reduces the downstream flow. Due to the flat area, the wetland/floodplain act as a strong buffer for floods. Peak flows are reduced and discharge might increase during flood recession. Further, due to the small slope flow velocities are slow which delay floodwaters arriving at the outlet near Gashua.

Due to the complex hydrological processes, HNW and the floodplains have been the subject of numerous scientific studies. The south-western part acts like a transit zone whereas the north-eastern part is characterized by threshold processes. According to different sources (satellite image studies, hydrological balance studies, hydraulic modelling studies) there are vast disagreements upon the actual area inundated during individual floods.

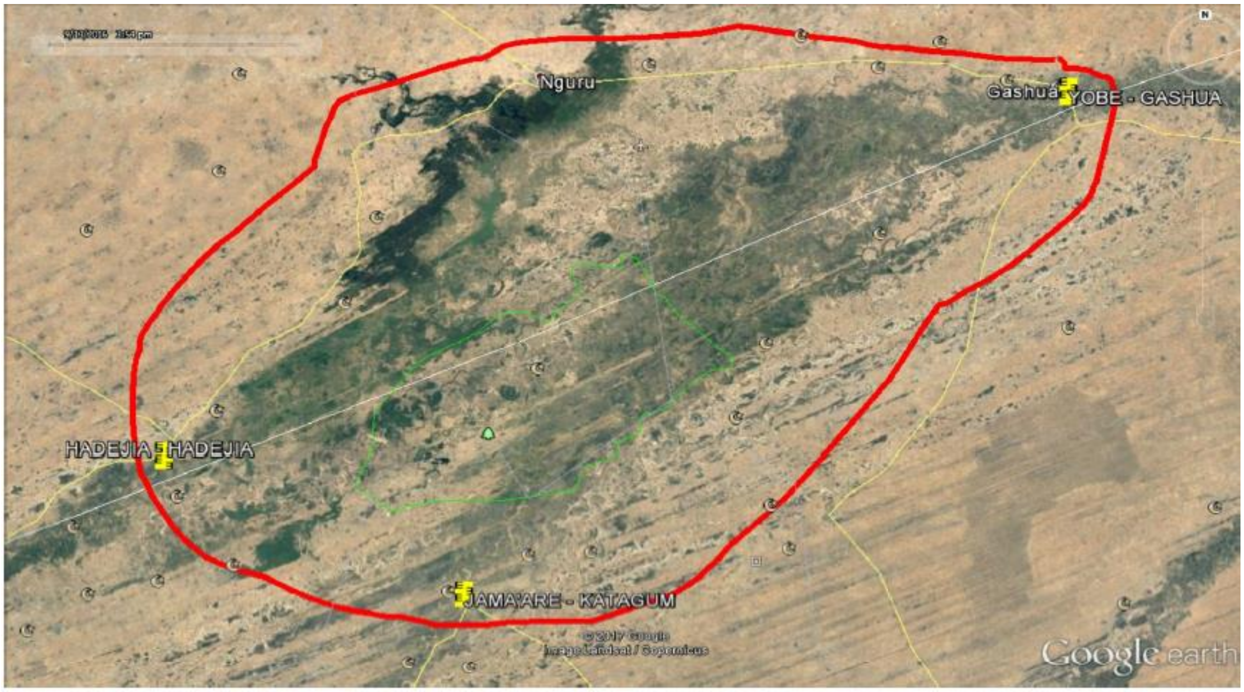

Figure 3.23: HNW wetland and Jama'are flood plains
Source: HJKY_TF and The SMEC Group, 2019

3.9.4 Hydrology and Water Availability Assessment

Hydrologically, Yobe sub basin is situated within the HJKY Basin and bounded to the East by Hadejia and Jama'are sub basins, to the south by Komadugu sub-Basin to the West by Lake Chad. Major tributaries of Yobe River are: Jama'are and Hadejia, and others in the upper part of the basin.

Yobe River is located on a very flat ancient alluvial plain overlying the lake sediments of the Chad Formation. There are also sand dunes in the area which influence the path of the river. The drainage area to Gashua is 62,150 km^2 (Diyam, 1996a). The Yobe River flows into Lake Chad to which it contributes, historically, about 1% of the annual inflow (Mott Macdonald, 1993). Approximately, 43% of the water that flows into the wetlands (Hadejia, Katagum and Kafin Hausa) leaves the wetlands at Gashua. The annual flow passing Gashua is characterized by the filling of the river channel and flooding of the adjacent Fadama land. The flood peak falls and with progressively greater lag time as it passes the gauge stations at Geidam, Damasak, Gashagar and Yau.

The water availability analysis was done based on historical records of flow of Yobe River at Gashua. The gauge station is located roughly 16.9 km upstream of the command area. The flow decreases in the downstream direction for it recharges the groundwater and due to anthropogenic effects, such as diversion for irrigation. The annual flow is assumed to decrease by 10%; the same factor has been used to deduce the flow hydrograph close to the command area. The available water for irrigation at the command site is shown in Figure 3.24, after provision of environmental and domestic demands.

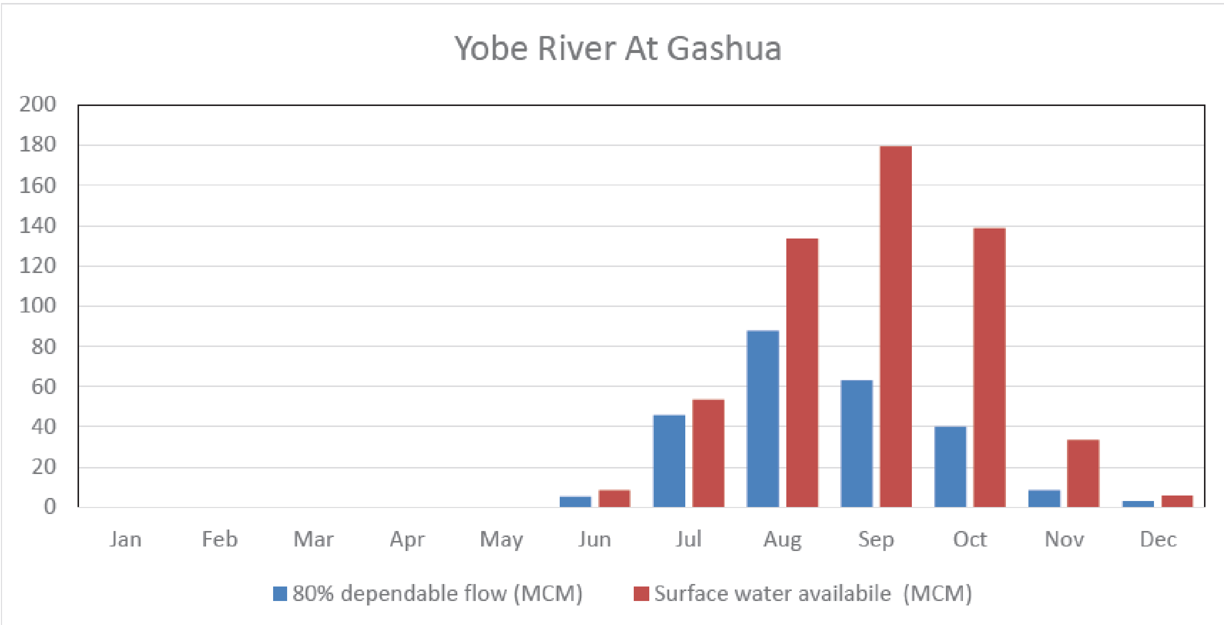

Figure 3.24: Available surface water for Gashua Irrigation Project (MCM)
Source: HJKY_TF and The SMEC Group, 2019

The water availability for irrigation has been computed as the balance of the 80% exceeded flow less all major uses (municipal water use, livestock water use, fishery water use) and the allocated environmental flow target.

3.10 Water Resources at Gashua

3.10.1. Naturalization of flows at Gashua

According to the SMEC Hydrology Reports of 2017 and 2019, flow naturalization was made possible through hydrologic modelling. WEAP-SHA model was developed for the whole basin and the effects of Tiga and Challawa dams using data from 1963 to 1973 before the construction of both dams and an assumption was made that the abstraction during this period was insignificant. Both dams were removed and the model was run from 1973 to 2016. The wetlands and floodplains were modelled as diversions where flows will be lost to groundwater recharge and filling the ponds on the floodplains.

However, due to the presence of the huge floodplains and wetlands upstream of the Gashua river gauge station, the effect was negligible on the mean flow. However, as shown in Figure 3.25, the observed flows at Gashua have lower peaks than the naturalised flow (WEAP-SH flows) most of the time. This decrease could be attributed to the routing effect of the wetlands and partially due to the upstream dams along Hadejia river. Moreover, increasing abstractions along the rivers and the ongoing siltation along the channels could result in reduction of peak flows.

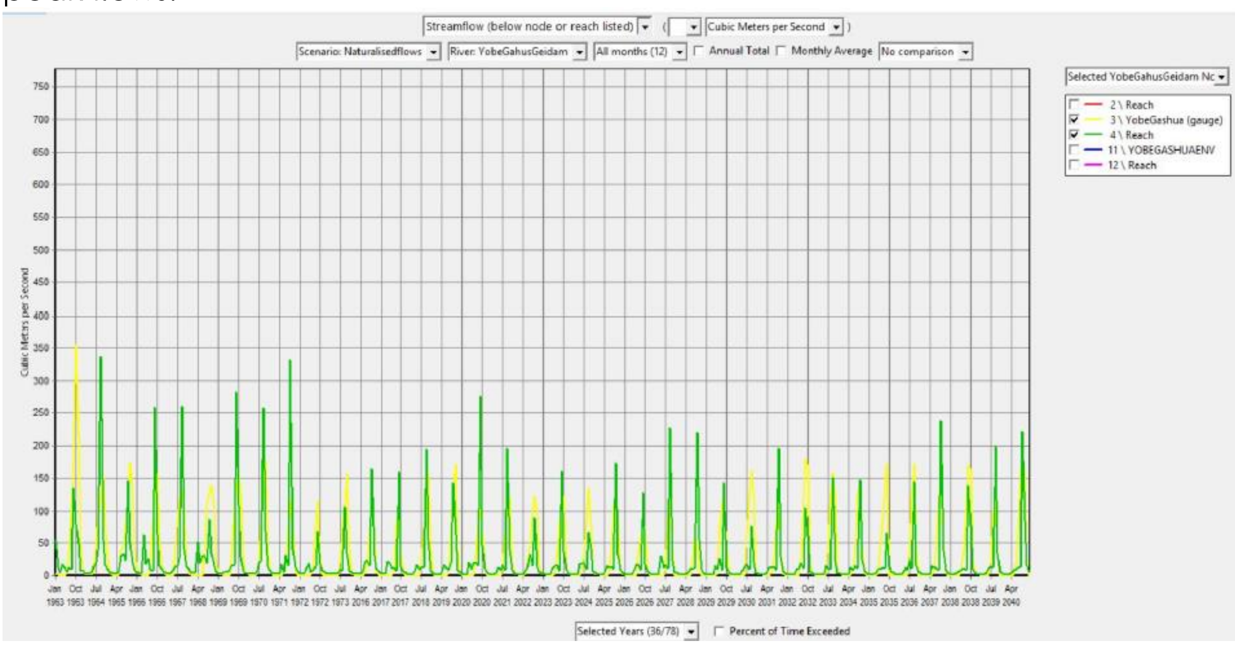

Figure 3.25: Comparison of naturalised and flow at Gashua RGS (1963 to 2040)

Source: HJKY_TF and The SMEC Group, 2019

The observed flows were used for analysing the water availability for irrigation and the model was used to predict the effect of the climate change.

3.10.2. Flow assessment at the proposed irrigation site

The water availability analysis was based on historical records of flow of Yobe River at Gashua. The gauge station is located roughly 16.9 km upstream of the command area. The flow decreases in the downstream direction because it recharges the groundwater and due to anthropogenic effects, such as diversion for irrigation. The annual flow is assumed to decrease by 10% and the same factor has been used to deduce the flow hydrograph close to the command area.

3.10.2.1 Annual Flow

Based on historical records from 1962 to 2004, the annual runoff has been plotted in *Figure* . The records have been obtained from Eu-WSSRP database. They are thoroughly checked for consistency and the unreliable data have been removed. The average annual runoff amounts to 978 MCM. The maximum runoff occurred in 1963 and amounts to 2234 MCM. 1963 is a very wet year in many parts of Africa from the experience of the hydrologist and it shows the consistency of the data. Moreover, the driest year is registered to be 1983, a year when most parts of Africa suffered from drought. The annual runoff was 343 MCM. The annual runoff shows a declining trend which could be due the increase evaporation losses at the upstream wetland in HNW.

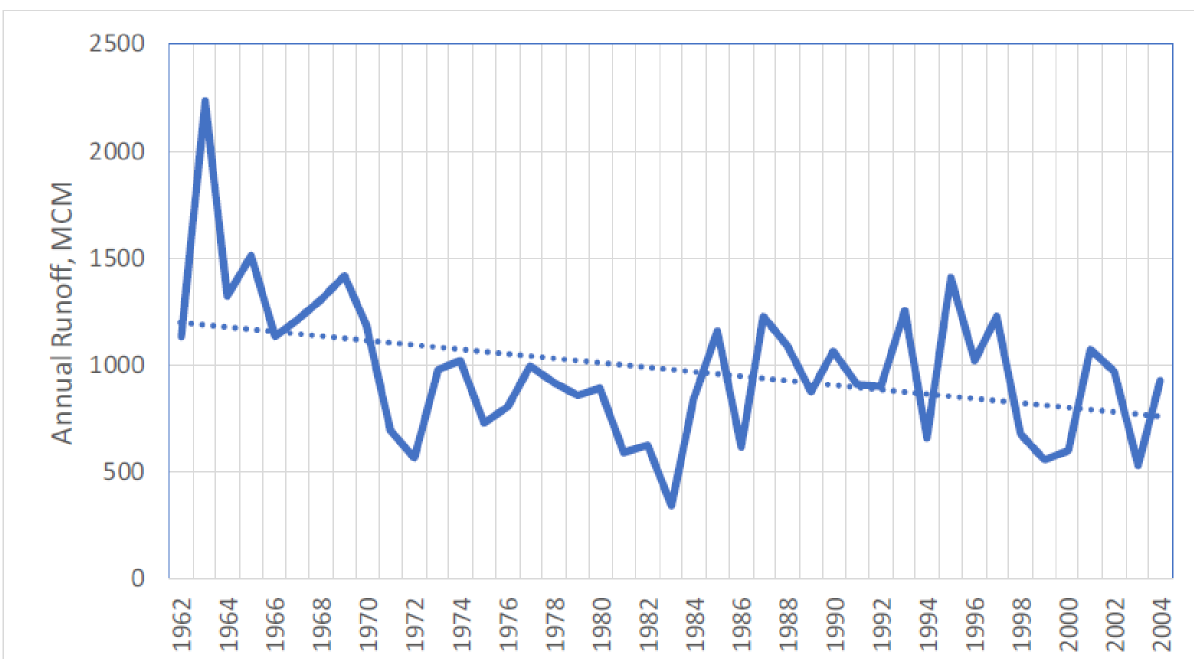

***Figure 3.26:* Annual Runoff available at Gashua Irrigation site (MCM)**
Source: HJKY_TF and The SMEC Group, 2019

The duration curve of the annual runoff (Figure 3.27) shows that the 80% dependable runoff amounts to 658 MCM which is 70% of the mean annual runoff. Hence, during dry years 658 MCM of runoff or less is expected to be available at the irrigation site.

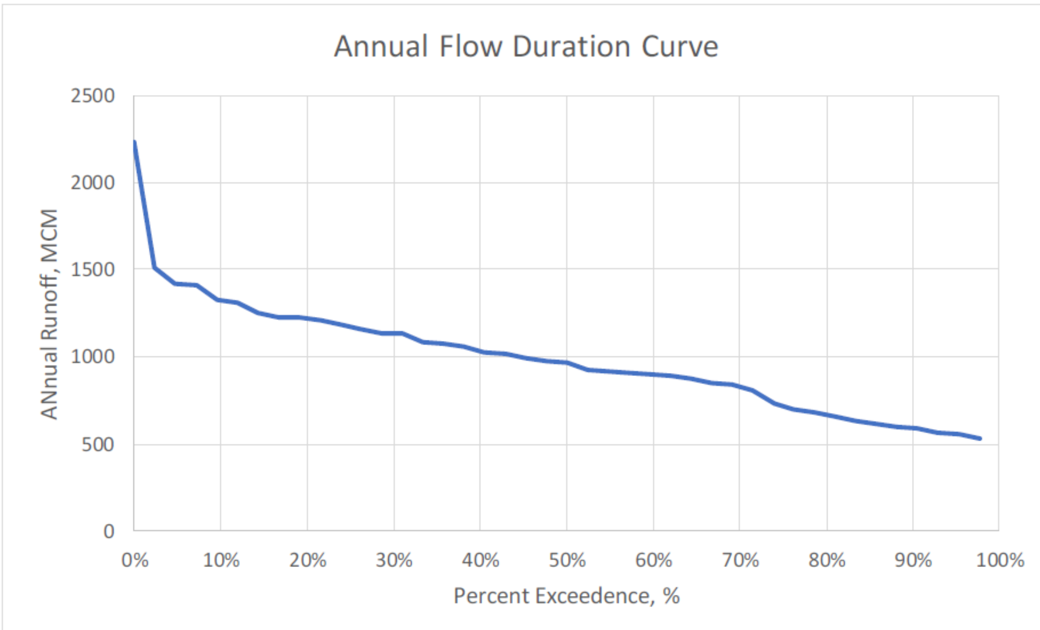

Figure 3.27: Annual Runoff duration curve
Source: HJKY_TF and The SMEC Group, 2019

3.10.2.2 Monthly Flows

The monthly runoff distribution (Figure 3.28) shows a strong seasonality with a unimodal character. The runoff varies from 0.3 MCM in April to a peak of 307 MCM in September. The river carries lean flows from January to May whereas the flow regime changes to flood in the months of August and September where the channel will overflow its banks.

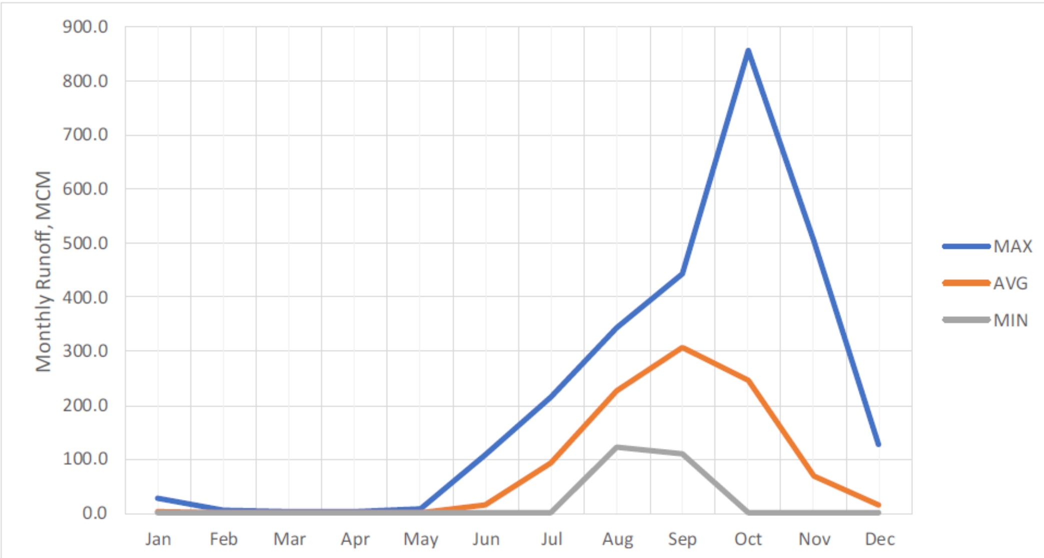

Figure 3.28: Long Term Monthly Runoff (MCM)
Source: HJKY_TF and The SMEC Group, 2019

3.10.2.3 Flow Duration curve

Flow duration curves were plotted for each month in order to extract the 80% exceeded flows. The flow duration curves were plotted on log-log paper in order to show the low flows clearly and the linear plot is found to be useful for extrapolation. The arrow on Figure 3.29 shows the 80% exceedance threshold.

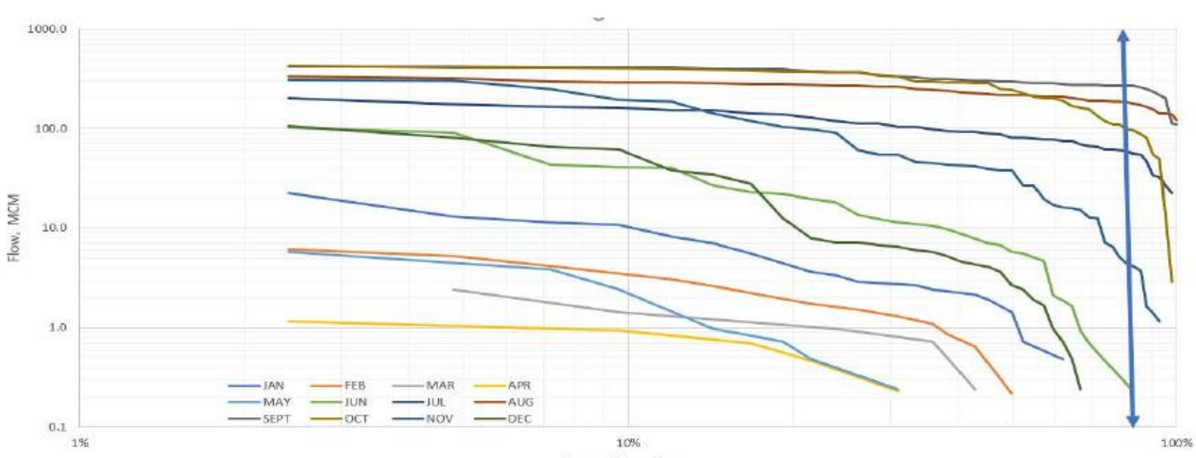

Figure 3.29: Flow duration curve for each month
Source: HJKY_TF and The SMEC Group, 2019

The 80% exceeded flows for each month are shown in *Table 10*3.30 along with the average and minimum month flows. Surface flow availability is scarce from December through to June and hence water users revert to water stored in the floodplain and ox-bow lakes where significant storage of surface water occurs.

***Table 10*.30: Long Term Monthly flow (80% exceedance)**

Month	Average Runoff (MCM)	Minimum Runoff (MCM)	80% exceeded Runoff (MCM)
Jan	3.3	0.0	0.250
Feb	1.1	0.0	0.080
Mar	0.5	0.0	0.084
Apr	0.3	0.0	0.060
May	0.6	0.0	0.069
Jun	15.5	0.0	0.320
Jul	93.2	0.0	59.300
Aug	226.2	122.5	183.000
Sep	307.4	111.0	267.000
Oct	245.4	0.0	93.800
Nov	69.8	0.0	4.140
Dec	14.7	0.0	0.000

Source: HJKY_TF and The SMEC Group, 2019

3.10.3 Municipal, livestock and fishery water uses

Water uses prevail between Gashua and Geidam and these are estimated as shown in Table 113.31 based on NWRMP (JICA, 2013). 80% of these estimated might occur in Gashua town as it is the largest settlement between Gashua and Geidam. The monthly distribution is assumed to be the same throughout. Hence, the annual water requirement has been equally distributed in each month. The total monthly demand per month is 2.30 MCM. But this had to be reduced by 80% to account for a reduction in catchment size.

Table 11.31: Water Uses between Gashua and the irrigation site (2018)

Month	Municipal water use (MCM)	Livestock Water Use (MCM)	Fishery water use (MCM)
Jan	1.51	0.28	0.05
Feb	1.38	0.26	0.05
Mar	1.51	0.28	0.05
Apr	1.51	0.28	0.05
May	1.51	0.28	0.05
Jun	1.51	0.28	0.05

Jul	1.51	0.28	0.05
Aug	1.51	0.28	0.05
Sep	1.51	0.28	0.05
Oct	1.51	0.28	0.05
Nov	1.51	0.28	0.05
Dec	1.51	0.28	0.05

Source: HJKY_TF and The SMEC Group, 2019

3.10.4 Environmental Flow Target

The GEFC approach has been used to estimate the environmental flow requirements. GEFC defines six Environmental Management Classes where different levels modifications to the hydrographs are allowed. For this case EMC C has been recommended where moderate modification of the natural hydrograph is allowed. This results in environmental flow targets as shown in Table 123.32.

Table 12.32: Environmental Flow Targets

Month	Environmental flow target (MCM)	Environmental flow target (CMS)
Jan	0.27	0.10
Feb	0.24	0.10
Mar	0.27	0.10
Apr	0.00	0.00
May	0.00	0.00
Jun	1.04	0.40
Jul	5.89	2.20
Aug	43.66	16.30
Sep	114.31	44.10
Oct	96.69	36.10
Nov	23.07	8.90
Dec	1.07	0.40

Source: HJKY_TF and The SMEC Group, 2019

4.5. Water availability for irrigation

The water availability for irrigation has been computed as the balance of the 80% exceeded flow less all uses (municipal water use, livestock water use, fishery water use) and allocated environmental flow target.

Table 13.33: Surface water availability for Gashua irrigation

Month	80% dependable flow (MCM)	Municipal water use (MCM)	Livestock Water Use (MCM)	Fishery water use (MCM)	Environmental Flow target (MCM)	Surface water available for irrigation (MCM)
Jan	0.0	1.51	0.28	0.05	0.27	0.00
Feb	0.0	1.38	0.26	0.05	0.24	0.00
Mar	0.0	1.51	0.28	0.05	0.27	0.00
Apr	0.2	1.51	0.28	0.05	0.00	0.00
May	0.3	1.51	0.28	0.05	0.00	0.00
Jun	8.4	1.51	0.28	0.05	1.04	5.49
Jul	53.6	1.51	0.28	0.05	5.89	45.83
Aug	133.4	1.51	0.28	0.05	43.66	87.87
Sep	179.3	1.51	0.28	0.05	114.31	63.13
Oct	138.6	1.51	0.28	0.05	96.69	40.10
Nov	33.4	1.51	0.28	0.05	23.07	8.45
Dec	6.0	1.51	0.28	0.05	1.07	3.09

Source: HJKY_TF and The SMEC Group, 2019

3.10.5 Irrigation demand

The irrigation demand has been computed for 2000 ha of land. The assumed cropping pattern are shown in

Table 14.34. The peak season demand was computed to be 11.1 cms based on climate data from Diifa. However, this is subject to variation based on specific agronomy requirements.

Table 14.34: Crop pattern

Season	Crops	Percentage of land	Annual water use (m^3/ha)
Dry	Cereals	20	6991
	Soyabean	15	7008
	Vegetable	60	5842
Wet	Rice	85	12932
	Vegetables	10	3860
All season	Fruit	5	26501

Source: HJKY_TF and The SMEC Group, 2019

3.10.6 Flood estimates

Generally, water starts flowing at Gashua by the end of June. The discharge rises steadily until the beginning of October to 140 – 180 m^3/s after which it decreases to 80 to 90 m^3/s at Geidam (November), 50 to 60 m^3/s at Damasak (December) and 30 to 40 m^3/s at Yau (December/January). This slow progress of the discharge peak indicates that the river has a large storage capacity in, for example, oxbow lakes and floodplains. Thompson (1995) calculated the mean time interval between the passage of percentages of total annual discharge between Gashua and Geidam at 58 days, and between Geidam and Yau at 66 days.

The threshold discharge values above which the Yobe river starts spilling into the floodplain was estimated at 115 m^3/s for Gashua, 85 m^3/s for Geidam and 15 m^3/s for Yau (Diyam 1986, and 1996a). The mean (1964 - 1996) period during which overbank flow occurred at Gashua was between August 25th and October 12th. The frequently inundated floodplain area is approximately 232 km^2 between Gashua and Geidam, 154 km^2 between Geidam and Damasak and 58 km^2 between Damasak and Yau. About 936 km^2 of flood plain between Gashua and Yau is inundated only during high flows (IWACO, 1985).

The mean daily maximum floods at Gashua, Geidam, Damasak Gashagar, and Yau are 164 m^3/s, 134 m^3/s, 68m^3/s, 55m^3/s and 44m^3/s respectively based data from EU-WSSSRP. The annual daily maximum discharges could be subjected to frequency analysis. The record lengths vary from 5 to 42 years.

Flood frequency analysis has been carried out for flows at Gashua. The GEV distribution with Method of Moments parameter estimation have been deployed as the goodness-of-fit test (using KS) yields this distribution as robust. The frequency plot is shown in Figure 9.30.

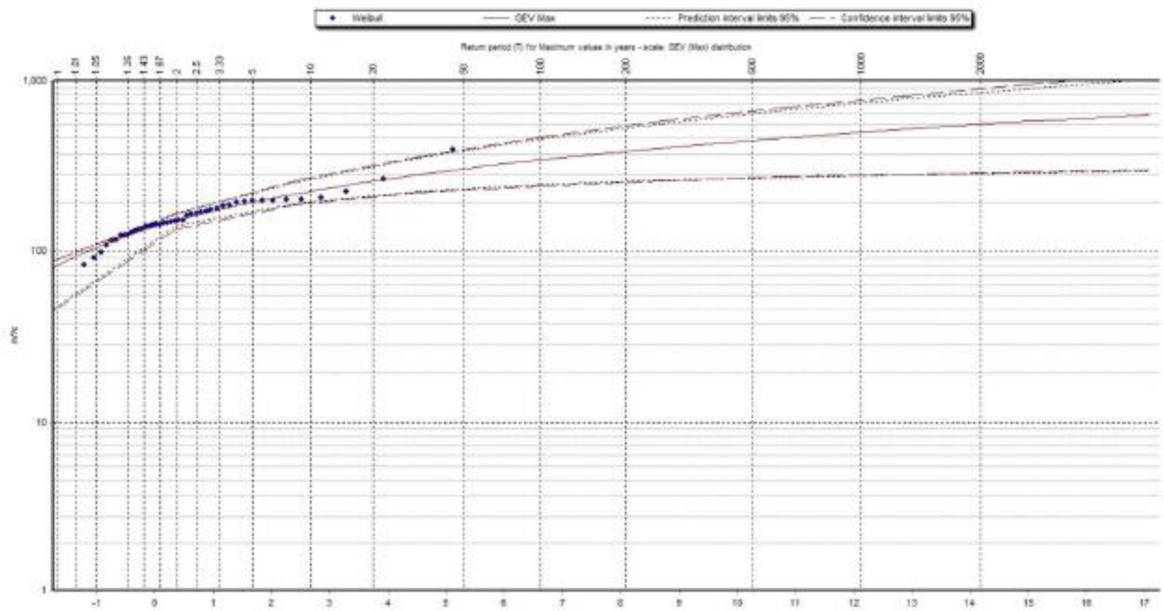

Figure 9.30: Flood frequency analysis (Gashua)
Source: HJKY_TF and The SMEC Group, 2019

The floods of various return periods are shown in Table 15.35. These floods should be reduced by as much as 10% as they are routed by the time the peaks reach the irrigation site.

Table 15.35: Flood Frequency analysis at Gashua RGS

Grid Point	**Distribution**	**Return Period**					
		2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Gashua	GEV/MoM	151	193	224	267	300	342

Source: HJKY_TF and The SMEC Group, 2019

There might be a slight reduction in flood magnitudes between the gauge station and the project site. However, this could be offset by an application of a frequency factor to the results of the flood frequency analysis. Hence, it is safe to adopt the same floods as at the gauge station for all practical purposes.

3.10.7 Effect of Climate Change

The calibrated WEAP-SHA model was used to predict the flow at Gashua from 2016 to 2040 as shown in Figure 10.31. The flows or runoff are forecasted to slightly decrease into 2040 based on the trend analysis. This is expected as any rainfall increases could be offset by an increase in potential evapotranspiration.

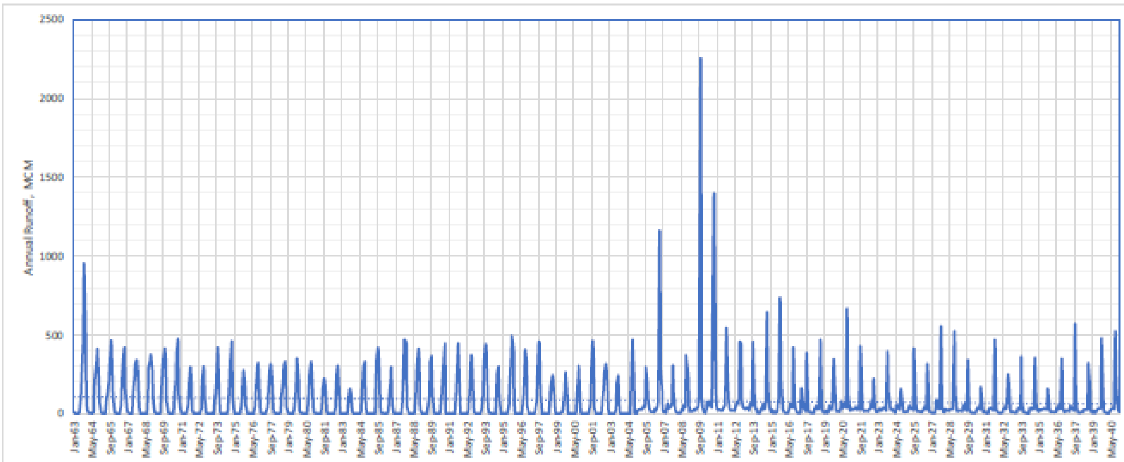

Figure 10.31: Monthly runoff forecast (MCM)
Source: HJKY_TF and The SMEC Group, 2019

The effect of the climate change has decreased the monthly flows overtime as shown in Figure 10.32. The volume of flow available for the year 2018 is less than the historical ones on which the water availability is based. Hence, further decreases in water resources availability is expected should be expected over time. More of the water resource should be abstracted from the floodplain storage, groundwater etc.

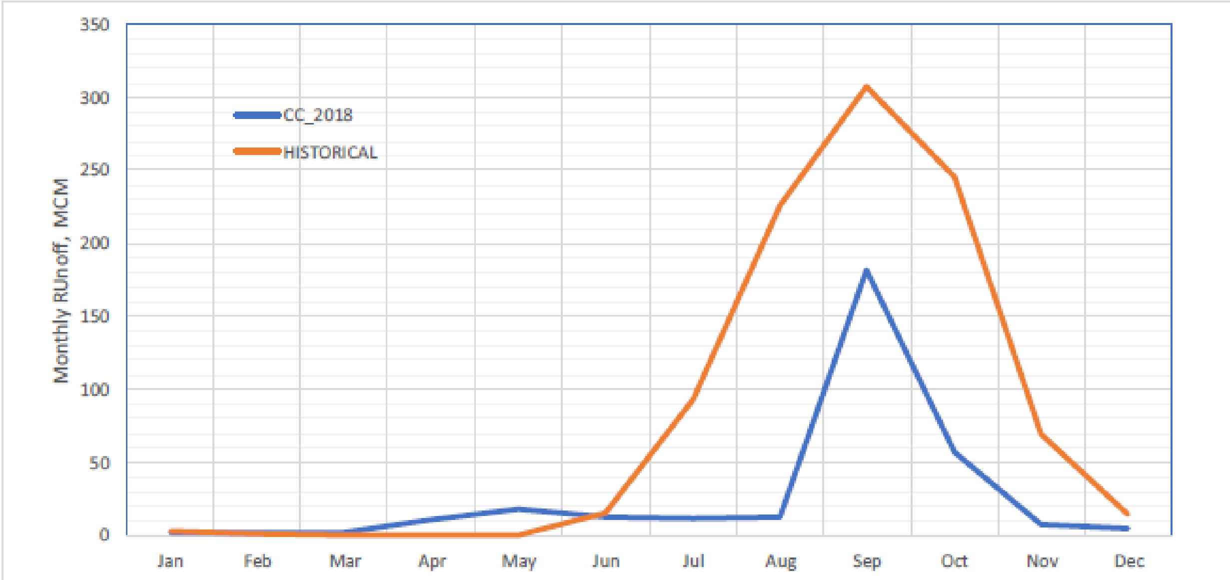

Figure 11.32: Effect of climate change on 2018 monthly flows
Source: HJKY_TF and The SMEC Group, 2019

3.10.8 Yobe River Water Quality

The thematic assessment assessed the influential physicochemical parameters of Yobe River (Gashua), Yobe state. Studies were conducted for a period of six months, from June to November 2015 using standard water analysis methods, to evaluate the potential and productivity of the river to enhance fish production for rural dwellers. The monthly variation of physicochemical parameters [temperature, conductivity, transparency, dissolved oxygen (DO), pH, ammonia, phosphorus (PO_2), alkalinity, free carbon dioxide (CO_2) and biochemical oxygen demand (BOD)] ranged from, 21-300 C, 0.38-0.74µS, 0.30-0.97m, 5-6.32mg/L, 6.8-7.8, 0.435-1.343 mg/L, 0.0070-1.7500 mg/L, 200-480 mg/L, 0.00030-0.00181 mg/L and 1.40-2 mg/L respectively. The results revealed that Yobe River contains high level of alkalinity, and other parameters were within the recommended range for a drinking water or tolerable limits for fish production. Hence, it is also of good quality for irrigation.

3.11 CROP AND PASTURE RECOMMENDED TO BE GROWTH IN THE PROPOSED GASHUA IRRIGATION SCHEME

Currently, the famers within the proposed scheme area cultivate crops like chili pepper sweet pepper, tomatoes, onion, carrot, cabbage, water melon, sorghum, okra, benny seed, maize, rice, wheat, millet and cowpea, while the pastoralist are purely into cattle, sheep and goat rearing.

3.11.1 CEREALS

3.11.1.1 Wheat (Triticum aestivum L.)

Wheat can grow on almost any soil, but for food growth it needs a clay loam texture, good structure and moderate water holding capacity are ideal for wheat cultivation. A soil ph of between 6.0 and 7.o, with a target ph of 6.4, is considered optimal for micronutrient availability and wheat growth.

Nutrient requirements

Nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S), iron (Fe), zinc (Zn), manganese (Mn), and copper (Cu) are considered important to for wheat cultivation.
Based on the soil textural class and the soil pH requirement, wheat will do well in sectors 8, 14.

3.11.1.2 Rice (Oriza sativa L.)

Soils with good water retention capacity with high amount of clay and organic matter are ideal for rice cultivation. Clay or clay loams are most suited for rice cultivation. Such soil is capable of holding water for long and sustain crops. Although pH of rice soil becomes neutral, it should be 5-8. Because, if soil is more acidic or more alkaline, it will need more time to become neutral. As a result, the rice plants will face unfavourable growing condition.

Nutrient requirements

N,P,K, Ca, Zn, Fe, Mg, S, Mn, Cu, and boron (B), chlorine (Cl), cobalt (Co), molybdenum (Mo), and nickel (Ni) are important nutrient for rice cultivation.

3.11.1.3 Maize (Zea mays L.)

Maize can be grown successfully in variety of soil ranging from loamy sand to clay loam. However, soil with good organic matter content having high water holding capacity with neutral Ph are considered good for high productivity.

Nutrient requirements

N, P, K, Mg, Ca, S, Fe, Zn, Mo, and Cl are considered important for the cultivation of maize.

Based on the soil texture class and the soil ph requirement for maize, it will grow best in 15 and 16

3.11.1.4 Sorghum (sorghum bicolor) (L.)Moench)

Both sorghum and millet do better in poor soil than maize. Even without fertilizer application, their deep rooting system help them to produce harvests in situation where maize will fail; their roots can penetrate up to 2 meters to reach moisture and nutrient while maize reaches down no more than about one meter. Sorghum and millet are often grown on lighter soils (sandy to loamy sandy) than maize. Sorghum is more tolerant of alkaline salts than other grain crops and can therefore be successfully cultivated on soil with a Ph between 6 and 7.5 sorghum can better tolerate short periods of water logging compared with maize. Soil with a clay percentage of between 10% and 30% are optimal for sorghum cultivation.

Nutrient requirements

N,P,K, Zn, S, Ca, and Mg are important for sorghum cultivation.

3.11.1.5 Pearl millet (pennisetum glaucum L)

Pearl millet also performs relatively well on sandy soil, under acidic soil conditions. In general pearl millet fits the same areas of adaptation as sorghum, except that it is somewhat more drought tolerant, and has a little earlier maturity it also tolerates low soil pH better than sorghum.

Nutrient requirements

N,P,K,S, Ca , Mg, Fe, Cu, B,Mn, Zn, Mo, and Cl are important for pearl millet cultivation.

3.11.2 GRAIN AND LEGUMES

3.11.2.1 Groundnut/peanut (Arachis hypogaea L.)

Groundnut plants needs well drained sandy loam or clay loam soil for better performance. The Ph of the soil should be between 5.5-7 with high fertility index.it is observed that heavy soil is unsuitable for cultivation because of difficulty in harvest and pod loss.

Nutrient requirements

N, P,K, Ca, Mg, S, Zn, Mn, Fe, Cu, B, Mo, Cl, Ni and cobalt (Co), sodium (Na), silicon (Si), selenium (Se),and aluminium (Al) are considered important for groundnut cultivation.

3.11.2.2 Cowpea (vigna unguiculata L. Walp.)

Cowpea performs well on a wide variety of soil conditions, but performs best on well drained sandy loams or sandy soil where soil Ph is in the range of 5.5 to 6.5.

Nutrient requirements

Nutrients especially N, P, K, S, Zn and Bo requirement for cowpea cultivation.

3.11.3 FRUITS AND VEGETABLES

3.11.3.1 Tomatoes (solanum Lycopersicon)

Tomatoes can be grown on soil with a wide range of textures, from light, sandy soils to heavy, clay soil. Sandy soils are preferable if early harvest is desired. Favourable Ph level is between 6.0-6.5 at higher or lower Ph levels micronutrients become less available for plant uptake.

Nutrient requirements

N, P, K, Ca, S, Mg, Fe, Mn, B, Zn, Cu, and Mo are considered important for tomatoes cultivation.

3.11.3.2 Chili pepper (capsicum)

Chilli can be grown in all types of soils, but the sandy loam, clay loamy and loamy soil with Ph of 5.5 to 7 are best suited for chilli. The soil must be well drained and well aerated. Acidic soils are not suitable for chilli cultivation. Better result will be obtained by growing in light soil should be between 6.5 and 7.5

Nutrient requirements

N, P, K,Ca,S,Mn,B,Zn,Cu, and Mo are important for chilli pepper cultivation.

3.11.3.3 Onion (Allium cepa L.)

Onions can be grown on many soils but medium textured soils (sandy loams) are preferred.

optimum Ph is in the range of 6-7 onions should be grown on friable soil, which contain high amounts of organic matter, have good water infiltration rates, and good moisture-holding capacity.

Nutrient requirements

N, P, K, Mg, S, B, and Zn are important for onion cultivation.

3.11.3.4 Carrots (daucus carota L.)

Carrots requires deep, well drained sandy loam soils with a friable texture. Carrots do not grow well in acidic soil below a Ph of 6.5-7-7.0 is ideal for carrot cultivation

Nutrient requirements

N ,P, K, S, Mg, Ca, Na, B, Zn, Mn, Fe, Cu, Al, and Mo considered important for carrot cultivation

3.11.3.5 Okra (Abelmoschus esculentus)

Soil for okra production can vary, with loams preferred, buteven heavier soils can produce well if the soil is drained well enough to prevent water-logging. Okra is tolerant of a wide range of soil Ph, but prefers soil with a ph between 6.0 and 6.8. if the soil ph is below 5.8, it should be limed to increase the ph to 6.0

Nutrient requirements

N, K, Ca, P, and Mg are considered important for cultivation

3.11.3.6 Cabbages (brassica oleracea)

Cabbages prefers a soil ph of 6.0-6.8 and it also needs fertile, well-drained moist soil with plenty of rich organic matter. It is grown in varied types of soil ranging from sandy loam to clay.

Nutrient requirements

N, P, K, Ca, Mg, S, and Zn are considered important cabbage cultivation

3.11.3.7 Watermelon (citrullus lanatus)

Water melons grow in many kinds of soil, but prefer light sandy, fertile loam types of soils for water melon, soil ph levels should be between 6.0-6.5

Nutrient requirements

N,P,K,Ca,Mg,S, and Zn are considered important watermelon cultivation.

3.11.3.8 Melons (Cucumis spp.)

Mellon grows best in a well-drained, sandy loam soil where they will receive a maximum amount of sunlight. If the soil is heavy (clay), add sand and organic matter such as rotted manure or compost to improve the soils drainage. A soil ph range of 6.2-6.8 is preferred for melons.

Nutrient requirements

N, P, K, Ca, B, Zn, S, and Mn are considered important melon cultivation

3.11.4 OTHERS

3.11.4.1 Sesame (sesamum indicum L.)

Sesame prefers slightly acid to alkaline soils (pH 5 - 8) with moderate fertility. Sesame is adaptable to many soil types, but it thrives best on well drained sandy loam soil. Sesame which has an extensive branched feeder root system, appears to improve soil structure. Sesame has a very low salt tolerance and cannot tolerate wet conditions.

Nutrient requirements

N, P, K, Mn, Zn, Ca, Mg, and Fe are important for sesame cultivation.

3.11.5 PASTURES

Permanent pasture and meadows are areas used for grazing domestic animals and cover large part of the land surface, ranging from sparsely covered wasteland to very intensively managed pastures and meadows. Grassland vegetation rarely consists of only one kind of grass, but is mostly composed of various grasses, a variety of herbs and often legumes, which supplies nutritious fodder for grazing animals.

3.11.5.1 A case for pasture production in the proposed Gashua irrigation scheme

Violent conflict between Fulani pastoralists and settled indigenous famers is one of Nigeria's most ubiquitous security challenges which have intensified in the age of climate change, with dwindling natural resource and land availability. This accounts for an increasing number of human and material losses, but also threatens unity among its regions. Thousands of Nigerians make a daily living from the sale, transport, processing, and marketing of livestock products including meat, milk skins and draught power, adding substantial value to Nigeria's livestock subsector. Nigerian cattle industry generates only 6.8billion USD of a potential 20 billion USD annually. The Fulani own over 90% of the nation's livestock population which accounts for one-third of agricultural GDP and 3.2% of the nation's GDP (Egbuta, 2018).

The major source of conflict between the Fulani pastoralist and settled indigenous farmers are land related issues, especially over grazing field, accounting for the highest percentage of the conflicts. As such, struggles over the control of economically viable lands cause more tension and violent conflict among these communities.

Over three years the project team will conduct field trials to 1) introduce improved soil cultivation and crop seeding techniques for quality fodder and forage crops seed production: 2) introduce equipment and management techniques for producing higher quality seed with lower cost and less effort. 3) Implement best mechanized system for reduced tillage. 4) Produce required quantity of breeders, foundation and certified seed of forage crops. 5) increase the production of high value seed by cooperatives and research stations .6) to implement best mechanized system for seed processing facilities.7) To generate technologies for upgrading seed processing/storage system. 8) Strengthen seed chain development schemes and help to maintain national standards. 9) To carry out training for professionals, field officers and farmer leaders in quality seed production. 10)Build capacity of cooperative for increasing trading of high-quality seeds; strengthen linkages with NGO/INGO'S and other stakeholders.

Project outcome will be disseminated throughout the country where conflict between pastoralist and famers occur through the extension network of fadama. The beneficiaries will be Fulani pastoralist and famers. Other part of the country where pastoralist move their animals to are expected to benefit from this project in future.

3.11.5.2 *Problem or opportunity*

Our herd is our life because to every nomad life is worthless without his cattle. What do you expect from us when our source of existence is threatened? The encroachment of grazing fields and routes by farmers is call to war (Hamesaidu, a pastoralist, Wuse, 2009-IRIN,2009). The continuing Fulani pastoralist; militancy for the survival of their cattle makes fierce struggle and violent conflicts with farmers inevitable. As farmers continuously encroach into the grazing routes, they leave the Fulani with no alternative to neither retreat no surrender. The traditional practice that focusses on the close integration between raising of livestock and enhanced farming have posed serious dialectics in the dynamic relationship between pastoralists and farmers in Nigeria and northern Nigeria in particular.

Conflict between pastoralist and famers have existed since the begging of agriculture and increased or decreased or decreased in intensity and frequency depending on economic, environmental and other factors. for example, increases in the ford sizes, due to improved conditions of the cattle, compelled the pastoralist to seek for more pasture beyond their limited range. climate change has constituted a great threat by putting great pressures on the land and thus provoking conflicts between them. However, improvements in human health and population have enhanced a much greater pressure on land. Since the 1980s therefore, there has been a marked expansion of cultivation of the fadama (riverine and valley-bottom) areas. This means that both the farmers and pastoralists have engaged in fierce struggle for access to such valuable lands which, more often than not, result in increased conflicts and violence.

The immediate benefits of this project will be to the Fulani pastoralist (representing over 90% of the nation's livestock population which accounts for one-third of agricultural GDP.

Nutrient requirement for pasture production

N, P, K, Mg, Ca, S, Fe, Zn, B, and Zn are important for cultivation.

3.12 CROP WATER REQUIREMENT

The crop requirement is the amount of water needed to compensate for the evapotranspiration loss from the crop field. Crop water requirement varies with time (Month) and space (Location) as well as crop condition. CROPWAT 8.0 was used to arrive at the crop water requirement.

It is proposed to use surface irrigation in the project area based on the prevailing topography soil conditions, cost and the skill of the local farmers. This method of irrigation is less expensive, simple to implement and easy to operate when compared with the sprinkler irrigation which has efficient water utilization and given higher yields. Furthermore, the sprinkler irrigation system is expensive and requires skilled operators.

3.12.1 Proposed Crops

Crop Production is greatly influenced by Climate (Rainfall, Temperature, Wind and Humidity) soil properties and fertility status, improved and new technologies, Management practices access to markets, availability of irrigation water, etc. Based on the soil Survey carried out and the current farming activities within the project area, the following crops have been proposed for production within irrigable area.

- **Cereals:** Wheat, Rice, Maize, Sorghum and Millet.
- **Vegetables:** Tomatoes, Chili, Onion, Carrot, Okra, Cabbage, watermelon, Melon.
- **Grains/Legumes:** Groundnut/Peanuts, Cowpea
- **Others:** Sesame

3.12.2 Crop Production

The dominant cropping system in the project area is mixed cropping and this practice by the farmers could be attributed to minimizing risk in crop production resulting from unexpected stoppage in rainfall during the critical growth stage of the crops.

The availability of water throughout the year will make crop production less dependent on seasons, as planting of crops can be done at any time without waiting for the rainy season. For example, crops such as **Rice**, **Maize** and

Vegetables are produced twice a year. Rice is one of the most cultivated crops, is now produced under rain fed between the month of June and October and under irrigations between the months of |November to April. The irrigation project in the area will boost crop production and enhance the income of the farmers. Farmers can produce two crops within a year with no risk of failure as water supply is guaranteed. Thus, attaining full intensity of double cropping (200%) when the project is fully developed is highly feasible.

3.12.3 Crop Pattern and Area

The Cropping pattern is often used when is a guarantee that within the farm acreage allotted to each crop to be grown would be strictly adhered to by farmers. And this cropping pattern is then used for the computation of crop water required and sizing of the irrigation system. In the absence of such assurance that farmers would abide by the proposed cropping pattern then expedient to design the system with the crop having the highest value of the water requirement.

Though this does not give the optimal design for the irrigation system it is however "safe" in the event all farmers decide to grow the crop with high water demand at the same time. Hence for this scheme the water requirement for the crop with the most water demanding from each crop group above would be computed and that with the highest water demand will be used in the design of the irrigation system capacity. The following crops have been chosen for each group; thus, for the (a) cereals group- rice; (b) vegetables group- Tomatoes; (c) grains/legumes group-cowpea and (d) others- Sesame

3.12.4 Reference Crop and Evapotranspiration (Eto)

The effect of Climate on crop water requirement is given by the reference or potential crop evapotranspiration, ET_0. The effect of the characteristics of the selected crops on the water requirements is given by the crop coefficient K_c. The relationship between ET_o and actual evapotranspiration (ETcrop) is thus:

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The estimation of the reference crop evaporation for the project area the FAO Crop water requirement Model (CROPWAT 8) was used the Climate/ET_0 module in Cropwat 8 calculates the Radiation and ET_0 data using the FAO Penman-Monteith approach. Table 3.36 shows the Climate/ ET_0 relationship.

Table 3.36: Evapotranspiration ET_0 (mm/month) for Lava Irrigation Project

MONTHLY ETD PENMAN-MONTIETH DATA								
Country: Nigeria **Altitude:** 332 m				**Station:** Gashua-Laba **Latitude:** 12.84°N **Longitude:** 11.14°E				
Month	Min Temp °C	Max Temp °C	Humidity %	Wind m/s	Sun hours	Rad MJ/m=/day	ET_0 Mm/Month
January	14.1	31.4	19	4.3	8.1	18.6	249.28
February	17.2	34.7	15	4.2	8.6	20.8	254.64
March	20.8	38.1	14	4.7	7.6	20.7	333.57
April	24.1	38.4	22	3.9	7.3	20.8	286.66
May	25.5	35.4	38	3.8	8.0	21.6	259.30
June	24.8	32.0	53	3.9	8.0	21.3	208.71
July	23.2	29.8	65	3.7	7.1	20.0	173.42
August	21.9	28.9	73	3.2	6.4	19.2	145.15
September	22.9	30.2	64	2.9	7.4	20.4	159.07
October	21.6	32.9	46	3.2	8.6	21.1	204.98
November	18.2	34.5	26	4.1	9.0	20.1	250.53
December	16.3	32.3	23	4.5	8.6	18.7	256.40
Average	20.9	33.2	38	3.9	7.9	20.3	2784.71

3.12.5 Crop Coefficient (Kc)

Crop Coefficients is a parameter used to take account of the crop characteristics on crop water requirements. There is a wide variation of KC values for different crops. This is mainly due to crop resistance of different plants to transpiration, differences in crop height, crop roughness, reflection, canopy cover, date of planting, rate of crop development, length of crop growing season and climatic conditions. Kc values of crops are usually determined experimentally and vary during the growing period of crops. It has minimum value during the initial stage, gently rises during the development, reaches maximum during the mid-season (Flowering stage) and declines during the late season (Maturity stage) of crops. The Kc Values and growing stages for the crops chosen to be used in computation of the crop water requirements for the sizing of the Gashua Irrigation scheme are shown in Table 3.37. It should be noted that over the years shorter duration variety of some these crops have been developed and such crops would require less crop water requirement. For sizing the irrigation system however, the varieties of crops with growth duration have been used.

Table 3.37: Growing Period and Crop Factor (Kc) for Crops

Crop	Growing Period (Days)	Kc			
		Initial	Crop Development	Mid-Season	Late
Rice	140	0.30	0.50	1.05	0.70
		30	40	55	15
Tomato	135	0.45	0.75	1.15	0.80
		30	40	40	25
Cowpea	110	0.35	0.75	1.10	0.50
		20	25	35	30
Sesame	110	0.35	0.75	1.10	0.25
		20	30	40	20

Source: FAO Irrigation and Drainage paper 56, 2006

3.12.6 Effective Rainfall

The effective rainfall is part of the rainfall which is effectively used by the crop after rainfall losses due to surface run off and deep percolation have been accounted for. The effective rainfall ultimately used to determine the crop irrigation requirements.

With the CROPWAT 8, the method used in the rain module for the computation of the effective rainfall is the United States Department of Agriculture (USDA) Soil Conservation Service method. Table 3.38 gives the effective rainfall using this formula.

Table 3.38: Effective rainfall data for Gashua Irrigation Project

MONTHLY RAIN DATA		
Station: Gashua Laba		
Eff. rain method	**USDA Soil Conservation Service Formula:** **Peff= Pmon * (125- 0.2 * Pmon)/125 for Pmon <= 250mm** **Peff = 125 + 0.1 * Pmon for Pmon > 250mm**	
	Rain mm	**Eff Rain mm**
January	0.0	0.0
February	0.0	0.0
March	0.0	0.0
April	4.3	4.3
May	15.9	15.5
June	76.0	66.8
July	161.6	119.8
August	250.6	150.1
September	89.4	76.6
October	13.0	12.7
November	0.0	0.0
December	0.0	0.0
Total	**610.8**	**445.7**

3.12.7 Soil Data

For the computation of the Crop Water requirement for the Various crops listed above, the soil data are also required. The soil type used and assumed to be predominant at the Gashua irrigation project area is sandy loam. The details of the soil are indicated in

Table 3.39.

Table 3.39: Soil data for Irrigation Project

SOIL DATA Soil name: Sandy Loam		
General Soil data:		
Total Available Soil Moisture (FC -WP)	290.0	mm/meter
Maximum rain infiltration rate	40	mm/day
Maximum Rooting Depth	90	centimetres
Initial Soil Moisture Depletion as % TA	0	%
Initial available soil moisture	290.0	mm/meter
Additional Soil Data for Rice Calculations:		
Drainage porosity (SAT – FC)	12	%
Critical depletion for puddle cracking	0.20	mm/day
Water availability and Planting	5	Mm WD
Maximum water depth	100	mm

3.12.8 Crop Evapotranspiration (ETc)

The value of the ETc and Crop water Requirement (CWR) are identical, whereby ETc refers to the amount lost through evapotranspiration and CWR refers to the amount of water that is needed to compensate for the loss. ETc can be calculated from the Climatic data by directly integrating the effects of crop characteristics into the Eto.

ETc = Eto × Kc

Where: **ETc =** Crop Evapotranspiration (mm/day)
Eto = Reference Crop Evapotranspiration (mm/day)
Kc = Crop Coefficient

The following tables show the CWR in mm for the various crops listed above using CROPWAT 8 programme.

Table 3.40: CWR of Rice (Planted on the 1/11 and harvested on 20/03)

CROP WATER REQUIREMENT							
ETo Station: Gashua-Laba		**Crop: Laba Rice 140**					
Rain Station: Gashua-Laba		**Planting date: 01/11**					
Month	**Decade**	**Stage**	**Kc Coeff**	**ETc mm/day**	**ETc Mm/dec**	**Eff Rain Irr.**	**Req.**
						Mm/dec	**Mm/dec**
October	**3**	LandPrep	1.05	7.55	75.5	1.1	285
November	**1**	Init	1.10	8.70	87.0	0.1	86.8
November	**2**	Init	1.10	9.41	94.1	0.0	94.1
November	**3**	Init	1.10	93.0	93.0	0.0	93.0
December	**1**	Deve	1.13	93.5	93.5	0.0	93.5
December	**2**	Deve	1.17	97.2	97.2	0.0	97.2
December	**3**	Deve	1.23	110.5	110.5	0.0	110.5
January	**1**	Mid	1.28	102.7	102.7	0.0	102.7
January	**2**	Mid	1.29	102.7	102.7	0.0	102.7
January	**3**	Mid	1.29	118.4	118.4	0.0	118.4
February	**1**	Mid	1.29	113.1	113.1	0.0	113.4
February	**2**	Mid	1.29	117.6	117.6	0.0	117.6
February	**3**	Mid	1.29	99.8	99.8	0.0	99.8
March	**1**	Late	1.27	132.0	132.0	0.0	132.0
March	**2**	Late	1.12	124.3	124.3	0.0	124.3
					1561.4	**1.2**	**1771.3**

Source

Table 3.41: CWR of Tomatoes (Planted on the 1/11 and harvested on 15/03)

CROP WATER REQUIREMENT							
ETo Station: Gashua-Laba		**Crop: GL Tomatoe**					
Rain Station: Gashua-Laba		**Planting date: 01/11**					
Month	**Decade**	**Stage**	**Kc Coeff**	**ETc mm/day**	**ETc Mm/dec**	**Eff Rain Irr.**	**Req.**
						Mm/dec	**Mm/dec**
November	**1**	Init	0.45	3.56	35.6	0.1	35.5
November	**2**	Init	0.45	3.85	38.5	0.0	38.5
November	**3**	Init	0.45	3.81	38.1	0.0	38.1
December	**1**	Deve	0.56	4.62	46.2	0.0	46.2
December	**2**	Deve	0.75	6.22	62.2	0.0	62.2

December	**3**	Deve	0.96	7.84	86.3	0.0	86.3
January	**1**	Mid	1.16	9.34	93.4	0.0	93.4
January	**2**	Mid	1.23	9.77	97.7	0.0	97.7
January	**3**	Mid	1.23	10.24	112.6	0.0	112.6
February	**1**	Mid	1.23	10.75	107.5	0.0	107.5
February	**2**	Late	1.23	11.15	111.5	0.0	111.5
February	**3**	Late	1.14	11.00	88.0	0.0	88.0
March	**1**	Late	1.01	10.56	105.6	0.0	105.6
March	**2**	Late	0.91	10.07	50.4	0.0	50.4
					1073.4	**0.1**	**1073.3**

Source

Table 3.42: CWR of Cowpeas (Planted on the 1/11 and harvested on 18/02)

CROP WATER REQUIREMENT							
ETo Station: Gashua-Laba		**Crop: GL Cowpeas**					
Rain Station: Gashua-Laba		**Planting date: 01/11**					
Month	**Decade**	**Stage**	**Kc Coeff**	**ETc mm/day**	**ETc Mm/dec**	**Eff Rain Irr.**	**Req.**
						Mm/dec	**Mm/dec**
November	**1**	Init	0.35	2.77	27.7	0.1	27.6
November	**2**	Init	0.35	2.99	29.9	0.0	29.9
November	**3**	Deve	0.53	4.49	44.9	0.0	44.9
December	**1**	Deve	0.86	7.13	71.3	0.0	71.3
December	**2**	Mid	1.14	9.41	94.1	0.0	94.1
December	**3**	Mid	1.17	9.59	105.5	0.0	105.5
January	**1**	Mid	1.17	9.43	94.1	0.0	94.3
January	**2**	Late	1.17	9.23	92.8	0.0	92.8
January	**3**	Late	1.03	8.58	94.4	0.0	94.4
February	**1**	Late	1.82	7.17	71.7	0.0	71.7
February	**2**	Late	0.64	5.82	46.6	0.0	46.6
					773.2	**0.1**	**773.1**

Source

Table 3.43: CWR of Sesame (Planted on the 1/11 and harvested on 18/02)

CROP WATER REQUIREMENT							
ETo Station: Gashua-Laba		**Crop: Gashua ava Sesame**					
Rain Station: Gashua-Laba		**Planting date: 01/11**					
Month	**Decade**	**Stage**	**Kc Coeff**	**ETc mm/day**	**ETc Mm/dec**	**Eff Rain Irr. Mm/dec**	**Req. Mm/dec**
November	**1**	Init	0.35	2.77	27.7	0.1	27.6
November	**2**	Init	0.35	2.99	29.9	0.0	29.9
November	**3**	Deve	0.50	4.27	42.7	0.0	42.7
December	**1**	Deve	0.79	6.52	65.2	0.0	65.2
December	**2**	Deve	1.07	8.83	88.3	0.0	88.3
December	**3**	Mid	1.19	9.78	107.6	0.0	107.6
January	**1**	Mid	1.19	9.61	96.1	0.0	96.1
January	**2**	Mid	1.19	9.48	94.8	0.0	94.8
January	**3**	Late	1.18	9.83	108.2	0.0	108.2
February	**1**	Late	0.84	7.34	73.7	0.0	73.4
February	**2**	Late	0.42	3.78	30.2	0.0	30.2
					764.1	**0.1**	**764.0**

3.12.9 Scheme and Conveyance Water Requirement (SWR)

The irrigation water to any irrigation scheme or conveyance command area can be calculated by adding up the requirements of each cropped area. Similarly, the irrigation water supply for each conveyance unit can be determined through CROPWAT *.0. The scheme module calculates the following: 1) Irrigation requirement for each crop scheme; ii) Net Scheme irrigation requirement; iii) irrigated as a percentage of the total area and; iv) irrigation requirement for the actual area. The following tables show the scheme water requirement (SWR) for the four crops chosen in order to determine how the Gashua irrigation infrastructure should be sized.

Table 3.44: SWR for Rice Crop at Gashua Irrigation Project

SCHEME SUPPLY												
Eto Station: Gashua-Laba						Cropping Pattern: Laba Rice 140						
Rain Station: Gashua-Laba												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Precipitation Deficit												
1. Laba Rice 140	323.9	330.5	256.3	0.0	0.0	0.0	0.0	0.0	0.0	285.4	273.9	301.1
Net Scheme irr. Req.												
In mm/day	10.3	11.8	8.3	0.0	0.0	0.0	0.0	0.0	0.0	9.2	9.1	9.7
In mm/month	323.9	330.5	256.3	0.0	0.0	0.0	0.0	0.0	0.0	285.4	273.9	301.1
In 1/s/h	1.21	1.37	0.96	0.00	0.00	0.00	0.00	0.00	0.00	1.07	1.06	1,.12
Irrigated area	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	100.0
(% of total area)												
Irr.req for actual area (1/2/h)	1.21	1.37	0.96	0.00	0.00	0.00	0.00	0.00	0.00	1.07	1.06	1.12

Table 3.45: SWR for Tomato Crop at Laba Irrigation Project

SCHEME SUPPLY												
Eto Station: Gashua-Laba						Cropping Pattern: GL Tomato						
Rain Station: Gashua-Laba												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Precipitation Deficit												
2. GL Tomato	303.7	307.0	156.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	112.0	194.7
Net Scheme irr. Req.												
In mm/day	9.8	11.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	6.3
In mm/month	303.7	307.0	156.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	112.0	194.7
In 1/s/h	1.21	1.37	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.73
Irrigated area	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	100.0
(% of total area)												
Irr.req for actual area (1/2/h)	1.13	1.27	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.73

Table 3.46: SWR for Cowpea Crop at Laba Irrigation Project

SCHEME SUPPLY												
Eto Station: Gashua-Laba						Cropping Pattern: GL Tomato						
Rain Station: Gashua-Laba												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Precipitation Deficit												
3. GL Cowpea	281.5	118.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	102.4	270.9
Net Scheme irr. Req.												
In mm/day	9.1	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	8.7
In mm/month	281.5	118.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	102.4	270.9
In 1/s/h	1.05	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	1.01
Irrigated area	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
(% of total area)												
Irr.req for actual area (1/2/h)	1.05	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	1.01

Table 3.47: SWR for Sesame Crop at Gashua Irrigation Project

SCHEME SUPPLY												
Eto Station: Gashua-Laba						Cropping Pattern: GL Sesame						
Rain Station: Gashua-Laba												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Precipitation Deficit												
4. GL Sesame	299.1	103.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.2	261.1
Net Scheme irr. Req.												
In mm/day	9.6	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	8.4
In mm/month	299.1	103.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.2	261.1
In 1/s/h	1.05	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	1.01
Irrigated area	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0

(% of total area)												
Irr.req for actual area (1/2/h)	1.12	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.97

The summary of the four crop characteristics chosen for the determination of the sizing of the Gashua Irrigation Infrastructure are presented in Table 3.48. For the purpose of design, the crop with the highest water requirement is utilized and that is rice with a peak requirement of 1.37lt/sec/ha in the month of February. This translates to ETc of 11.84mm/day.

Table 3.48: Summary of crop characteristics

Crop	Crop Duration	Irrigation Water Requirement (mm)	Peak Irrigation Requirement (lt/sec/ha)	Month of Peak Irrigation Requirement
Rice	140	1771.3	1.37	February
Tomato	135	1073.3	1.27	February
Cowpea	110	773.1	1.05	January
Sesame	110	764.0	1.12	January

Source

3.13 Project Work Plan

3.13.1 Duration of Study

In view of the details with which the assignment is to be taken, the project is to be concluded within a period of two months as shown in the work plan below.

Table 3.49: Proposed ESIA Work Plan

S/N	TASK/TIME	JUNE 2021				JULY 2021			
		1	2	3	4	5	6	7	8
1.	Desk studies • Literature review • Review of Existing Baseline Information								
2.	Preliminary Field Studies and Assessment • Reconnaissance Studies • Identification of Site Boundaries • Mapping Information • Screening • Scoping								
3.	Inception Report • Preparation • Production								
4.	Presentation of Inception Report								
5.	Detailed Field Studies • Physical (geology, soil types/strength, chemical properties, water bodies, landforms/profile etc.) • Ecological (flora and fauna) • Human (Socio-economic studies, heritage, geographic, history, culture, political and administrative boundaries etc.)								
6.	Analysis of Field Information								
7.	Impact Assessment Framework • Activities and Impacts (manufacturing, education, technology, agriculture, tourism or services sectors) • Impacts Nature and Type • Impact Magnitude • Receptor Sensitivity (Resilience and Value) • Impact Significance • Waste • Unplanned Events • Cumulative Impacts • Transboundary Impacts								
8.	Submission of Draft ESIAR								
9.	Draft ESIAR review (Client, Federal Ministry of Environment) and Presentation of Draft ESIAR								
10.	Preparation of Final Environmental and Social Impact Assessment Report								
11.	Submission of Final Environmental and Social Impact Assessment Report								

3.13.2 Deliverables

According to the Terms of Reference and Work Plan, the deliverables are shown in Table 3.50

Table 3.50: Deliverables

S/N	Deliverables	Milestone	Due Date
1.	Contract Signing and Commencement of Services	Week 1	8th June, 2021
2.	Submission of Inception Report	Week 2	17th June, 2021
3.	Submission of Scoping Report	Week 4	30th June, 2021
4.	Submission of Draft ESIA Report	Week 6	14th July, 2021
5.	Receipt of Comments on Draft ESIA Report	Week 7	21st July, 2021
6.	Submission of Final ESIA Report	Week 8	30th July, 2021

CHAPTER FOUR

4.0 DESCRIPTION OF PROJECT ENVIRONMENTAL (BASELINE)

The ESIA Process that has been employed for the project consists of several distinct but inter-related activities. The process involved the collection, collation, analysis, interpretation and presentation of information which was used to:

- Assess performance against a set of requirements or targets related to specific issues;
- Evaluate compliance with environmental legislation and corporate policies; and,
- Measure performance against the requirements of environmental management system.

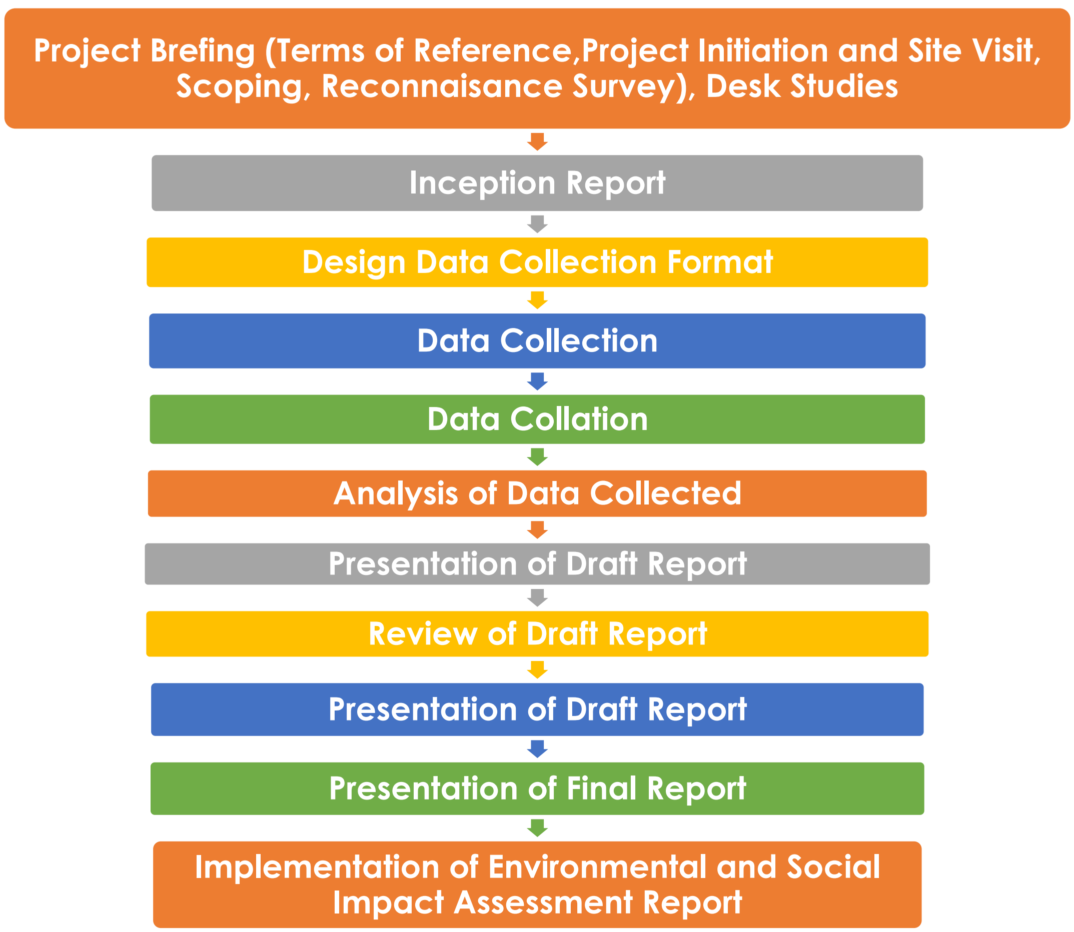

Figure 4.1: Environmental and Social Impact Assessment Process

Source: Envicons Team Consultant Limited, 2021

4.1 Preliminary Activities

4.1.1 Project Initiation and Reconnaissance Survey

Having signed the project contract, the consultant carried out a reconnaissance survey visit to the project site and has held an inception meeting with the project proponent. At the meeting, the consultant:

i. Presented its work plan,
ii. Reviewed the project with the client,
iii. Carried out Hazard Analysis for Project Implementation,
iv. Reviewed logistics and security,
v. Advised proponents (at project initial stage) of all information that may be demanded and the dates on which it will be required,
vi. Requested from proponents the following:
    a. Documents such as detailed project description;
    b. History of Client and intended engineering description for the proposed project;
    c. Detailed activities to be undertaken;
    d. Site survey maps of the project area;
vii. Had clear Understanding any other expectation from the consultant;
viii. Agreed with the client on the start-up date;
ix. Established reporting lines.
x. Undertook its site visit and data collection from Monday 5th July, 2021 to 9th July, 2021.

4.1.2 Desk Studies

The consultant has undertaken an exhaustive literature review of secondary data which has provided background information on the project and study area. Data sources included books, reports, journal articles, satellite imagery, maps, previous studies and reports on the project area and the internet.

4.1.3 Stakeholders and Community Consultation

4.1.3.1 Community Consultation

The community consultation was very inclusive as the various segments of the community were fully represented and engaged. Prior to the visit of the consultant, all five (5) settlements around the project site were informed of the exercise by the CBDA Programme Officer, Mal. Abubakar and because of the prior notice, the communities were fully mobilized for the exercise. At the time of visit to the communities, the men were waiting in front of the palace of the Lawan (Mai-Anguwa), while the women were in another compound waiting to be briefed and interviewed. It is worthy of note that most of the respondents did not go to their farms until after the exercise.

During the community consultations, the CBDA Executive Director (Engineering), stated the purpose of our visit in line with the proposed rehabilitation and expansion of the Gashua Irrigation scheme to each community visited. The communities were all excited about the project and prayed for blessing and success of the project, thereafter they granted permission to conduct the questionnaire survey on both the men and women of the community.

Plate 4.1: The CBDA Executive Director (Engineering) and the Consultant addressing the Lawan and members of RenaKunu Community.
Source: Envicons Field Survey, 8th July, 2021

For the questionnaire administration exercise, 10 enumerators (5 males and 5 females) were engaged. While the male enumerators attended to the male respondents, the female respondents attended to their female counterparts who were all assembled in one location. Two enumerators (Male and Female) were placed in each village. The male respondents were made up of the Chief, male farmers and youth. Similarly, the female respondents consisted of married and widowed women who are engaged mainly in dry and wet season farming.

4.1.3.2 Project Scoping Workshop

The consultant held a project scoping workshop at the NEAZAP Gashua Office Hall, Stakeholders at the meeting include the Bursari Local Government Vice Chairman and three (3) members of the Local Government Council, Client's Delegation, The Executive Director (Engineering) and Programme Officer of the Chad Basin Development Authority, the Monitoring Team and State Comptroller from the Federal Ministry of Environment, Yobe State Ministry of Environment and representative of the traditional rulers and members of the 5 identified communities, women were also included as part of the community representatives to ensure gender inclusion. The CBDA ED briefed the stakeholders on the purpose of the meeting before self-introduction of all participants. The consultant gave a brief background of the project, this gave an understanding of the context and scope of the project, relevance and importance of the project and impacts on the Project Affected Persons and Communities.

The consultant's address elicited positive responses, ranging from the desire for the implementation of the project due to the success of the first 100 hectares which has demonstrated great value as compared with their cultivation practices before the project. They were also excited about the prospect of farming throughout the season and the expected increase in crop production and its contribution to poverty alleviation. They expressed willingness to convert their farming methods from the traditional wet season farming to the advanced technology when implemented as most of them are beneficiaries of the 100Ha pilot project and are hoping for more land from the expanded project.

The local authorities express their eagerness to see the implementation of the proposed scheme stating that the development of irrigation farms is a priority of the Yobe State Government, they promised their full cooperation in all aspects of the project.

During the scoping workshop, a number of issues were raised and discussed. This allowed stakeholders to express their concerns and make recommendations about the project based on the agenda set for the consultation, the issues raised are summarized as follows:

1. **Acceptance and Support of the Project:** All stakeholders expressed their acceptance and support for the project. They expressed their gratitude to the government for its commitment to rehabilitate and expand the irrigation scheme.

2. **Herders and Farmers Clash:** When asked about challenges faced by the communities, they mentioned instances of Herders cattle eating up their crops. In response, the Local Government informed the stakeholders of government's proactive measures to forestall the crises by clearly demarcating the cattle routes in such a way that the farmers will not farm on them. This way, Encroachment on farms will be highly minimized and avoid seasonal conflicts thereby promoting peaceful co-existence. The government has also undertaken massive awareness to both the Cattle

Herders and the farmers within the communities, the communities have high expectations from the government to resolve the issues.

3. **Expectations from the Project:** The communities members believe that the introduction of the Irrigation farming is a booster to their agricultural activities especially during the dry season. This will also generate massive employment for the youth in the project affected communities and Gashua town.

4. **Inadequate Resources:** Representative of the communities' residents expressed concerns of inadequate improved seeds, insecticides, fertilizers, machinery and other equipment for farming. A concern noted by the consultant.

In all, the stakeholders believe that their communities, Yobe State and Nigeria at large will benefit from the proposed irrigation scheme.

Plate 4.2: A Cross-section of Stakeholders at the Scoping Workshop

Source: Envicons Field Survey, 8th July, 2021

Plate 1:3 The Consultant addressing Stakeholders at the Scoping Workshop
Source: Envicons Field Survey, 8th July, 2021

Plate 4.4: Women participating at the Scoping Workshop
Source: Envicons Field Survey, 8th July, 2021

Plate 4.5: The Consultant with the Bursari Local Government Vice Chairman and members of the Local Government Council, HJKY-TF Delegation, and Staff of CBDA, FMEnv and Yobe State Ministry of Environment
Source: Envicons Field Survey, 8th July, 2021

Plate 4.6: Group Photograph of Stakeholders after the Scoping Workshop
Source: Envicons Field Survey, 8th July, 2021

After the scoping workshop, the consultant and officials of CBDA, FMEnv and Yobe State Ministry of Environment paid a consultative visit to the Emir of Gashua at his palace, the consultant informed the Emir of the Project and the study being carried out. The Emir welcomed the delegation and applauded the team for their work so far and afterwards gave his blessings.

Plate 4.7: The Consultant addressing the Emir of Gashua during a Project Consultative Visit with Staff of CBDA, FMEnv and Yobe State Ministry of Environment
Source: Envicons Field Survey, 8th July, 2021

4.1.3.3 Stakeholder Involvement

Stakeholders' involvement shall continue across all stages of the ESIA study to ensure quality, efficiency and effectiveness. The following have been identified as critical stakeholders to be consulted on this project:

- Community Based Organizations (including women and youth organizations)
- Department State Service, Yobe State
- Faith Based Organizations
- Federal Road Safety Commission (FRSC) Yobe State Command
- Ministries of Water Resources, Environment, Justice, Agriculture and Natural Resources, Health and Human Resources, Works, Commerce, Trade and Industries, Information, Land and Solid Minerals, Transport and Energy, Humanitarian Affairs and Disaster Management.
- National Union of Road Transport Workers (NURTW)
- Nigeria Security and Civil Defense Corps (NSCDC) Yobe State Command
- Nigerian Television Authority (NTA), Yobe
- Non-Governmental Organizations
- Project affected Communities
- Project affected Local Government (Bursari Local Government Area)
- The Nigeria Police Force Yobe State Commands
- Yobe Broadcasting Corporation (YBC)
- Yobe State Controller, Federal Ministry of Environment (FMEnv)
- Yobe State Emergency Management Agency
- Yobe Television (YTV)

4.2 Socio-Economic Characteristics of the Project Affected Communities (PAC)

The socio-economic survey for the study was carried out in the five (5) communities within the defined catchment of 3km radius of the project site namely Garin Alkali, Jurgwaya, Mari, Laba and RenaKunu. Data was collected using structured questionnaire, interviews, active observation, focus group discussions, reports and statistics from Relevant Government Ministries, Departments and Agencies (MDAs). The survey ensured gender balance by targeting women within the communities through the engagement of female enumerators to improve access to the women. To ensure accurate data collection, the consultant deployed Online Data Kit (ODK) using the KoboCollect App on the mobile devices of enumerators, the data collected was uploaded to a central account, each submission was tagged with the geo-location and time of data collection.

Data such as historical background, existing population data, existing communal facilities and infrastructure within the study area were obtained through direct observation, interview and data supplied by CBDA.

Plate 4.8: The Consultant with Enumerators after their training before the field survey

Source: Envicons Field Survey, 8th July, 2021

Plat4.9: One of the female enumerators administering the questionnaire to one of the women of Mari Community
Source: Envicons Field Survey, 8th July, 2021

Plate4.10: Male Respondents waiting to provide their responses to the male enumerator at Mari Community
Source: Field Survey, 8th July, 2021

The scope of the socio-economic survey covered all 5 project affected communities (PACs), while Mari, Laba, Renakunu and Jurgwaya are within the catchment area, Garin Alkali was considered due to the presence of beneficiaries from the initial 100 hectares. From data collected from the Gashua project office of CBDA, the following is the population of the 5 communities surveyed.

The target of the questionnaire survey was the representative of households and a sample size of 10% was initially drawn as a representative percentage; however, given the mobilization of members of the communities by the CBDA and

community heads at Mari, Laba, Renakunu and Jurgwaya, most respondents were available for the survey. In the case of Garin Alkali, farmers within the community were targeted, therefore sampling was not applied instead the survey captured majority of the population as shown in
Table 1.

Bursari Local Government had a population of 139,782 as at 2006 according to the 2006 National Population Census. Using the national growth rate of 3.5 %, 2021 projections put its population at 234,184. However, the 2006 Census only gave aggregate figures, only going as low as the Local Government Level, therefore, the population of communities and wards could not be determined as is the case of the PACs. The consultant in conjunction with the CBDA Programme Officer who has been working with the communities has instead estimated the population of the PACs as presented in
Table 4.1.

Table 4.1: Estimated Population of Project Affected Communities

S/N	COMMUNITY	POPULATION	NUMBER OF RESPONDENTS
1	Mari	200	60
2	Laba	150	46
3	RenaKunu	250	76
4	Jurgwaya	300	129
5	Garin Alkali	1100	160
	Total	**2000**	**471**

Source: Envicons, CBDA, 2021

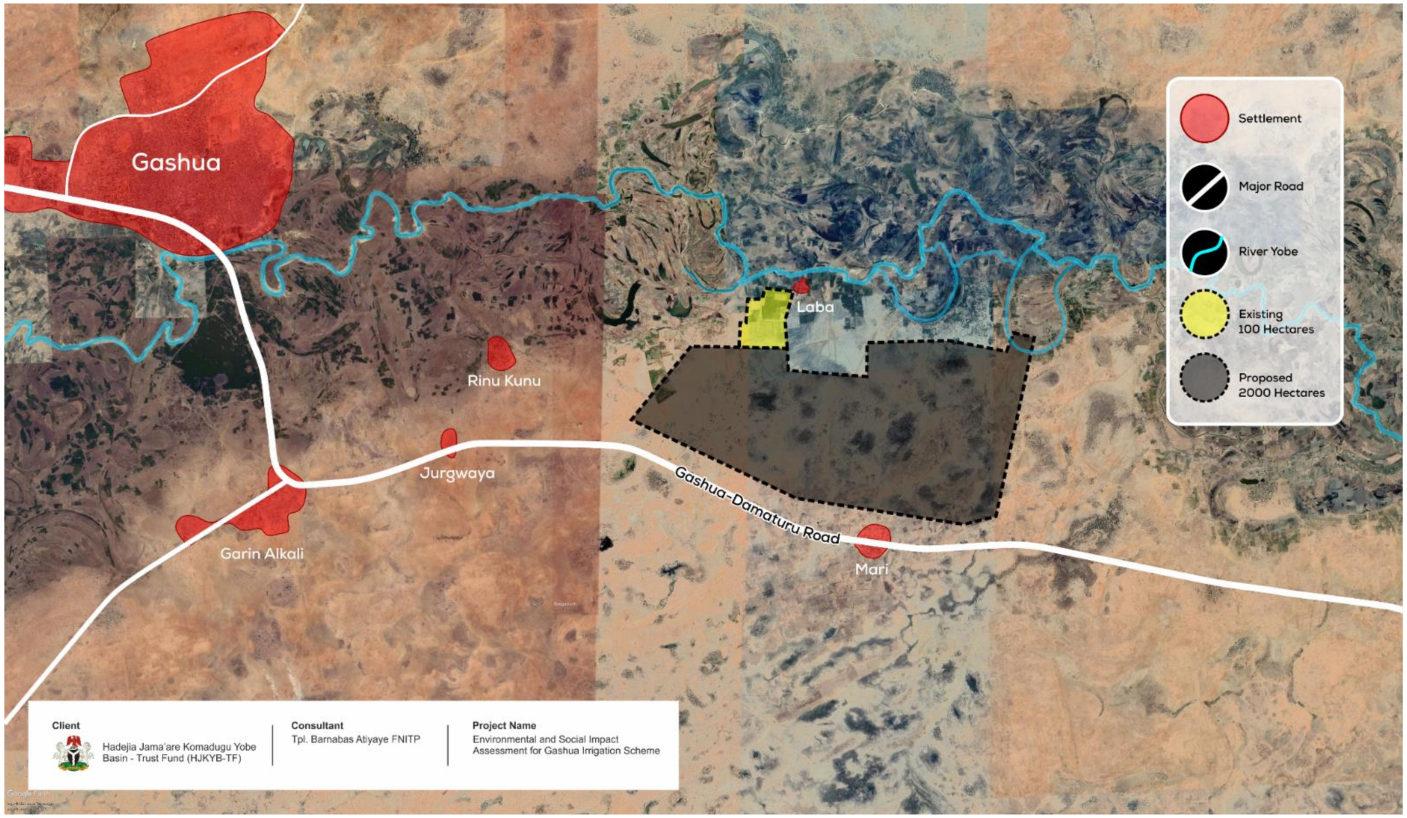

Figure4.2: Gashua Irrigation Scheme in context of Project Affected Communities and Gashua

Socio economic data in relation to the Gashua Irrigation scheme is very important as it depicts the socio-economic characteristics of the communities situated within or around the proposed project area. This information can guide decision and policy making, it also helps in ascertaining the needs of these stakeholder communities and their expectations from the proposed project. Data collection was done through trained enumerators who engaged the stakeholder communities using online data kit (ODK).

The socioeconomic studies included collection and analysis of demographic indices like age, sex, marital status, family size, education, occupation, qualification, religion, number of wives and income level. The main purposes of socio-economic evaluation in the proposed Gashua irrigation scheme were to ascertain the nature of beneficiaries, their expectations, their acceptance of the project, their occupation and how it relates to the proposed project amongst others. These socio-economic findings were able to help in ascertaining project requirement and how best it would serve the stakeholder communities which it was intended for. More so these findings also depicted the level of acceptance these communities had for the irrigation project.
The questionnaires were designed to interview adult men and women who were household representatives within these stakeholder communities who collectively provided information on the socio-economic characteristics of their community, hence given deep insight on the socio-economic background of the settlement.

4.2.1 Gender

Both genders that took part in the survey within these five communities were almost equally represented as 52.44% were males and 47.56% were females as presented in

Table 16. This trend was almost replicated in all the communities that participated in the survey. It was the intention of the Consultant that the data collected involved both genders. Thus, conscious effort was taken to include women in the survey in line with gender mainstreaming practices. Figure graphically depicts these findings.

Table 162: Gender of Respondents

	Project Affected Communities					TOTAL	Percentage
	Garin Alkali	**Jurgwaya**	**Mari**	**Laba**	**Renakunu**		
Male	93	64	30	24	36	**247**	**52.44%**
Female	67	65	30	22	40	**224**	**47.56%**
Total	**160**	**129**	**60**	**46**	**76**	**471**	**100%**

Source: Envicons Field Survey, 8th July, 2021

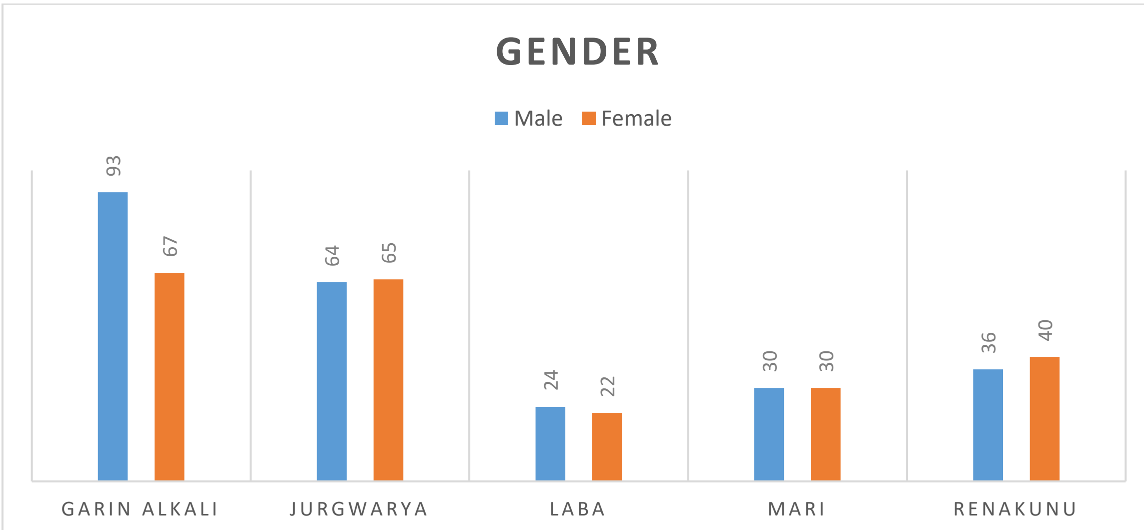

Figure 4.3: Gender of Respondents
Source: Envicons Field Survey, 8th July, 2021

4.2.2 Age

Majority of the persons that participated in the survey were between the age of twenty-six (26) and fifty (50). This also signifies age group most capable of directly benefiting from the project through farming practices, as they are either too young or aged to actively have such occupation (see section 4.2.8). The age distribution is presented in Table 4.3 and graphically illustrated in Figure 4.3.

Table 4.3: Age of Respondents

	Project Affected Communities					Total	Percentage
	Garin-Alkali	**Jurgwaya**	**Mari**	**Laba**	**Renakunu**		
18 - 25 years	22	20	23	8	11	84	17.8
26 - 35 years	39	32	15	11	27	124	26.3
34 - 50 years	69	44	17	19	22	171	36.3
Above 50 years	30	33	5	8	16	92	19.5
Total	**160**	**129**	**60**	**46**	**76**	**471**	**100**

Source: Envicons Field Survey, 8th July, 2021

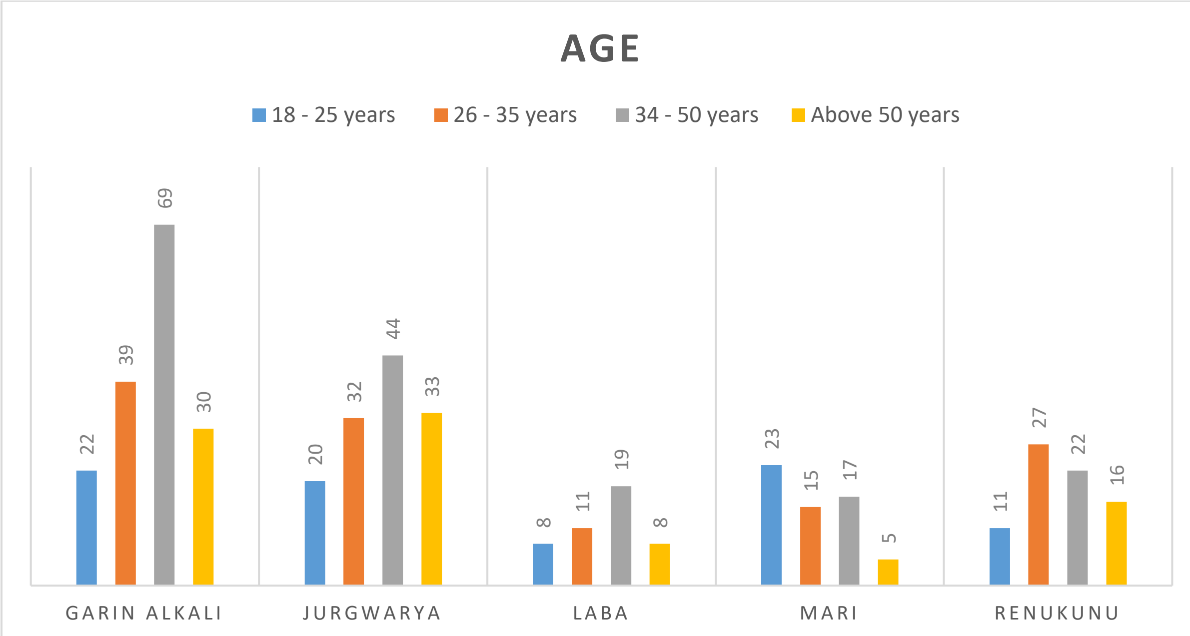

Figure 4.4: Age of Respondents
Source: Envicons Field Survey, 8th July, 2021

4.2.3 Religion

All 471 respondents within the five communities surveyed were Muslims as no traditionalist and no Christians were found within these communities. This could be attributed to the fact that it is a core rural community in Northern Nigeria.

4.2.4 Marital Status

The questionnaire administration targeted family heads to represent their families, assumed to be the best capable people to present wholesome responses on behalf on their families. As such, 85% of the respondents who participated in the questionnaire survey across the five project affected communities were married. 6% were single, 3% divorced and 7% widowed. These findings are presented in detail in Table 4.4.

Table 4.4: Marital Status of Respondents

	Project Affected Communities					Total	Percentage
	Garin Alkali	**Jurgwaya**	**Mari**	**Laba**	**Renakunu**		
Married	128	109	55	44	62	398	84.5
Single	15	5	5	2	3	30	3
Divorced	7	4	0	0	1	12	6
Widow(er)	10	11	0	0	10	31	6.5
Total	**128**	**109**	**55**	**44**	**62**	**398**	**100**

Source: Envicons Field Survey, 8th July, 2021

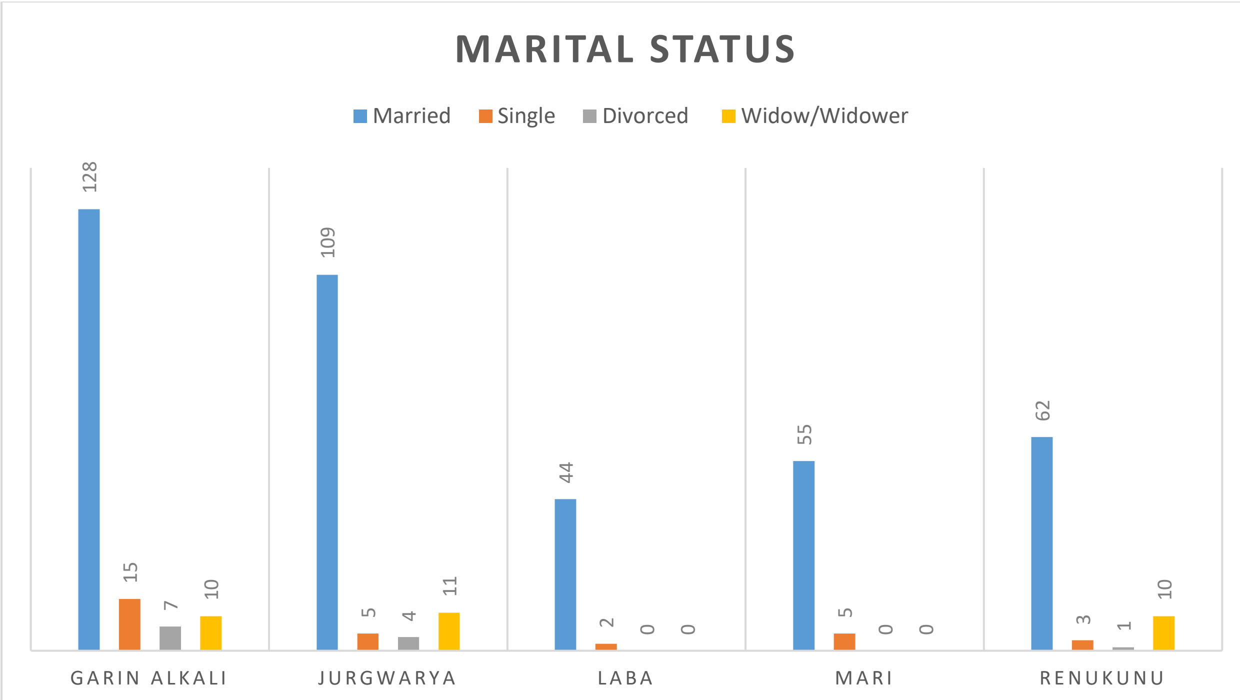

Figure 4.5: Marital Status of Respondents
Source: Envicons Field Survey, 8th July, 2021

4.2.4 Number of wives

The family type within the stakeholder communities is primarily polygamous in nature, a nod to the most practiced religion. 76% of the married respondents live within polygamous families. This trend replicates itself within all the five project affected communities identified. The comprehensive figures for all communities are displayed in Table 4.5.

Table 4.5: Number of wives

	Project Affected Communities					Total	Percentage
	Garin Alkali	**Jurgwaya**	**Mari**	**Laba**	**Renakunu**		
One	30	50	4	6	4	94	23.62
Two	38	26	17	26	22	129	32.41
three	45	33	32	10	33	153	38.44
Four	15	2	1	1	3	22	5.5
Five and above	0	0	0	0	0	0	**0**
Total	**128**	**111**	**54**	**43**	**62**	**398**	**100**

Source: Envicons Field Survey, 8th July, 2021

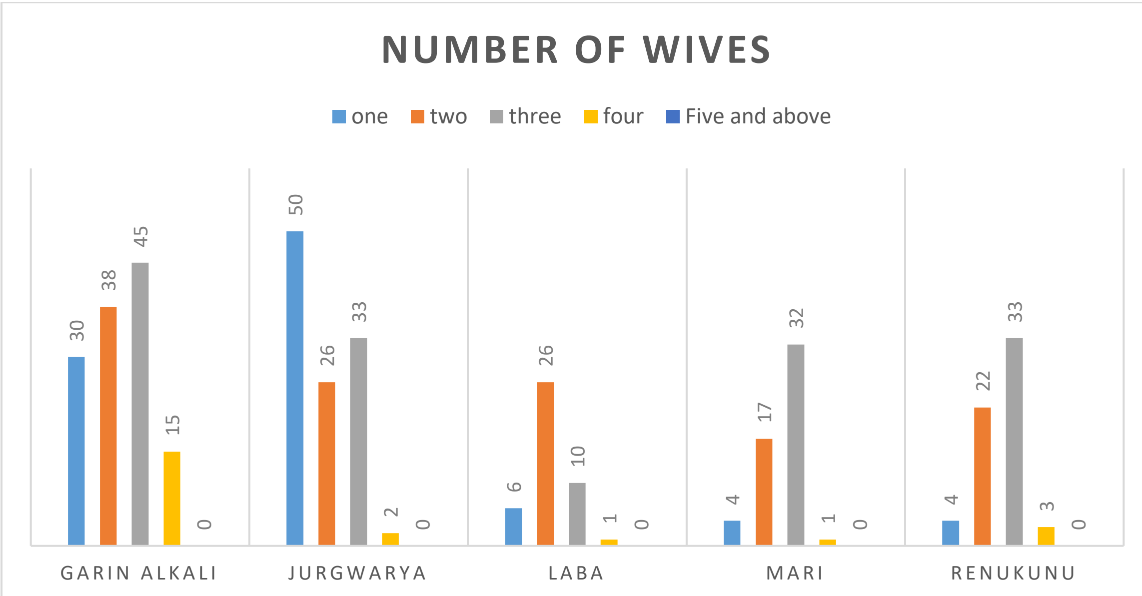

Figure 4.6: Number of wives
Source: Envicons Field Survey, 8th July, 2021

4.2.5 Family Size

The most common family size within the five communities are above eight people per family, higher than the Nigerian average of six. This is a reflection of the culture (religion and family type) and the agricultural activities typically carried out which requires more hands for higher output. Incidentally, these communities are not large in coverage area except for Garin Alkali which has a relative population size as well. Table 4.6 depicts the distribution of family sizes within the five project affected activities.

Table 4.6: Family size

	Project Affected Communities					Total	Percentage
	Garin Alkali	Jurgwaya	Mari	Laba	Renakunu		
one to three	27	54	4	7	5	97	20.9
four to six	44	33	12	8	35	132	28.4
seven to eight	29	18	16	8	15	86	18.5
above eight	60	20	26	23	19	150	32.3
Total	**128**	**111**	**54**	**43**	**62**	**465**	**100**

Source: Envicons Field Survey, 8th July, 2021

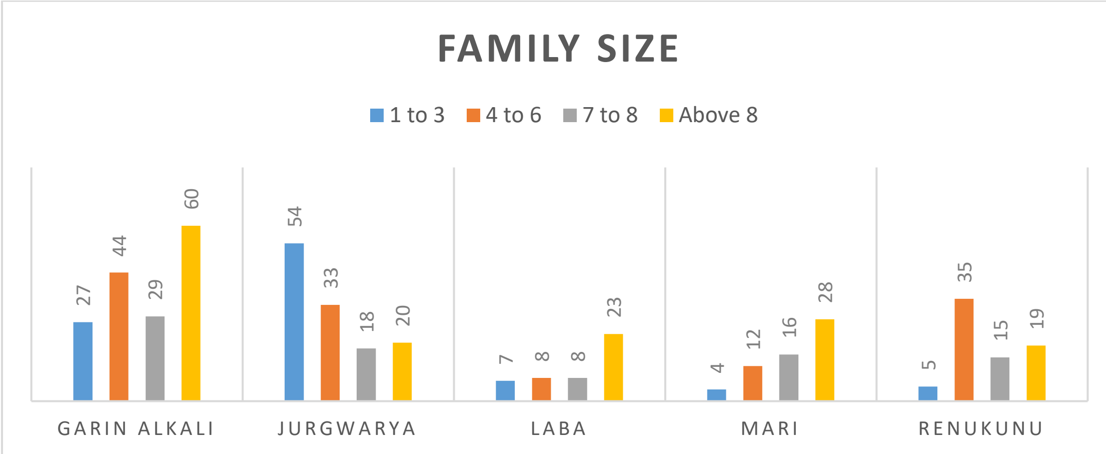

Figure 4.7: Family size within the PAC
Source: Envicons Field Survey, 8th July, 2021

4.2.6 Educational Level

Another reflection of the community's religion is in the most common type and level of education acquired by the respondents. 35% (most) of the respondents had attained only Qur'anic/Islamic education at the time the survey was carried out (Table 4.7). This can also be attributed to this form of education being the cheapest in the study area, requiring little to no physical infrastructure. 27% of the residents within these five PACs had no formal education, and some of those that that did never completed a secondary education for their respective reasons.

Table 4.7: Level of Education within the Five PACs

	Project Affected Communities					Total	Percentage
	Garin Alkali	**Jurgwaya**	**Mari**	**Laba**	**Renakunu**		
No formal education	15	44	25	16	27	127	27%
Qu'ranic Education	56	31	19	27	32	165	35%
SSCE and below	72	48	15	3	12	150	32%
OND	12	5	1	0	3	21	4.46%
HND/Bachelors' Degree	5	0	0	0	2	7	1.49%
Post Graduate	0	0	0	0	0	0	**0%**
Other, specify (NCE)	0	1	0	0	0	1	**0.2%**
TOTAL	**160**	**129**	**60**	**46**	**76**	**471**	**100**

Source: Envicons Field Survey, 8th July, 2021

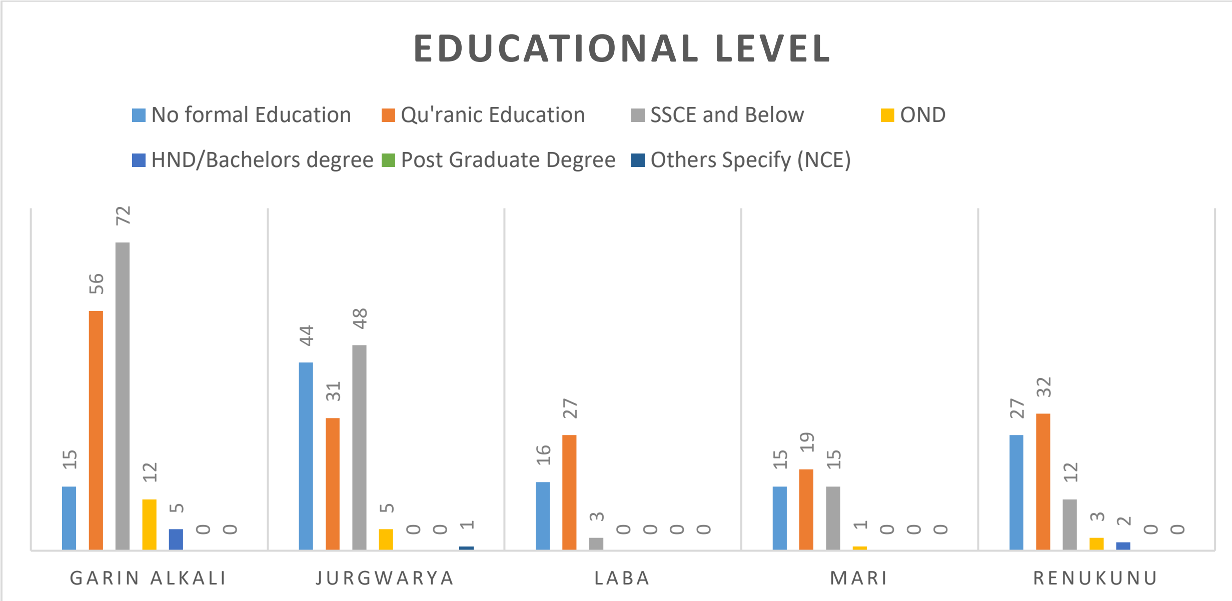

Figure 4.8: Educational level within the PACs
Source: Envicons Field Survey, 8th July, 202

4.2.7 Employment Status

The PACs are rural communities with limited access to places of employment or employment opportunities which can be found within towns and big cities. More so, given the fact that majority of the residents within these PACs have a very low educational background as depicted in Table . It further reduces their chances of employment if there are available. Hence most of these residents are either self-employed or unemployed as depicted graphically in Figure 4.8.

Table 4.8: Employment status within the PACs

Project Affected Communities						Total	Percentage
	Garin Alkali	Jurgwaya	Mari	Laba	Renakunu		
Unemployed	29	44	35	30	41	179	38.3%
Self-employed	103	83	25	19	30	260	55.7%
Employed	18	0	0	0	0	18	3.9%
Retired	10	0	0	0	0	10	2.14%
Student	0	0	0	0	0	0	0%
TOTAL	**160**	**127**	**60**	**49**	**71**	467	**100%**

Source: Envicons Field Survey, 8th July, 2021

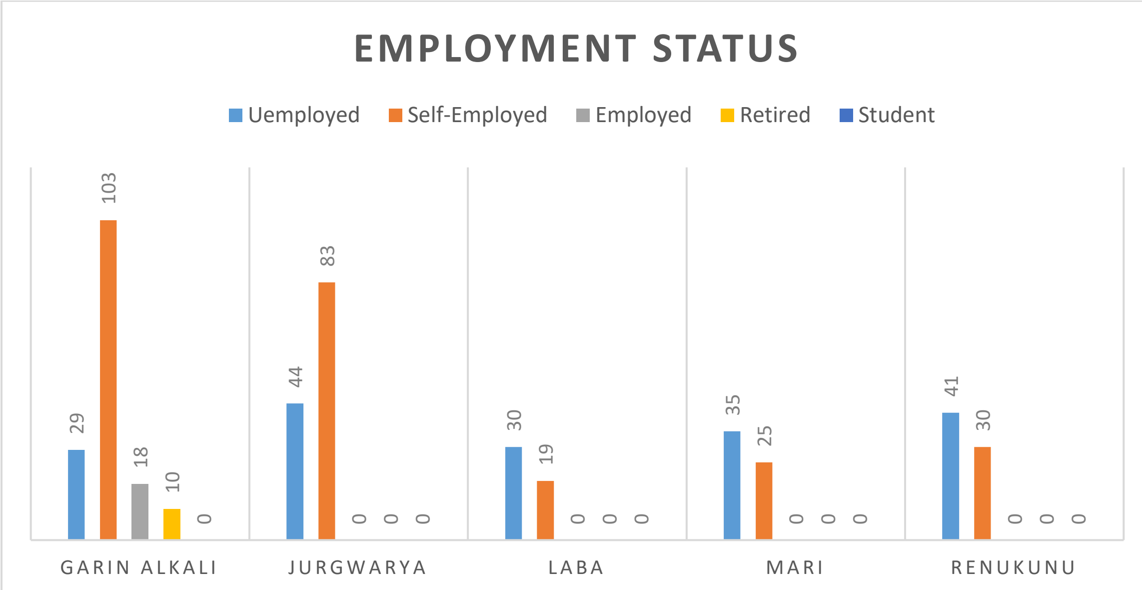

Figure 4.9: Employment Status within the PACs
Source: Envicons Field Survey, 8th July, 2021

4.2.8 Occupation

Based on observation which was later backed up by the findings from the analysed questionnaires, it was deduced that the primary occupation of the residents within these communities is farming. Other common occupation found within these communities are trading and artisanship. Most of the famers regard themselves as being self-employed as seen in Figure 12. This is akin to most other rural communities in the Nigerian state, where farming is the primary occupation. Other occupations observed within the PACs and their distribution are presented in Table 4.9

Table 4.9: Types of Occupation within the PACs

	Project Affected Communities					Total	Percentage
	Garin Alkali	**Jurgwaya**	**Mari**	**Laba**	**Renakunu**		
Artisan	14	17	20	2	12	65	14%
Trader	8	31	12	13	4	68	14.6%
Fishing	0	1	2	0	5	8	1.7%
Farming	119	69	26	28	35	277	59.6%
Civil Servant	11	3	0	0	0	14	3%
Professional	0	0	0	0	0	0	0%
Others	8	8	0	3	14	33	7.1%
TOTAL	**160**	**129**	**60**	**46**	**70**	**465**	**100%**

Source: Envicons Field Survey, 8th July, 2021

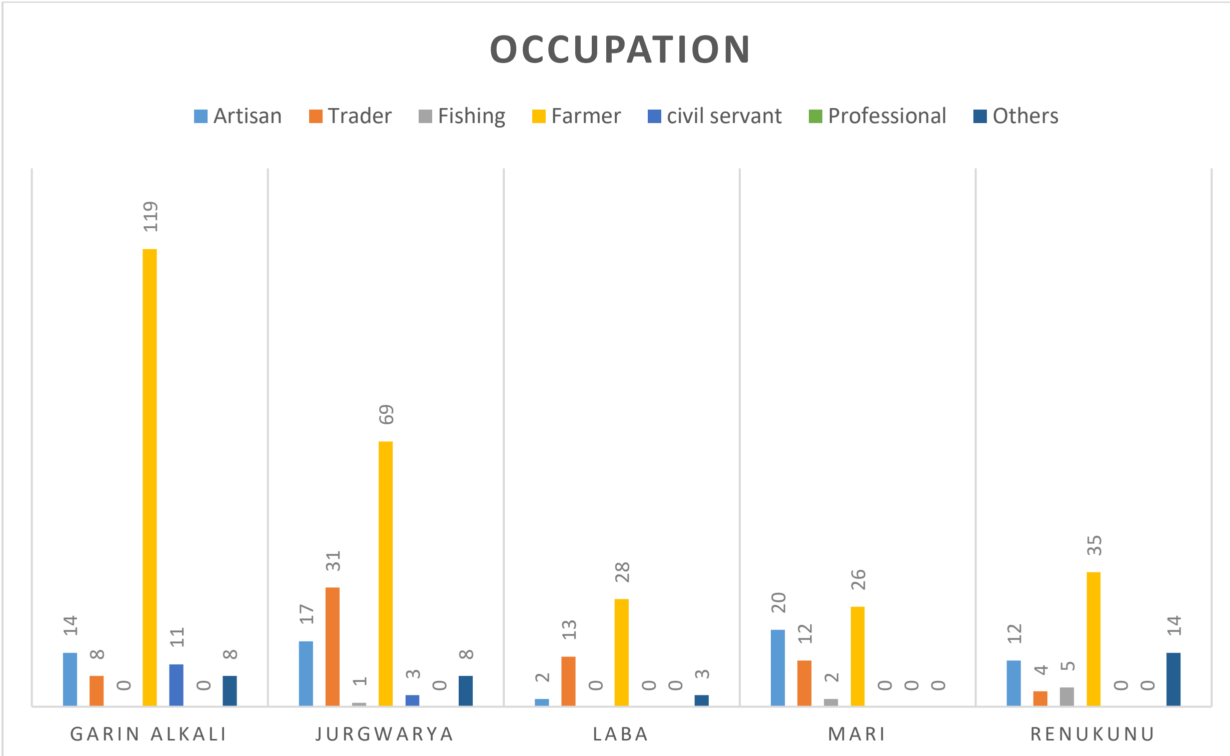

Figure 12.10: Occupation within the PACs
Source: Envicons Field Survey, 8th July, 2021

4.2.9 Monthly Income

Mostly having no formal educational or only Qur'anic education and being either unemployed or self-employed farmers, majority of the respondent's monthly income is seasonal depends highly on sales of their agricultural produce. It was deduced that 358 out of the 468 respondents earn below N18,000 monthly, far below the recently increased national minimum wage of N30000 per month. This clearly depicts the level of poverty within these communities, worsened by the number of dependents on the family head (see 4.2.9 Monthly Income). These figures are elaborated in

Table 4.10. More so, only in Garin Alkali were there any respondents that earned over N100,000 monthly.

Table 4.10: Monthly income

	Project Affected Communities					Total	Percentage
	Garin Alkali	**Jurgwaya**	**Mari**	**Laba**	**Renakunu**		
18,000 and below	110	116	56	22	54	358	76.50
N18,001 to N50,000	20	12	4	10	16	62	13.25
50,001 to 100,000	19	0	0	13	5	37	7.91
100,001 to 150,000	7	0	0	0	0	7	1.50
Above 150,000	4	0	0	0	0	4	0.85
TOTAL	**160**	**128**	**60**	**45**	**75**	**468**	**100**

Source: Envicons Field Survey, 8th July, 2021

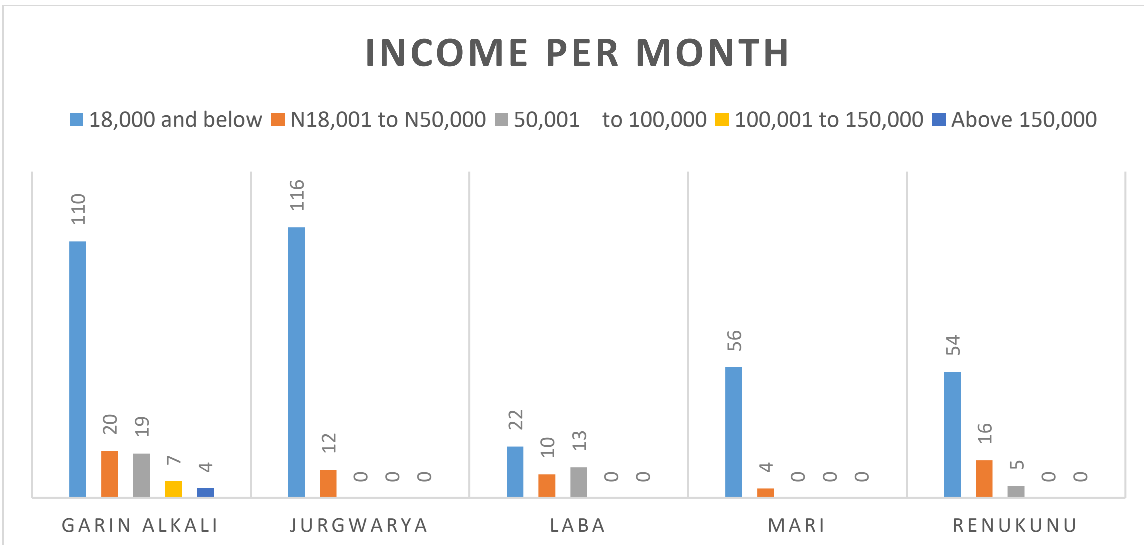

Figure 4.11: Monthly income within the PACs
Source: Envicons Field Survey, 8th July, 2021

4.2.10 Primary mode of transportation

There exists a variety in the mode of transportation within these communities, but the most patronized besides the use of foot are commercial motorcycles/tricycles and commercial vehicles as presented in

Table 4.11. Most of the journey within these communities are short distances with the frequent destination being nearby farms mostly within a kilometre away from their homes. Commercial vehicles and motorcycles are used more when the respondent's journey to larger markets or towns such as Gashua for either business or pleasure.

Table 4.11: Primary mode of transportation

	Project Affected Communities					Total	Percentage
	Garin Alkali	**Jurgwaya**	**Mari**	**Laba**	**Renakunu**		
Private Vehicle	6	0	0	2	1	9	2
Commercial Vehicle	22	2	12	18	3	57	12.9
Private Motorcycle/ Tricycle	11	0	0	0	0	11	2.5
Commercial Motorcycle/ Tricycle	11	27	13	8	3	62	14
Bicycle	0	11	7	2	1	21	4.8
Foot	107	89	28	15	43	282	63.8
TOTAL	**157**	**129**	**60**	**45**	**51**	**442**	**100**

Source: Envicons Field Survey, 8th July, 2021

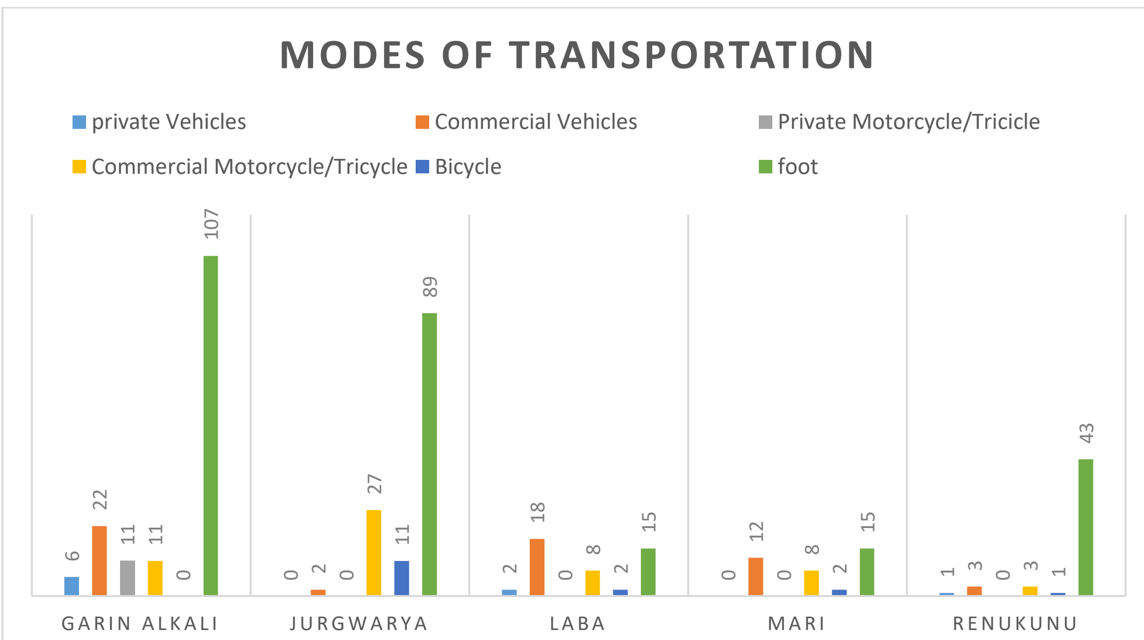

Figure 4.12: Modes of transportation within the PACs
Source: Envicons Field Survey, 8th July, 2021

4.2.11 Years lived within the Community

As presented in Table 4.12, most of the residents within the settlements are indigenous and have lived there for most of their lives – often since birth. Only a few of them migrated into the communities signifying a low level of in-migration to these communities. Garkin Alkali and Jurgwaya are the communities with the highest number of new residents (10 years or less) as shown in Table 4.12.

Table 4.12: Years spent living within the PACs

	Project Affected Communities					Total	Percentage
	Garin Alkali	**Jurgwaya**	**Mari**	**Laba**	**Renakunu**		
0-5 years	3	20	4	0	2	29	6.35
6-10 years	21	24	1	1	5	52	11.38
11-15 years	16	13	1	5	6	41	8.97
16-20 years	21	1	9	6	5	42	9.19
more than 20 years	99	60	45	34	55	293	64.11
TOTAL	**160**	**118**	**60**	**46**	**73**	**457**	**100.00**

Source: Envicons Field Survey, 8th July, 2021

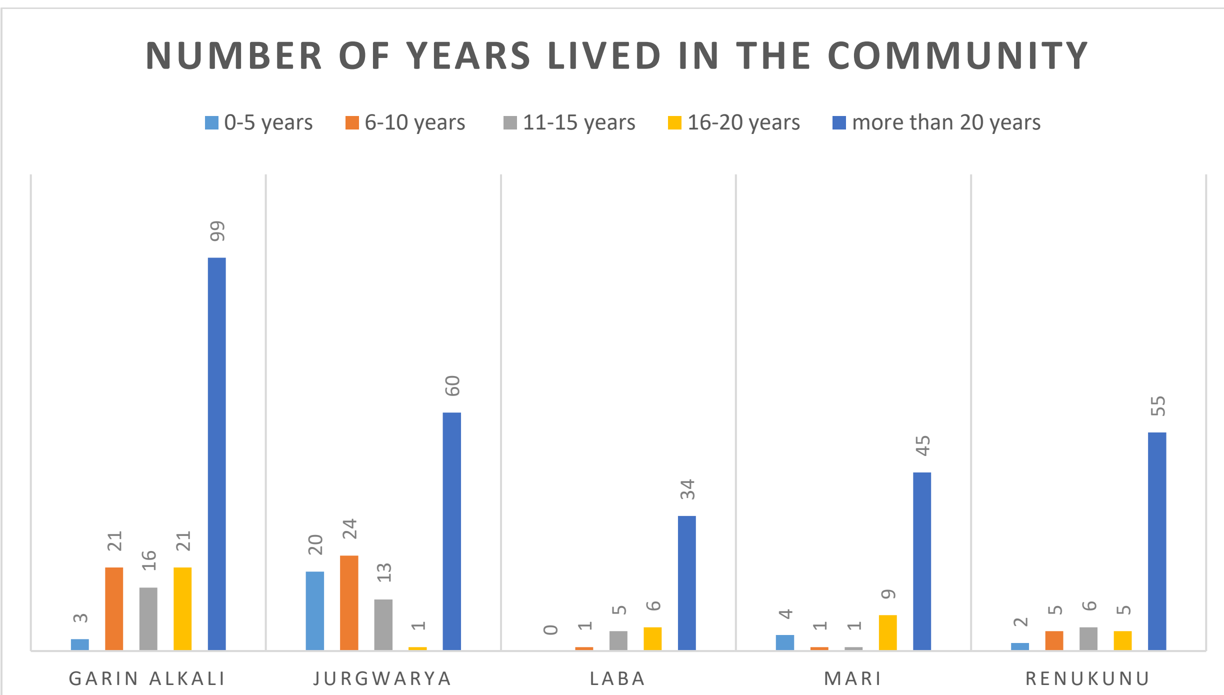

Figure 4.13: Years spent living in the PACs

Source: Envicons Field Survey, 8th July, 2021

4.2.12 Types of Health facilities and walking distance to these Health facilities

Based on the surveyed data, most of the respondents confirmed that there are more health facilities in Garin Alkali than other communities, with none in Mari and Laba as shown in Table 4.13. This implies that residents of Mari and Laba visit health facilities outside their communities at a 30-minute walking distance when necessary. The respondents within Garin Alkali, Jurgwarya and Renakunu that have these facilities at proximity to their settlements can access these facilities on foot within 10 minutes (Figure 4.14).

Table 4.13: Confirmation of Health Facilities within the PACs

	Project Affected Communities					Total	Percentage
	Garin Alkali	**Jurgwarya**	**Mari**	**Laba**	**Renakunu**		
Hospital	107	52	7	0	16	182	35.20
Clinic	35	67	0	0	60	162	31.33
Chemist/Drug Store	42	13	57	1	45	158	30.56
Traditional Medicine	0	1	2	0	0	3	0.58
None	12	0	0	0	0	12	2.32
TOTAL	**196**	**133**	**66**	**1**	**121**	**517**	**100.00**

Source: Envicons Field Survey, 8th July, 2021

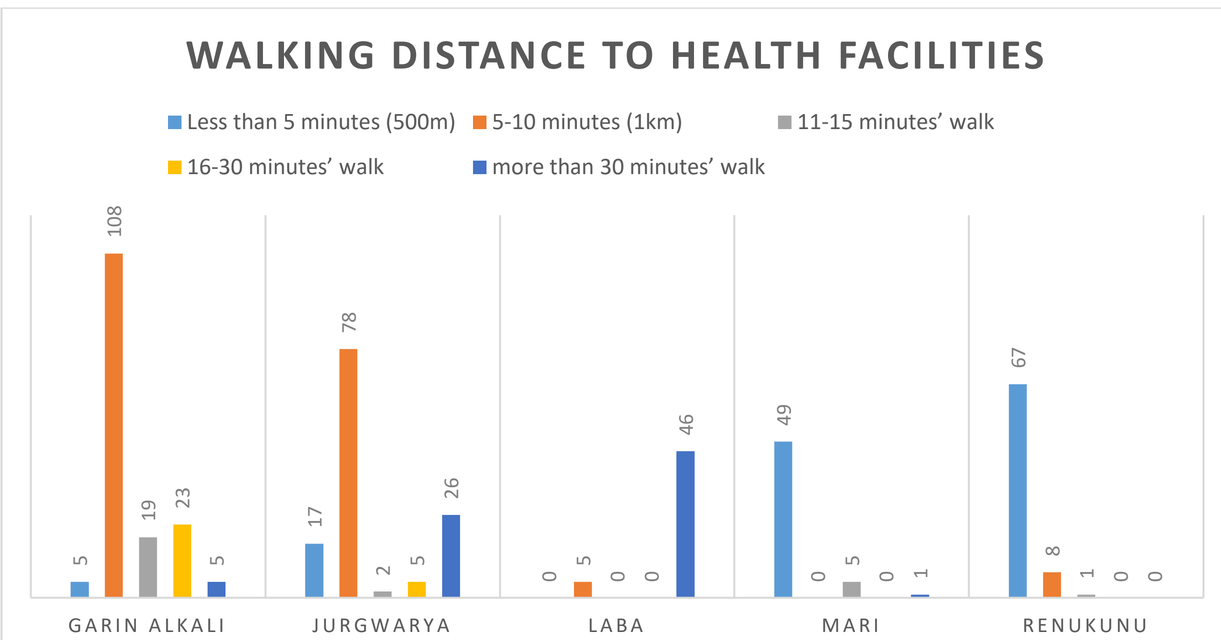

Figure 4.14: Walking distance to Health facilities

Source: Envicons Field Survey, 8th July, 2021

4.2.13 Prevalent Diseases existing within the PACs

Given the fact that these communities exist close to the previous irrigation area and also the river Yobe, diseases that may prevail in locations like this are mostly malaria and typhoid. This statement was affirmed by the findings of the survey as 378 and 246 respondents mentioned that typhoid and malaria respectively are the most prevalent diseases suffered in these five communities. On a specific note, the people in Mari settlement added that they have common, and increasing, cases of kidney disease which is peculiar to their settlement. These findings are presented in Table 4.14.

Table 4.14: Prevalent Disease within the PACs

	Project Affected Communities					Total	Percent age
	Garin Alkali	**Jurgway a**	**Mari**	**Laba**	**Renaku nu**		
Malaria	25	115	60	46	0	182	30.94
Typhoid Fever	128	103	39	57	51	162	27.54
Cholera	35	6	0	3	0	158	26.86
Diarrhoea	0	4	1	2	0	3	0.51
others, specify	0	6	12	1	0	12	2.04
TOTAL	**188**	**234**	**112**	**109**	**51**	**517**	100

Source: Envicons Field Survey, 8th July, 2021

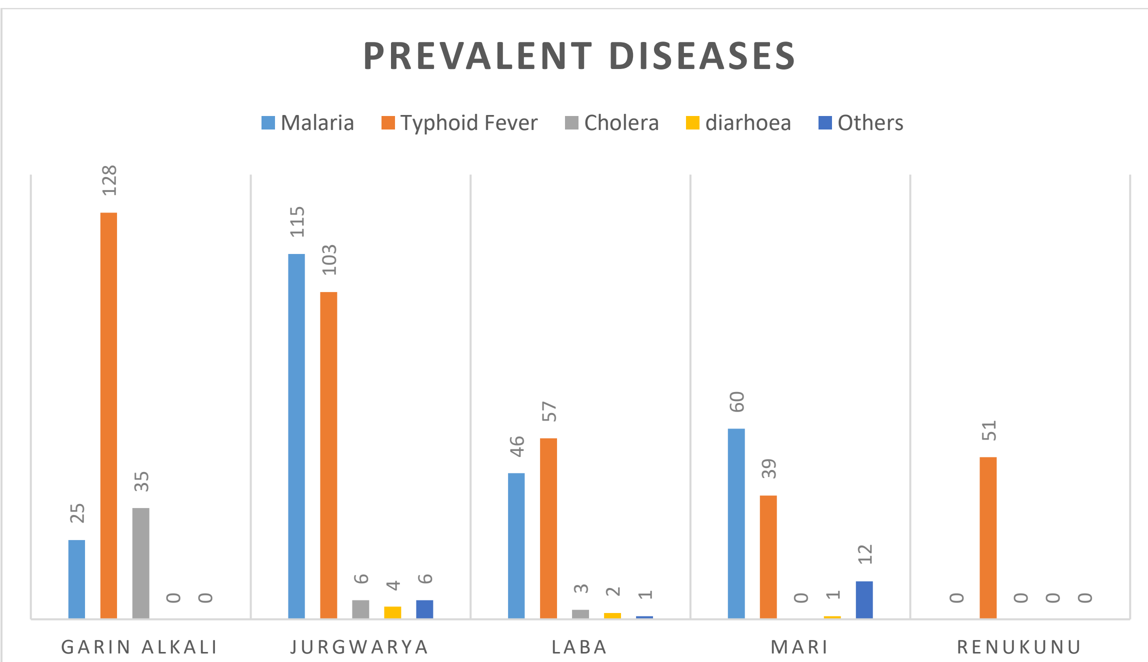

Figure 4.15: Prevailing Diseases within the PACs
Source: Envicons Field Survey, 8th July, 2021

4.2.14 Type of Educational facilities within the PACs

Primary schools are the most common educational facilities in the settlements, with respondents from only Laba failing to confirm the availability of any educational facility Table . It is believed however that Jurgwarya and Renakunu communities may have been referring to the same educational facility because these settlements are at close proximity to each other. Availability of educational facilities can infer the level of education within these communities. As such, a correlation may exist between the unavailability of educational facilities and the relatively low level of education as previously shown in Table 4.15. On the other hand, the will to learn and income level can influence individual choices on whether to acquire education or not.

Table 4.15: Confirmation of Educational Facilities within PACs

	Project Affected Communities					Total	Percentage
	Garin Alkali	**Jurgwaya**	**Mari**	**Laba**	**Renakunu**		
Primary School	132	107	60	0	76	375	79.62
Secondary School	28	1	0	0	0	29	6.16
Higher Institution	0	1	0	0	0	1	0.21
None	0	20	0	46	0	66	14.01
TOTAL	**160**	**129**	**60**	**46**	**51**	**471**	**100**

Source: Envicons Field Survey, 8th July, 2021

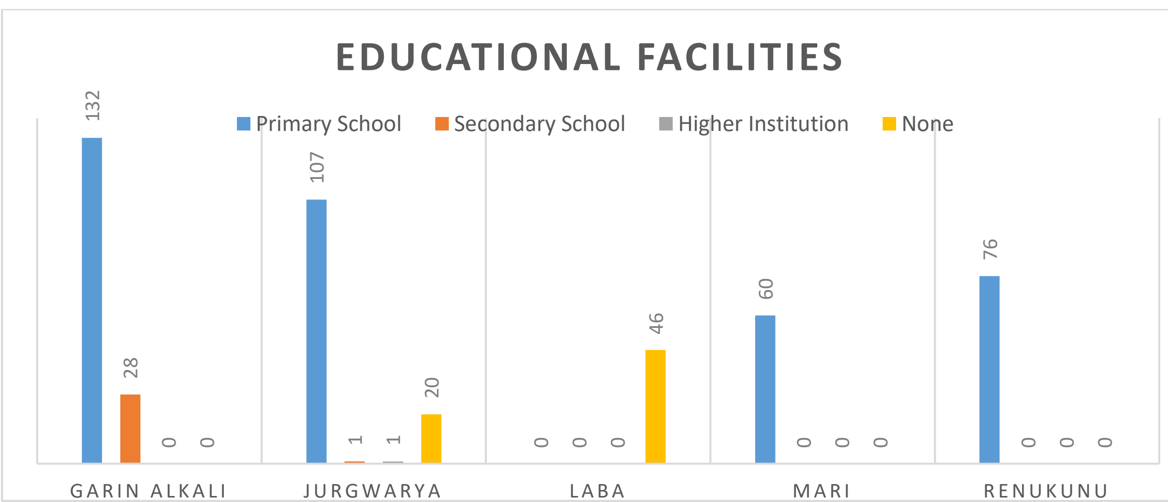

Figure 4.16: Educational Facilities within the PACs

Source: Envicons Field Survey, 8th July, 2021

4.2.15 Walking Distance to Educational Facilities

The research sought to find the proximity to the nearest educational facilitates from the five communities. It was deduced that most of these communities' access educational facilities which are mostly primary schools are within 10 minutes by walking except for Laba which is the most remote community with no educational facility within. This is further explained with the aid of Table 4.17 while Table 4.16 summarizes the list of facilities available within the five communities.

Table 4.16: Walking distance to available educational facilities within PACs

Project Affected Communities						Total	Percentage
	Garin Alkali	**Jurgwaya**	**Mari**	**Laba**	**Renakunu**		
Less than 5 minutes (500m)	11	61	55	0	65	192	42.67
5-10 minutes (1km)	112	46	5	0	8	171	38.00
11-15 minutes' walk	8	0	0	0	3	11	2.44
16-30 minutes' walk	16	0	0	46	0	62	13.78
more than 30 minutes' walk	13	1	0	0	0	14	3.11
TOTAL	**160**	**108**	**60**	**46**	**76**	**450**	**100**

Source: Field Survey; July, 2021

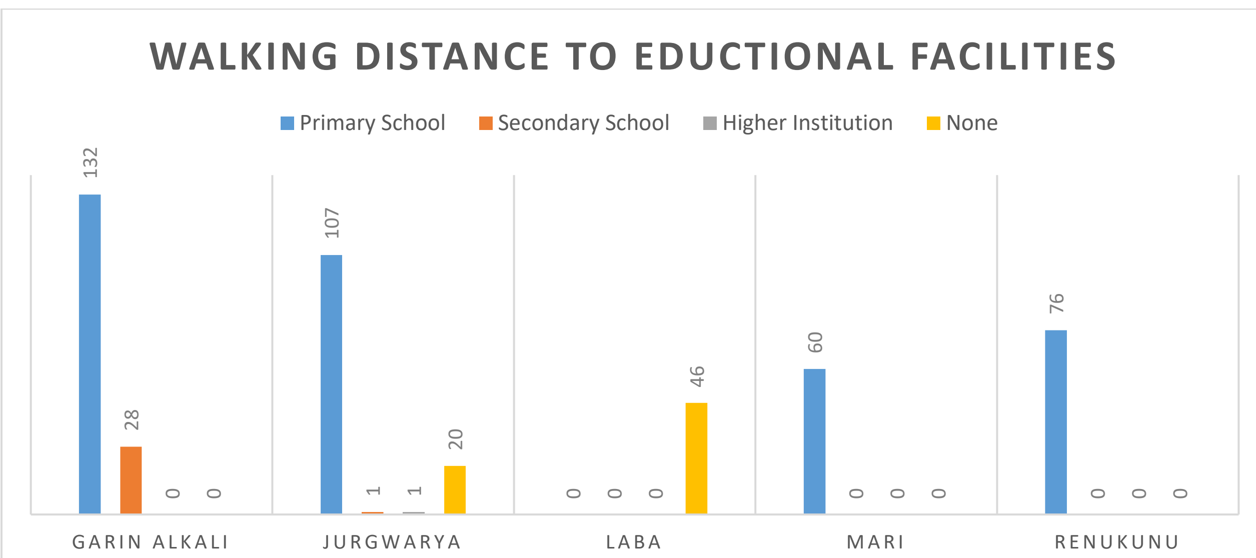

Figure 4.17: Walking distance to Educational Facilities within the PACs
Source: Envicons Field Survey, 8th July, 2021

Table 4.17: Communal Facilities within Project Affected Communities

S/N	COMMUNITY	BOREHOLE	WELL	PRIMARY SCHOOL	SECONDARY SCHOOL	CLINIC/PRIMARY HEALTH CENTRE	POLICE STATION
1.	Laba	2	-	-		-	-
2.	Garin Alkali	6	-	1	1	1	1
3.	Jurgwaya	6	4	1		-	-
4.	Mari	4	2	-		-	-
5.	RenaKunu	8	2	1		-	-
	Total	**32**	**8**	**3**	**1**	**1**	**1**

Source: Envicons Field Survey, 8th July, 2021

4.2.16 Waste Management within the PACs

Waste management is key in every settlement because it affects the sanitation and health of the immediate environment and it begins from individual housing unit. According to the survey findings, 266 out of the total 471 respondents attested to having a waste bin within their houses, in which 188 out of the total respondents indicated that they separate their waste before disposal and only 171 actually recycle their waste by finding another use for the waste items. A composite Table 4.18 summarizes the responses.

Table 4.18: Waste management within PACs

Question	Response	Project Affected Communities					Total	%
		Garin Alkali	Jurgwarya	Mari	Laba	Renakunu		
Do you own a waste bin in your house?	**Yes**	71	87	42	1	65	266	56
	No	89	42	18	45	11	205	44
	Total	**160**	**129**	**60**	**46**	**76**	**471**	**100**
Do you separate your waste before disposal?	**Yes**	71	53	40	0	24	188	40
	No	89	76	20	46	52	283	60
	Total	**160**	**129**	**60**	**46**	**76**	**471**	**100**
Do you recycle your waste?	**Yes**	64	58	26	0	23	171	36
	No	96	71	34	45	53	299	63
	Total	**160**	**129**	**60**	**45**	**76**	**470**	**100**

Source: Envicons Field Survey, 8th July, 2021

4.2.17 Method of waste Disposal within PACs

There are numerous ways of handling and disposing waste within a given settlement and each of these methods have their repercussion on the immediate environment if not done properly. Based on the survey findings it was discovered that each community had their own way of waste disposal, going by the majority, one can clearly say incineration is the primary method of waste disposal in Garin Alkali, the Use of Dumping sites in Jurgwarya, Open dumping in Laba and dumping on farmlands in Renakunu. It is worthy to note that those who chose the "other" option all specified that they dump their waste on farmlands. These preferences are shown in Table 4.19 and Figure 4.18.

Table 4.19: Method of waste disposal within PACs

	Project Affected Communities					Total	Percentage
	Garin Alkali	**Jurgwaya**	**Mari**	**Laba**	**Renakunu**		
Dumping Site	3	45	17	25	0	90	20.04
Pit for burning	108	16	19	7	0	150	33.41
Dumping by road side	40	45	17	25	0	127	28.29
Others	26	10	15	0	31	82	18.26
TOTAL	**177**	**116**	**68**	**57**	**31**	**449**	100.00

Source: Envicons Field Survey, 8th July, 2021

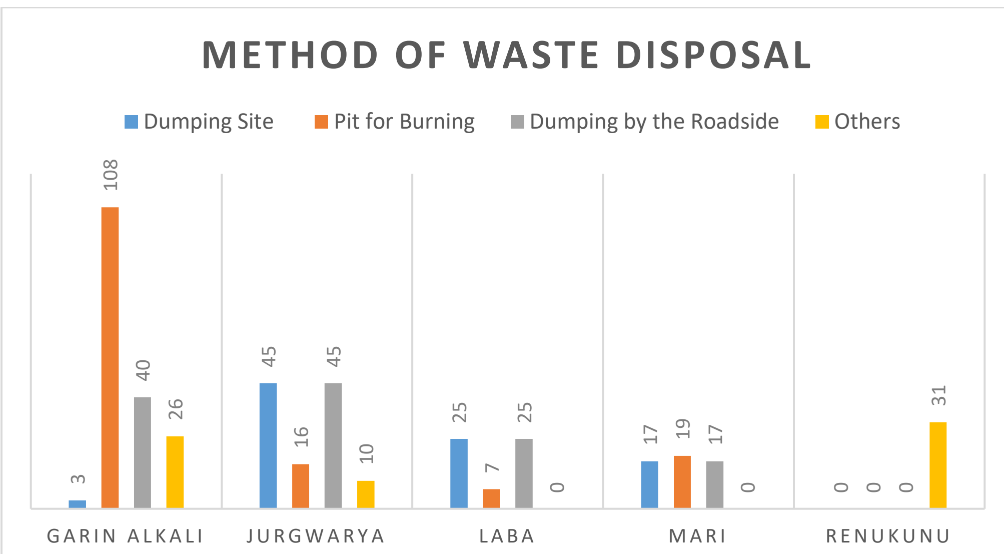

Figure 4.18: Method of waste disposal within the PACs
Source: Envicons Field Survey, 8th July, 2021

4.2.18 Frequency of waste Disposal

Frequency of waste disposal can translate to the level of purchase and consumption of items. Waste generation within rural communities like these focus areas are much less than those in more urban areas and rural waste composition is often less toxic and more biodegradable. However, it was observed that most of this respondent across all the five communities dispose waste on a daily basis as shown in Table 4.20. In Garin Alkali, incineration is also done on a daily basis which has negative environmental effects, particularly air pollution.

Table 4.20: Frequency of waste disposal within PACs

	Project Affected Communities					Total	Percentage
	Garin Alkali	**Jurgwaya**	**Mari**	**Laba**	**Renakunu**		
Daily	114	91	44	42	53	344	73.35
Bi-weekly	0	8	0	4	12	24	5.12
Weekly	46	30	16	0	9	101	21.54
Bi-monthly	0	0	0	0	0	0	0.00
Monthly	0	0	0	0	0	0	0.00
TOTAL	**160**	**129**	**60**	**46**	**74**	**469**	**100.00**

Source: Envicons Field Survey, 8th July, 2021

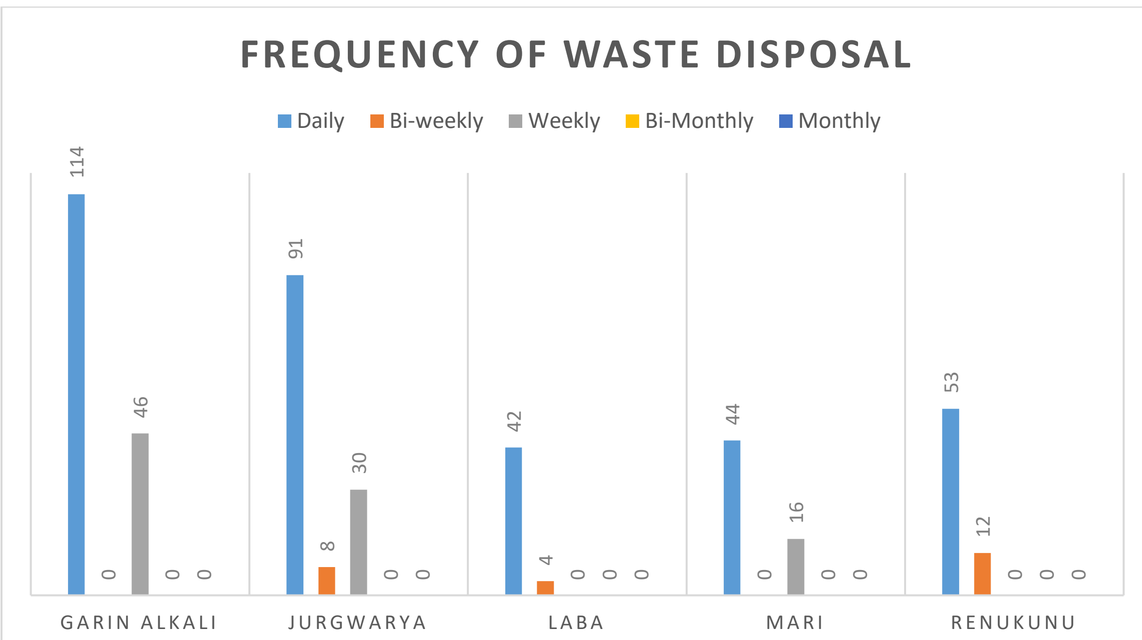

Figure 4.19: Frequency of waste disposal within the PACs
Source: Envicons Field Survey, 8th July, 2021

4.2.19 Toilet Type

Toilet systems refer to the method of collection of human waste or sewerage. According to collected data, it was established that the most common toilet system within these PACs is the "Pit Laterite" also known as pit toilet which is very common amongst rural communities because of their low construction and maintenance costs. However, such toilets have an effect on ground water quality, depending on their concentration in a given area (Alfonse, Zvikomborero, & Webster, 2019). Therefore, there could be a correlation bewteen these PACs being small clustered settlements, many households having their own pit laterines, the community reliance on underground water from manual boreholes and wells (

Table 4.21), and the prevaling cases of typhoid and diarrhea. This, however, requires further studies to be confirmed. Table 4.21 shows the distribution of toilet types.

Table 4.21: Toilet types within the PACs

Project Affected Communities						Total	Percentage
	Garin Alkali	**Jurgwarya**	**Mari**	**Laba**	**Renakunu**		
Open defecation	5	5	8	10	4	32	6.87
Pit Latrine	132	124	51	36	68	411	88.20
Water Closet	23	0	0	0	0	23	4.94
TOTAL	**160**	**129**	**59**	**46**	**72**	**466**	**100**

Source: Envicons Field Survey, 8th July, 2021

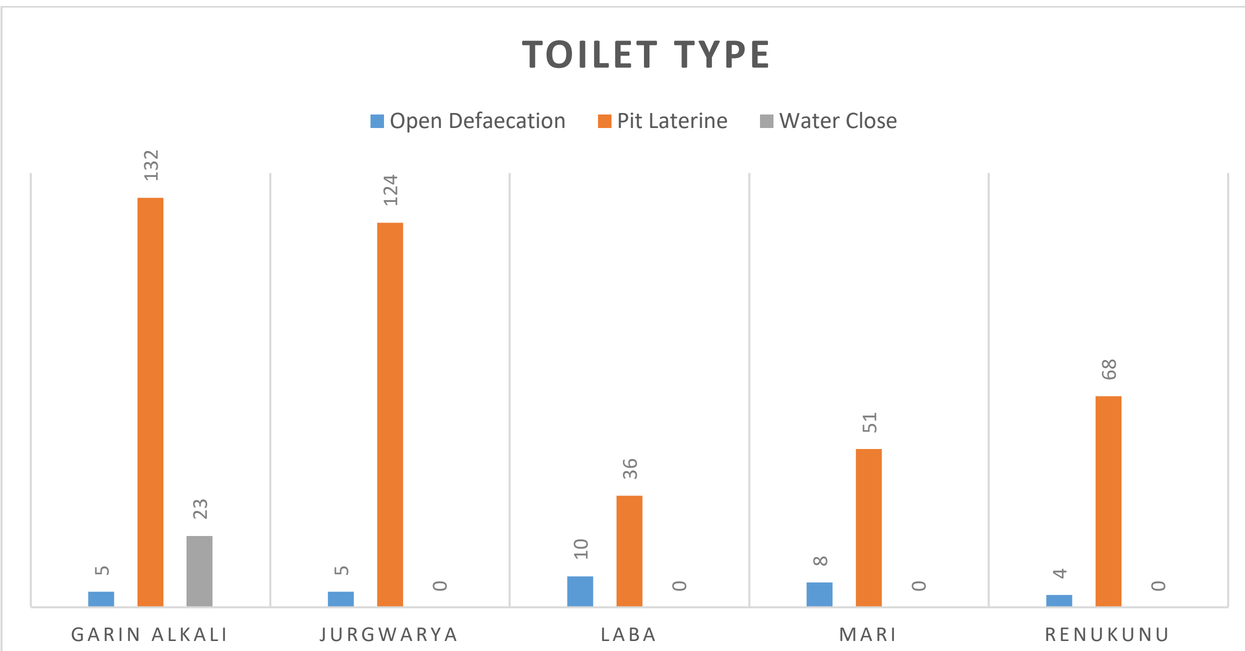

Figure 4.20: Types of toilets within the PACs
Source: Envicons Field Survey, 8th July, 2021

4.2.20 Source of Water

Boreholes and wells serve as the most relied sources of water for domestic use within the communities as shown in

Table 4.22. This shows a dependence on ground water which is common among rural communities nationally where there is no access to pipe-borne water systems.

Table 4.22: Source of water within the PACs

	Project Affected Communities					Total	Percentage
	Garin Alkali	**Jurgwarya**	**Mari**	**Laba**	**Renakunu**		
Stream/river	2	0	0	16	32	50	10.10
Well	2	66	0	0	0	68	13.74
Borehole	130	0	55	15	44	244	49.29
Pipe-borne water	69	63	0	1	0	133	26.87
TOTAL	**203**	**129**	**55**	**32**	**76**	**495**	**100.00**

Source: Field Survey; July, 2021

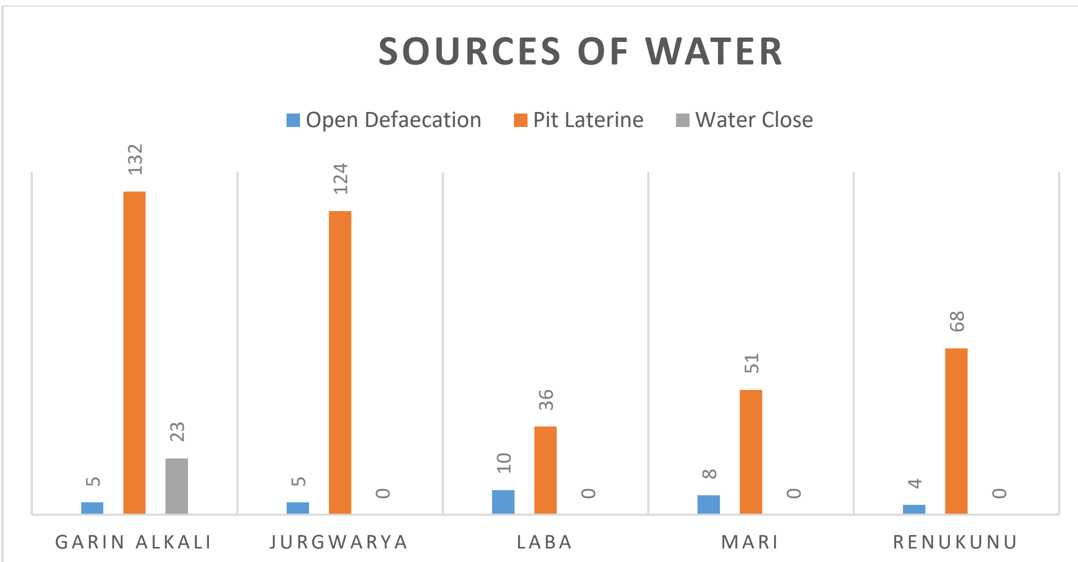

Figure 4.21: Sources of water for Domestic use within the PACs
Source: Envicons Field Survey, 8th July, 2021

4.2.21 Source of Power

Power in this context, refers to electricity or any form of illumination within communities. From the analysed data, it was observed that Garin Alkali is the only PAC that has electricity supply from the Power Holding Company of Nigeria (PHCN) as shown in Table 4.23. This is attributed to the fact that these Garin Alkali is closer to Gashua, is the largest PAC amongst the five, and is also regarded as a semi urban settlement. The remaining four communities do not have access to electricity as they indicated using local lanterns and candles for illumination at night.

Table 4.23: Source of Power supply within the PACs

	Project Affected Communities					Total	Percentage
	Garin Alkali	**Jurgwarya**	**Mari**	**Laba**	**Renakunu**		
PHCN	160	0	0	0	0	160	33.97
Solar	0	0	0	0	0	0	0.00
Generator	4	35	0	0	0	39	8.28
Local (Lanterns, candles)	0	92	59	46	75	272	57.75
TOTAL	**164**	**127**	**59**	**46**	**75**	**471**	**100.00**

Source: Envicons Field Survey, 8th July, 2021

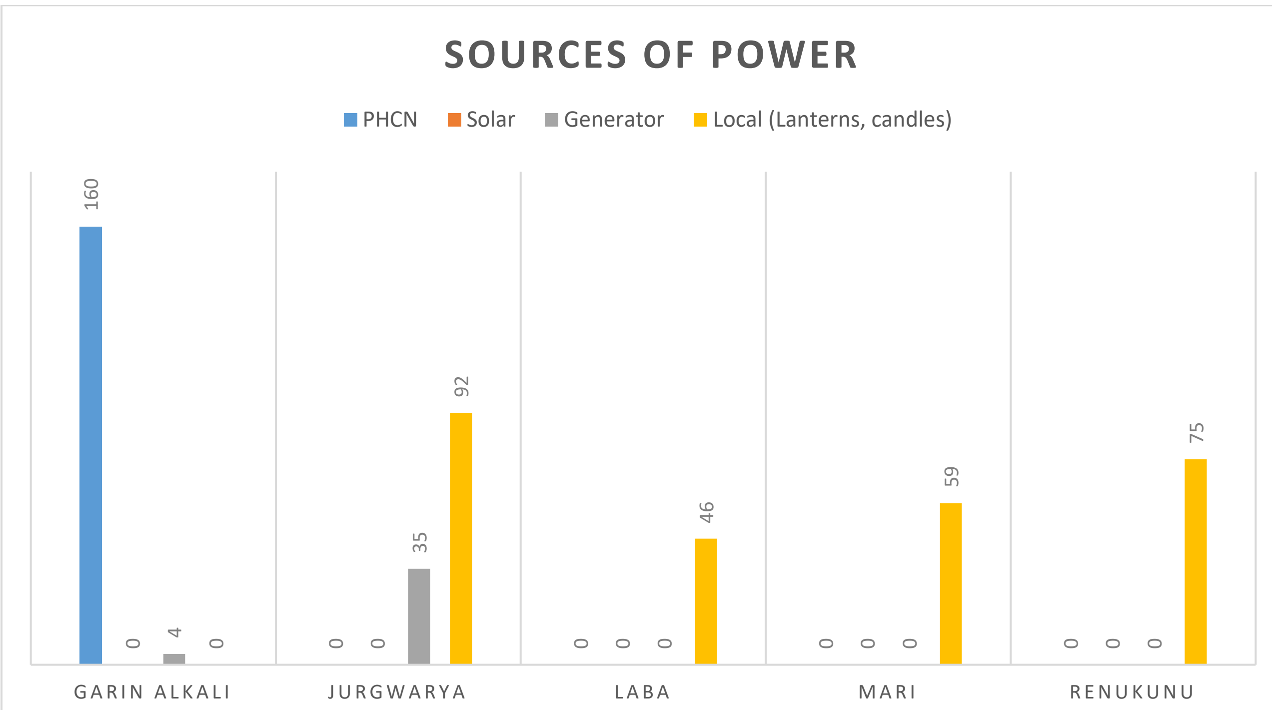

Figure 4.22: Sources of Power use within the PACs
Source: Envicons Field Survey, 8th July, 2021

4.2.22 Source of Energy for cooking and other uses

There are various sources of energy for domestic use in the contemporary society, but rural communities are rarely exposed to modern energy use. Hence, they stick to the old method of using fuel wood and charcoal for their cooking. This scenario is replicated amongst these 5 PACs which are mostly rural communities as shown in Table 4.24. The dependence on fuel wood as a primary source of domestic energy could be detrimental to both health (through frequent smoke inhalation when cooking which can lead to respiratory diseases) and the immediate environment (through desertification as a result of firewood sourcing).

Table 4.24: Source of Energy for cooking within the PACs

Project Affected Communities						Total	Percent age
	Garin Alkali	**Jurgwarya**	**Mari**	**Laba**	**Renakunu**		
Firewood	156	103	35	38	76	408	96
Kerosene	0	0	0	0	0	0	0
Gas	0	0	0	0	0	0	0
Electric Cooker	0	0	0	0	0	0	0
Charcoal	10	4	0	3	0	17	4
TOTAL	**166**	**107**	**35**	**41**	**76**	**425**	**100**

Source: Envicons Field Survey, 8th July, 2021

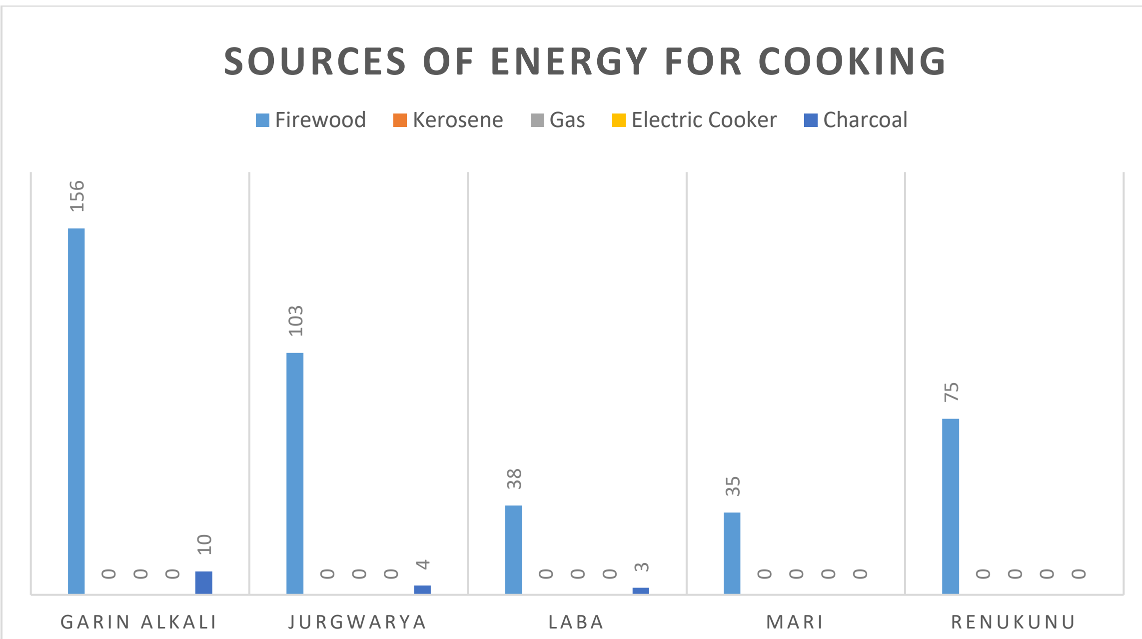

Figure 4.23: Sources of Energy for cooking within the PACs
Source: Envicons Field Survey, 8th July, 2021

4.2.23 Environmental challenges experienced within the PACs

The survey sought to know any environmental challenges faced by the PACs occurring naturally or as a result of man's activities. As such, the respondents were asked if they've experienced environmental challenges and 340 out of 471 respondents indicated that they have with flooding being the most prevalent case (Figure 134.24).

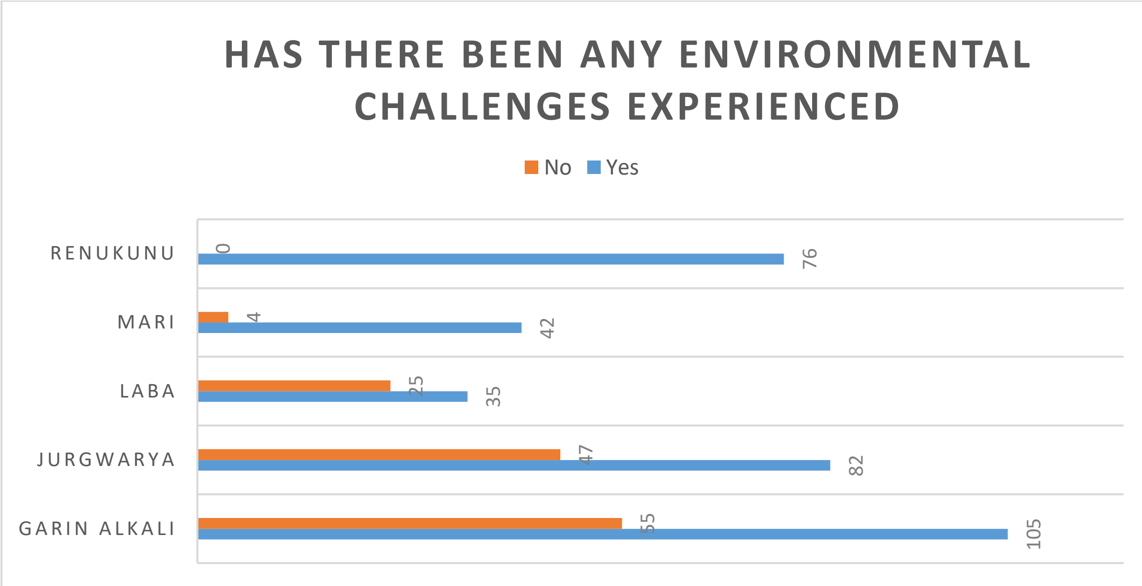

Figure 13: Experienced Environmental challenges within PACs
Source: Envicons Field Survey, 8th July, 2021

Table 4.25: Types of Environmental Challenges Experienced within the PACs

Project Affected Communities						Total	Percentage
	Garin Alkali	**Jurgwarya**	**Mari**	**Laba**	**Renakunu**		
Flooding	130	20	27	21	69	267	76.72
Erosion	58	7	6	0	1	72	20.69
Drought	3	4	0	0	2	9	2.59
Others	0	0	0	0	0	0	0.00
TOTAL	**191**	**31**	**33**	**21**	**72**	**348**	**100.00**

Source: Envicons Field Survey, 8th July, 2021

4.2.24 Knowledge on Gashua Irrigation Scheme

This question was asked in order to ascertain the level of awareness about the proposed project as shown

Table 4.26. It was deduced more or the respondents were aware of the project as it had long existed with a promise of expansion. However, respondents from Jurgwarya settlement appeared to be less knowledgeable about the irrigation project for reasons not explored by this study.

Table 4.26: Knowledge/ Awareness of the Gashua Irrigation Project within the PACs

	Project Affected Communities					Total	Percentage
	Garin Alkali	**Jurgwarya**	**Mari**	**Laba**	**Renakunu**		
Nothing	4	107	27	4	13	155	32.98
Very little	14	6	5	15	28	68	14.47
Little	83	6	24	3	14	130	27.66
Average	39	2	3	9	3	56	11.91
Very much	20	7	1	15	18	61	12.98
TOTAL	**160**	**128**	**60**	**46**	**76**	**470**	**100.00**

Source: Envicons Field Survey, 8th July, 2021

4.2.24 Objection to the Project

These questions were asked to the PACs to know their level of acceptance or objection of the project and to also gauge the adverse impact the project might have on their livelihood. Based on the findings of the survey, 92% of the respondents which is 431 out of 469 of the five PACs do not object to the project implementation because they are aware of the derivable economic opportunities. However, the remaining 8% which is 38 of these respondent's object to the project for unclarified reasons. Figure 4.25 clearly depicts these percentages.

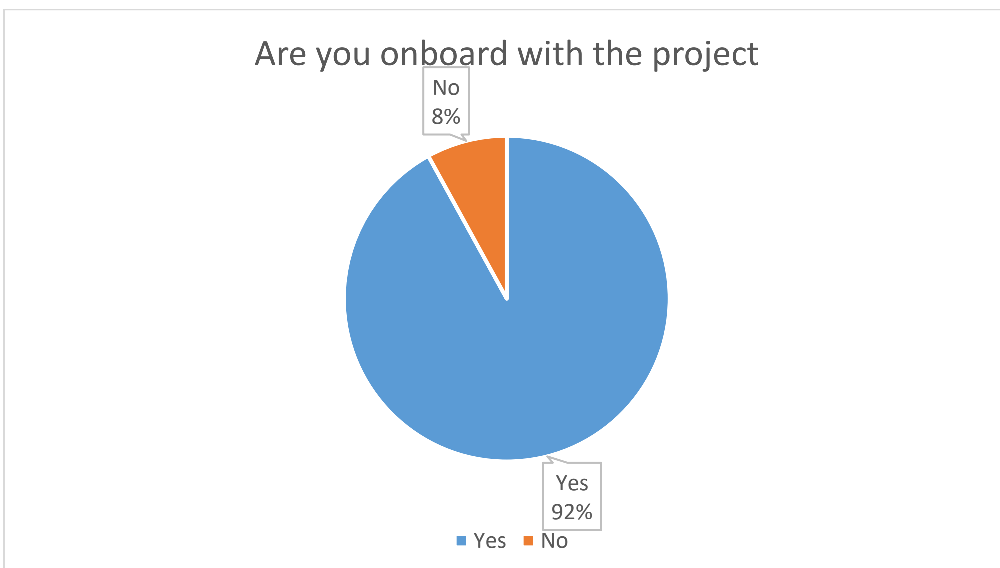

Figure 4.25: Response on objection to the project within the PACs
Source: Envicons Field Survey, 8th July, 2021

4.2.25 Unrest or tension within the Project Area

In some occasions, unrest or tensions arise as a result of development which brings together people with diverse ways of life and diverse opinions. Therefore, this survey sought to ascertain if there had been previous conflicts within this area, to be able to predict future unrest. With regards to this, 307 (65.5%) respondents indicated that there have been no unrest or tension within the area while the other 162 (34.5%) respondents indicated that there have been past unrest and tension within the designated project area (Figure 4.26). As a result, it became imperative to explore the conflict resolution mechanisms applicable to the study area.

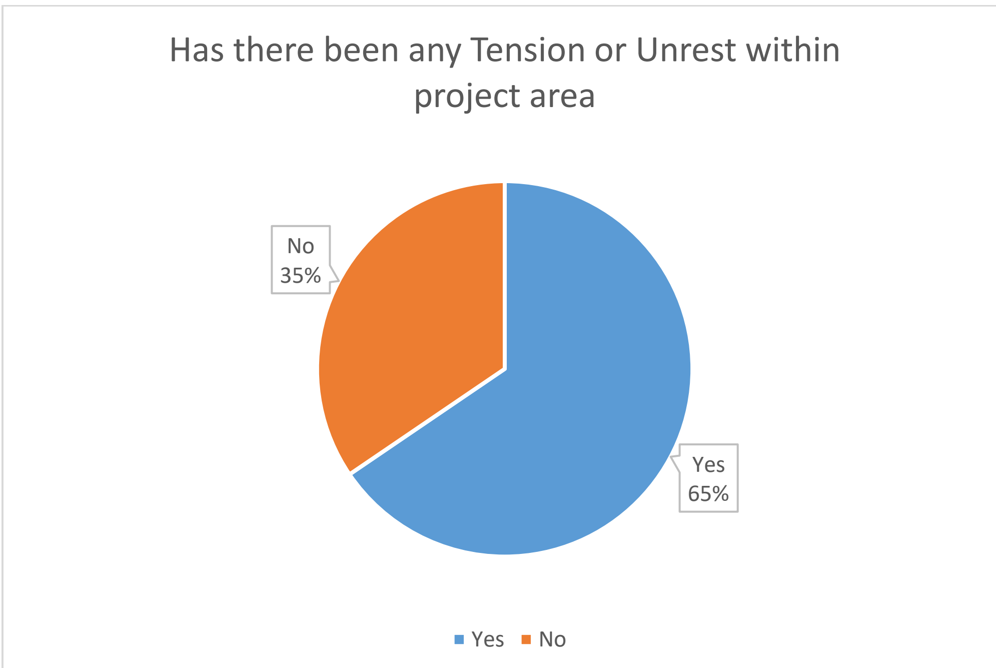

Figure 4.26: Response on Tension or Unrest within the project area
Source: Envicons Field Survey, 8th July, 2021

4.2.25.1 Conflict Resolution Mechanism

The quest for Peace and Security includes all activities within the specific framework of conflict resolution mechanism. It consciously targets the attitudes and behaviours of parties to a conflict as well as community peace and stability with the primary goal of preventing violence and a secondary goal of facilitating to its resolution. In the traditional societies, mediation, adjudication, reconciliation, and arbitration are tools of conflict resolution. While there are rare cases of clashes, the most common clashes occur between farmers and herdsmen. In the event of such clashes or any other conflict, the matter is first reported to the

Lawan/Mai-Agwan (Village Head) and is settled amicably. Where the matter could not be resolved at the level of the Village Head, it is reported to the Police Station at Garin Alkali where the Divisional Police Officer (DPO) presides over the matter. Where there is no resolution at this level, the matter is charged to court in the case of a criminal matter or referred to the Emir at Gashua in the case of a civil matter. This is illustrated in Figure 144.27.

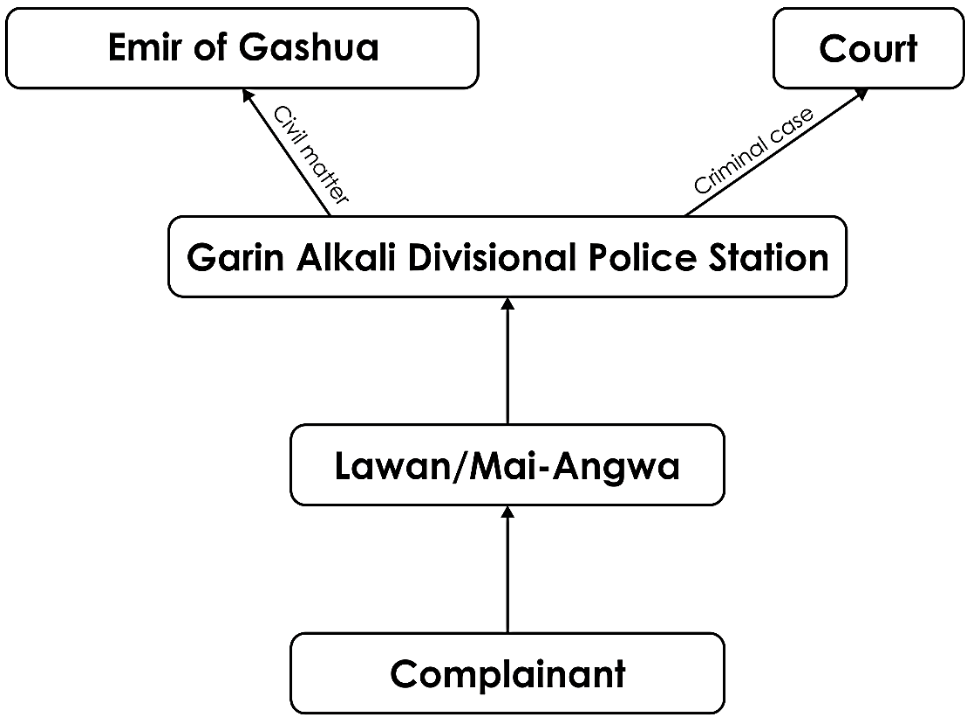

Figure 1427: Conflict Resolution Channel
Source: Envicons Field Survey, 8th July, 2021

4.2.26 State of Infrastructure within the Community

Besides the observation of available infrastructure within these PACs, the respondent perception of the state of available infrastructure was also sought. Based on collected data, only respondents in Garin Alkali and Jurgwarya settlements indicated to having good states of infrastructure. This includes the Gashua-Damaturu road which is in very good condition and the availability of schools and health facilities. The other remote settlements like Renakunu and Laba appeared to be disadvantaged in quality of available facilities

To further elaborate the state of infrastructure within these PACs, collective opinions are tabulated in Table 4.27.

Table 4.27: State of Infrastructure within the five PACs

	Project Affected Communities					Total	Percentage
	Garin Alkali	**Jurgwarya**	**Mari**	**Laba**	**Renakunu**		
Very poor	0	34	13	30	17	94	19.96
Poor	15	31	18	16	5	85	18.05
Pair	36	13	29	0	48	126	26.75
Good	105	49	0	0	4	158	33.55
Very good	4	2	0	0	2	8	1.70
TOTAL	**160**	**129**	**60**	**46**	**76**	**471**	**100.00**

Source: Envicons Field Survey, 8th July, 2021

4.3 ANALYSIS COLLECTED SAMPLES

Biophysical Environment Conditions

The representative samples collected for this exercise were soil, air, noise, and water samples collected at various parts of the project site, in order to establish the baseline quality of environmental features before the impact of the project. The coordinates of these samples were taken from the field. These coordinates were plotted on the proposed site boundary to show the spread of sample collection (see figure 4.28).

4.3.1 Air Quality

Air pollution, both indoor and outdoor, is a major environmental health problem which in most places is over looked. It comes from sources such as dust, gases and smokes and is generated mainly by human activities but also naturally. In recent times there has been apprehension of indoor air quality for obvious reasons.

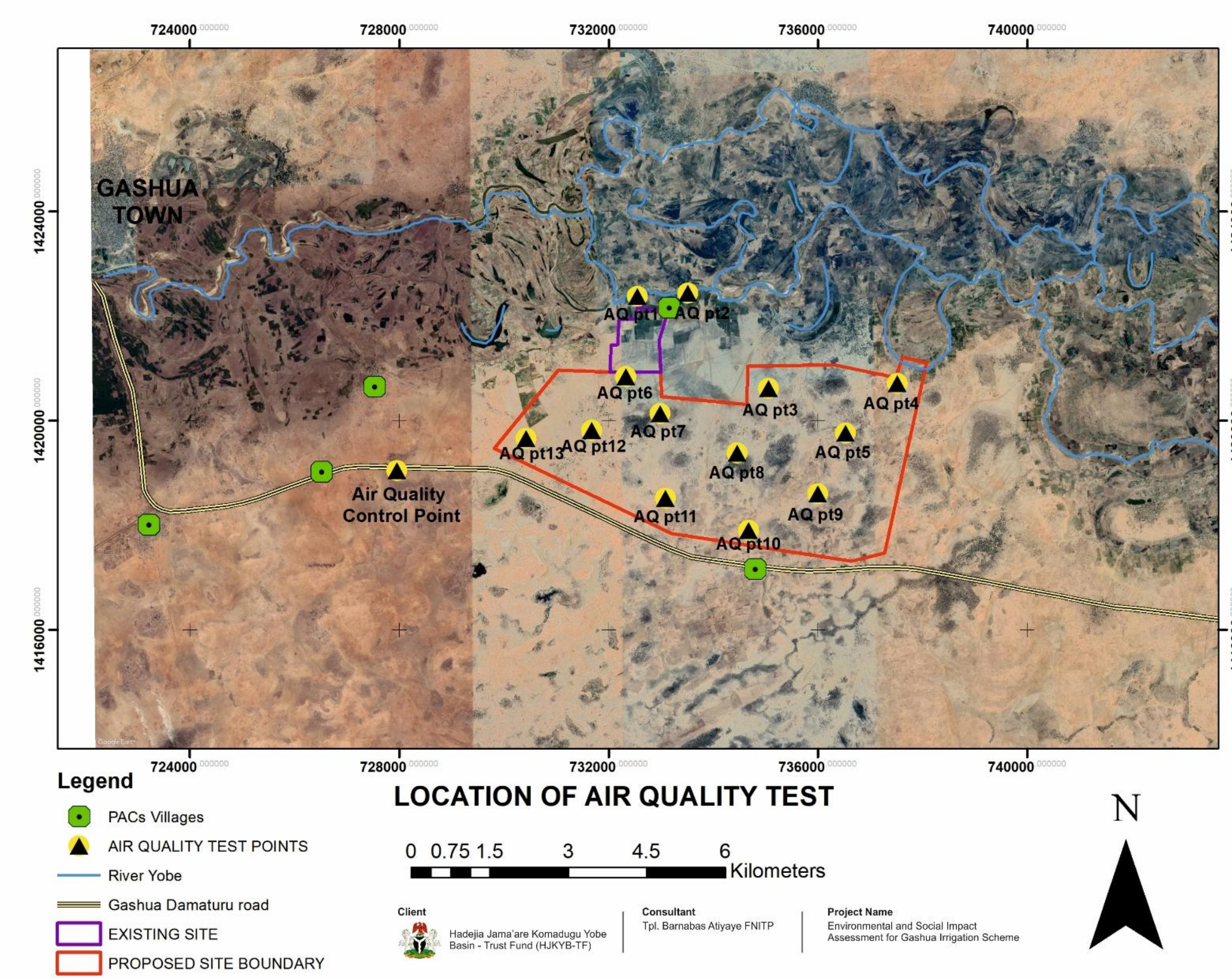

Figure4.28: Distribution of collected air samples

Source: Envicons Field Survey, 8th July, 2021

i. Air Quality Assessment Method.

The quality of ambient air is of paramount importance to environmental chemistry and air quality. Ambient air constitutes a wide range of air pollutants ranging from particulate matter of different sizes and compositions, critical air pollutants such as Oxides of Sulphur (SOx), Carbon Monoxide (CO), Oxides of Nitrogen (NOx), and methane (CH_X). Abnormal concentrations of these pollutions in the ambient air are a consequence of anthropogenic activities within an environment. The ambient air quality was measured at a height of three feet above ground level and a measurement was carried out accordingly. Methods of analysis employed in this study are those selected by World Health Organization (WHO) as well as those adapted from the United States Environmental Protection Agency (USEPA). The Federal Ministry of Environment in Nigeria has adopted the methods for the purpose of surveillance and monitoring of air pollutants. The theoretical methods are unique to each pollutant and are therefore shown in
Table 1728.

Table 1728: Air Quality Analytical and Test Methods

S/N	COMPONENTS	MEASUREMENT	TYPE/METHOD
1.	Carbon Monoxide (CO)	Field	Crowcon GASMAN (Handheld detection instrument) In Situ
2.	Ammonia (NH_3)	Field	Crowcon GASMAN (Handheld detection instrument) In Situ
3.	Sulphur Oxides (SO_X)	Field	Crowcon GASMAN (Handheld detection instrument) In Situ
4.	Hydrogen Sulphide (H_2S)	Field	Crowcon GASMAN (Handheld detection instrument) In Situ
5	Nitrogen oxides (NOX)	Field	Crowcon GASMAN (Handheld detection instrument) In Situ
6	Oxygen/Methane/Hydrogen (O_2, CH_X, H_2S, CO)	Field	MSA ALTAIR (Multi Gas Monitor) (Handheld detection instrument) In Situ
7	Suspended Particulate matter	Field	Haz- Dust particulate matter In situ
8	Noise Meter/Relative Humidity/ Temperature	Field	Environmental Meter In situ

Source: Envicons Field Survey, 8th July, 2021

ii. Quality Assurance and quality control measures

A quality control programme was established at the beginning of the fieldwork in order to ensure the validity of results and comparability of acquired environmental and biological data. This involved detailed procedural guidelines for sampling, preservation, labelling, and storage and laboratory analysis. To ensure the accuracy and reliability of in-situ field measurements, field instruments were calibrated prior to use and cross checked from time to time.

Field data sheets were carefully kept and inspected at the end of the day's field work to make sure that no sample is missed. Other quality control measures adopted in the field included:

a. Representation of samples and repeatability of data
b. samples collection, preservation and storage
c. adequate labelling
d. Minimizing laboratory sampling error or bias and
e. Data verification.

Data sheet for relevant environmental and ecological observations as well as laboratory logbook for laboratory-based aspects of the study were kept through-out the duration of the field work. To ensure that results obtained during analysis compare favourably with the in-situ environment, all samples were analysed soon after collection. Standard laboratory quality control procedures were adhered to.

iii. Sampling points

The sampling points were selected randomly within the study area and those around the immediate vicinity covering the recommended 500M-1000M radius. The sampling points were adequately captured by the use of a GPS and photo identifiable features on satellite imagery of the location. The overriding considerations in the selection of sampling points included accessibility, ecological features and geographical location of settlement and sitting of control points in apparently undisturbed areas.

iv. CROWCON GASMAN/MSA ALTAIR (Detection Instrument)

An intrinsically safe personal gas detector is designed to warn the user of dangerous conditions in the immediate vicinity. It is designed to monitor for the presence of flammable gases, enrichment of oxygen, also for presence of other toxic gases. With the unit placed in normal air (site of visit) the switch was turned on to the GAS position and ready for use while the MSA Altair has an on and off switch button which was switched on and allowed for few minutes to be stable before readings were taken. Reading unit is parts per million (ppm) for all the gases measured.

v. Haz-Dust Particulate

This is portable particulate monitoring device that uses infrared electromagnetic radiation to sense airborne particles. The sensing method is traditionally referred to as near forward light scattering. The mass concentration read out is expressed in milligrams per cubic meter (Ug/m^{-3}). The equipment is hand held so that the display would be in an upward facing position to enable the expert to take reading.

vi. Decibel (sound level Meter) /Relative Humidity/Temperature

This instrument has three measuring ranges (30-80, 50-100, 80-130). A proper measuring range is selected by pressing the Range Button after powering on the unit. The instrument is held at a height so that the microphone sensor measures the noise level, the sound level value of decibel (dB) will be displayed on the Liquid Crystal Display (LCD). It also measures relative humidity and the temperature by simply selecting the button for each parameter.

vii. Air Quality and Noise Levels at Proposed Gashua Irrigation Schemes Yobe.

Air pollution is a major health problem affecting developing Countries around the world. Increasing amounts of potentially harmful gases and particles are being emitted into the atmosphere on a global scale, resulting in damage to human health and the environment.

Air pollution could result from stationary and mobile sources. Stationary sources include agricultural production, quarrying manufacturing of chemicals, power generation, community sources (e.g. heating of and building-most especially in temperate zones) municipal wastes and sewage sludge incinerations, fireplaces, cooking facilities etc. while mobile sources comprise of any form of combustion engine vehicles.

Air quality at Gashua Irrigation Schemes was carried out randomly to determine the quality of ambient air within the proposed project site. Pollutants measured during the field data gathering includes **NO_2**, **SO_2**, **CO**, **H_2S**, **NH_3**, **CH_4**, **O_2** and **SPM** within the site, while temperature, relative humidity and noise were equally measured for the environment climatic condition.

Plate 4.11: Ambient Noise Level Measurement

Plate 4.12: Weather Parameters Measurement

Plate 4.13: Air Quality Measurement

Table 1829: Result of Gaseous Pollutants Concentration in the Study Area.
AIR QUALITY (8th -9th JULY, 2021)

SAMPLE LOCATION	TIME	GEOGRAPHICAL LOCATION in UTM	PARTIC Mg/M³	NOISE dB	RELATIVE HUMIDITY %	WIND SPEED	TEMP ⁰C	CH_4 ppm	CO ppm	SO_2 Ppm	NH_3 Ppm	H_2S ppm	O_2 ppm	NO_2 ppm
Point 1	11:51am	ELEV. 336 M 732544.57 mE 1422372.91 mN	0..11	50.7	51.0	16.5	34.1	0	01	0.00	0.00	0.00	20.8	0.01
Point 2.	12:55pm	ELEV. 333 M 733516.09 mE 1422440.58 mN	0.16	58.7	48.9	19.7	35.4	0	01	0.00	0.00	0.00	20.8	0.01
Point 3.	01:27pm	ELEV. 337 M 735057.86 mE 1420612.85 mN	0.13	85.7	44.9	16.4	37.9	0	01	0.00	0.00	0.00	20.8	0.02
Point 4.	02:01pm	ELEV. 335 M 737519.45 mE 1420705.91 mN	0.11	57.1	44.0	9.8	38.1	0	01	0.00	0.00	0.00	20.8	0.01
Point 5.	02:43pm	ELEV. 334 M 736527.37 mE 1419755.3214 mN	0.12	54.8	44.9	11.0	38.4	0	01	0.00	0.00	0.00	20.8	0.01
Point 6.	02:57pm	ELEV. 336 M 732328.49 mE 1420838.66 mN	0.11	51.8	42.8	12.7	36.7	0	01	0.00	0.00	0.00	20.8	0.01
Point 7.	03:19pm	ELEV. 331 M 732981.57 mE 1420132.76 mN	0.14	45.9	44.4	8.1	37.4	0	01	0.00	0.00 0	0.00	20.8	0.01
Point 8.	09:27am	ELEV. 339 M 734453.41 mE 1419378.55 mN	0.07	48.6	68.3	11.8	29.9	0	02	0.00	0.00	0.00	20.8	0.02
Point 9.	09:33am	ELEV. 339 M 736000.48 mE 1418602.21 mN	0.08	67.8	68.1	9.9	28.8	0	01	0.00	0.00	0.00	20.8	0.02
Point 10.	09:40am	ELEV. 343 M 734671.62 mE 1417896.92 mN	0.07	58.7	61.8	14.7	30.0	0	02	0.00	0.00	0.00	20.8	0.02
Point 11.	09:47am	ELEV. 341 M 733086.79 mE	0.07	64.8	59.9	8.8	30.8	0	01	0.00	0.00	0.00	20.8	0.01

		1418509.85 mN												
Point 12	09:53am	ELEV. 339 M 731679.58 mE 1419813.50 mN	0.08	48.4	58.9	9.2	30.9	0	01	0.00	0.00 0	0.00	20.8	0.02
Point 13.	09:59am	ELEV. 339 M 730425.28 mE 1419658.24 mN	0.08	52.0	59.0	10.1	31.0	0	02	0.00	0.00	0.00	20.8	0.02
Point 14. Control	10:07am	ELEV. 338 M 727956.15 mE 1419039.87mN	0.08	68.2	60.2	12.9	30.7	0	02	0.00	0.00	0.00	20.8	0.02
FMENV LIMIT	**-**		**<0.25**	**90**	**-**	**-**	**<40**	**-**	**10**	**0.01**	**0.05**	**0.05**	**20.9**	**0.06**

Source: Envicons Field Survey, 8th July, 2021

viii. Total Suspended Particulate Matter.

This occurs in the atmosphere in the form of dust, smoke, and other aerosols. Tiny airborne particles or aerosols that are less than 100 micrometres are collectively referred to as Total Suspended Particulate (TSP). These particles constantly enter the atmosphere from natural and human sources. Human sources include; Motor vehicle use, combustion products from space heating, industrial processes, Power generation and dust releasing activities while natural sources include: Soil, Bacteria and viruses, fungi, molds and yeast, Pollen and salt particles from evaporating sea water. Total Suspended particulates at the study area fall between 0.07- 0.16ug/m^3 which is within the recommended limit of 0.25ug/m^3 set by Federal Ministry of Environment (FMENV).

This shows significant low variation; the level of particulate values could be attributed to the wet season that has comment gradual in this area the medium dusty area couple with the fact of the agriculture activities within the day and the gradual coming of wet season currently experience in which shows average particulate matter within the site.

ix. Noise and Vibration

Noise is the periodic fluctuations of air pressure. Noise is a collection of sounds in environment in relation to its psychological effect on the receptors. Unpleasant sound can also be referred to as noise. However, in an office environment or other environment sounds are produced by almost every component that makes the environment workable and suitable for living organisms i.e., vehicular movement, pumping machines, the air conditioning system, generators set and equipment's that makes sound in the environment. While in small industry and large we have higher noise level because of the heavy equipment's that are been used in the industries. At the study area noise level was found to be within the acceptable limit of FEMENV. The values gotten at the study area reads 42.8dB (A) to 68.3dB (A). This is within the federal Ministry of Environment recommended standard of 90dB (A). All the fourteen (14) points including the control was taken, it shows that it's within the acceptable limit. This is attributed to the fact major farming activities has not much commence and all the villages are a little bit far from the project site most of the noise gotten are from pumping machine or from vehicular movement because the project is a bit close to the road the probability of the noise increasing when the project commence is possible fact from all indication but standard guideline and procedures will be adhered to so as to ensure that it is not above the recommended standard set by Federal Ministry of Environment.

x. *Gaseous Pollutants*

Oxides of Nitrogen (NO_X), oxides of Sulphur (SO_X), Oxides of Carbon (Co_x) Ammonia (NH_3), Hydrogen sulphide (H_2S) and Oxygen (O_2) were also measured within the study area and results presented above.

xi. *NO_2 (Nitrogen dioxide)*

Nitrogen dioxide (NO_2) is a red-brown pungent gas that is typically formed as a result of combustion processes. It is heavier than air with a vapor density of 1.58 compared to 1.0 for standard air. The odour threshold for NO_2 is between 1-6 parts per million (1,880-11,280 ug/m^3).

Nitrogen dioxide gas is highly reactive, corrosive to metals and is a strong oxidizing agent. It combines with water to form nitric acid (HNO_3) and nitric oxide (NO). Nitrogen dioxide is toxic to various animals as well as to humans. Its toxicity relates to its ability to form nitric acid with water in the eye, lung, mucus membrane and skin. Laboratory studies show susceptible humans such as asthmatic persons exposed to high concentrations of NO_2 can suffer lung irritation and potentially, lung damage and illnesses of the respiratory organs.

NO_2 was recorded between 0.01ppm - 0.02ppm within the study area. These readings are within the recommended limit of 0.06 set by FMEnv for Nigeria environment. This cannot be disputed to the fact, that work has not commence on site the issues of air pollution is of great minimum and the traces are from vehicular movement and some patches of burning.

xii. *Sulphur Dioxide (SO_2)*

Sulphur dioxide SO_2 is a colourless, water-soluble gas that is reactive and has a pungent odour. Sulphur dioxide is detectable to the human nose at concentration of around 0.5-0.8 parts per million. Concentrations of SO_2 in ambient air typically occur as a result of combustion processes in particular the burning of high sulphur fuels, although specific industries such as fertilizer manufacturing also discharge SO_2. Sulphur dioxide is subject to a series of transportation processes in the atmosphere, which can result in, sulphurous and sulphuric acids sulphites and sulphates being formed.

Sulphur dioxide causes its irritants effects by stimulating nerves in the lining of the nose and throat and the lung's airways. This causes a reflex cough, irritation, and a feeling of chest tightness which may lead to narrowing of the airways. Asthmatics are generally considered the most sensitive group in the community to concentration of **SO_2**.

SO_2 was not detected at any point during air quality analysis, the values read 0.00 ppm during the analysis which shows that it is in conformity with the Federal Ministry of Environmental standard. These gaseous components of the air are expected to be released from fuel combustion engines during the operational phases of the project.

xiii. Carbon Monoxide (CO)

Carbon monoxide (CO) is a colourless, odourless and tasteless gas that is a product of the incomplete combustion of solid, liquid and gaseous carbon-based fuels. CO results from burning of gasoline, natural gas, coal, oil etc. Breathing CO reduces the ability of blood to transport oxygen to body cells and tissues; cells and tissues need oxygen to work. It may be particularly hazardous to people who have heart or circulatory (blood vessel) problems and people who have damaged lung or respiratory tract. Sources of carbon monoxide concentration in ambient air are typically motor vehicle emission and domestic home heating in most urban centre areas.

Concentrations of carbon monoxide in the indoor environment from indoor sources can also pose a major health threat. High concentrations of CO indoors can occur as a result of emission from non-vented gas cookers and heaters. Carbon monoxide impacts on health by reducing the oxygen carrying capacity of the blood. This occurs because CO binds more readily to haemoglobin than oxygen does and results in the formation of carboxyhaemoglobin (COHb), which leaves less haemoglobin available for transferring oxygen around the body. Carbon monoxide was detected within the study area at difference point reading from 1ppm-2ppm which is far below the maximum limit of 10ppm set by FMEnv. This has to do with the fact that no activities have commence on the site presently but their likely to be increase of CO when work commence in earnest

xiv. Oxygen (O_2)

The air we breathe contains approximately 20.9% oxygen. Most of the remaining 79% is made up of nitrogen with smaller quantities other gases such as argon and carbon-dioxide. Low levels of oxygen can lead to impaired judgment, lack of coordination, behaviour changes, dizziness, fatigue, and ultimately collapse and death. Oxygen level at the project area of the environment was 20.8% throughout the air quality readings which is within the recommended standard set by Federal Ministry of Environment.

xv. Hydrogen Sulphide (H_2S)

Hydrogen sulphide is a colourless gas with the characteristic's foul odour of rotten eggs; it is heavier than air, very poisonous, corrosive and flammable. It often results from the bacterial breakdown of organic matter in the absence of oxygen gas, such as in swamps and sewers. This process is commonly known as anaerobic digestion. Hydrogen sulphide was not detected at any point within the study area. That's mean its reads 0.00 ppm at the fourteen (14) points where the air quality was taken including the control point.

xvi. Ammonia (NH_3)

Ammonia is a colourless gas with a pungent odour that is noticeable at concentration above 50ppm. It is poisonous if inhaled in great quantities and irritating to the eyes, nose, and throat in lesser amounts. At normal atmospheric pressure, ammonia has a boiling point of -28 EF (Emission Factor) and a freezing point of -107.86 EF. It is highly soluble in water, with one volume of water absorbing 1.148 volumes of ammonia at 32 EF. Ammonia was not detected at any Point during the air quality analysis at the project site.

The table below shows some primary pollutant and their adverse effects; Particular matter and other aero allergen have little (infinitesimal) impact on the environment under review.

Table 4.30: Primary pollutants and their adverse effects.

Pollutant	Effect above limit
Carbon monoxide (CO)	Reduces oxygen carrier leading to damage of the central nervous system
Carbon dioxide (CO_2)	Causes asphyxiation, blood acidosis
Sulphur IV oxide (SO_2)	Causes irritation of the respiratory tract
Nitrogen II oxide (NO_2)	Causes inflammation of the lungs but less toxic
Ammonia (NH_3)	Causes throat and upper respiratory tract damage and may affect heart action.
Hydrogen Cyanide (HCN)	Causes enlarged thyroid glands, dermatitis scarlets rash and nose irritation.
Chlorine (Cl_2)	Causes fatigue inflammation of mucus membrane of the nose, susceptibility to tuberculosis and corrosion of teeth.
Methane (CH_4)	Simple asphyxiation
Particular matter (PM)	Causes lung cancer, silicosis, heart diseases, exacerbate asthmatic symptoms, chronic bronchitis and death.

4.3.2 Hydrogeology

Samples of Ground water (GW) and Surface water (SW) samples were collected from the project site; Gashua Irrigation Schemes Yobe and taken to Zabson Laboratory located at Masaka, Nasarawa State for analysis following the standard operational procedures. Three (3) ground water samples were collected while five (5) surface water samples were collected within the project site. In-situ measurement for pH, temperature, conductivity and Dissolved oxygen were conducted with hand-held meters in the filed for each parameter; for other physio-chemical analysis, duplicate water samples were collected in to one-litre plastic bottled and duly labelled and stored in an insulated refrigerated container and later analysed at the laboratory. The result of the physical, chemical and microbiological characteristics of the collected water samples is presented in **Table31.**

Plate 4.14 Surface Water Sample Coding

Plate 4.15: Borehole Water Sampling

Plate 4.16: *In-situ* Measurement of Borehole Water Sample Parameters

Plate 4.17: Collection of ground and surface water samples, in situ testing and labelling
Source: Envicons Field Survey, 8th July, 2021

Physico-chemical properties of Groundwater
The following parameters were investigated for the ground water and surface water at the Project site; levels of heavy metals including **Pb**, **Cu**, **Zn**, **Cd**, **Ni**, **Mn**, **Fe**. Other parameter includes pH, Electrical Conductivity, Total Suspended Solids (TSS), Total Hardness, Total Dissolved Solids (TDS), **Ca**, **Mg** where relevant. Also, **BOD**, **COD**, was also analysed

Microbiology analysis of ground water samples were also carried out. The analytical results are shown in table 4.32. The FMEnv limits have also been included for ease of references.

The physical and chemical properties of closet surface water within the project site was assessed. Sample was collected from a stream source, sharing boundary with the project site. Summary of assessed physical and chemical characteristics of the surface samples measured in-situ is presented below:

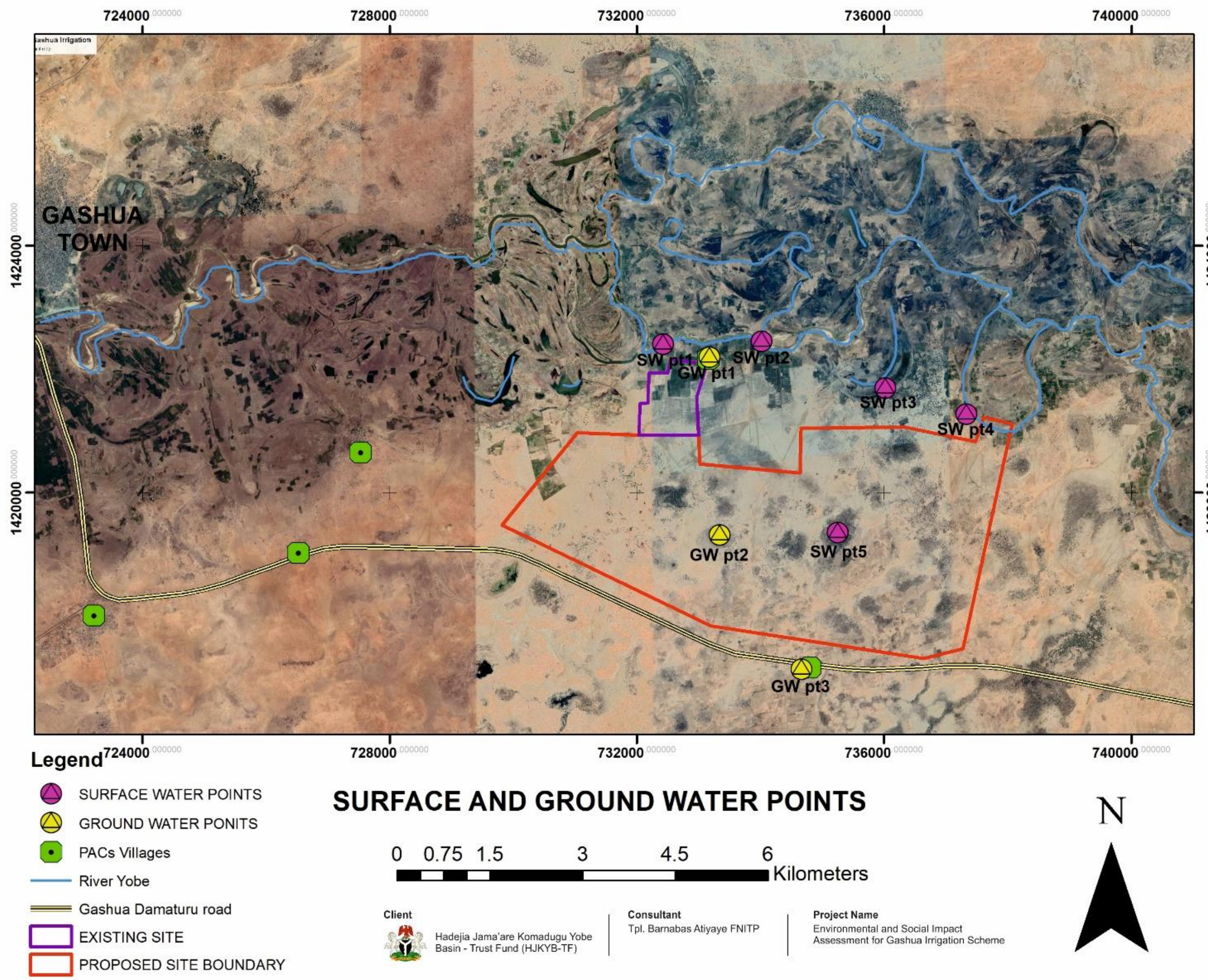

Figure 1529: Distribution of Surface and Ground water samples

Table4.31: PHYSICO-CHEMICAL ANALYSIS OF SURFACE WATER SAMPLE

S/N	PARAMETERS	SW1 U/stream (GIS)	SW2 Midpoint (GIS)	SW 3 D/stream (GIS)	SW 4 (GIS)	SW 5 (GIS)	FMEnv. STD
		732422.66 mE 1422399.55 mN	734016.93 mE 1422448.40 mN	736015.81 mE 1421686.41mN	737326.84 mE 1421264.02 mN	735249.54 mE 1419342.1 mN	
A.	**PHYSICAL TEST RESULTS**						
1.	ODOUR	UNOBJECTIONA BLE	UNOBJECTIONA BLE	UNOBJ/ECTIONA BLE	UNOBJECTIONA BLE	UNOBJECTIONA BLE	-
2	COLOUR	Brown	Brown	Brown	Colourless	Brown	Colourless
3	TEMPERATURE (°C)	34.0	33.1	34.0	33.9	33.3	25-35
4.	pH	7.8	7.7	7.7	7.3	6.9	6-9
5.	DISSOLVED OXYGEN (mg/l)	6.40	6.60	6.80	1.10	6.80	7.0
6.	ELECTRICAL CONDUCTIVITY (µS/cm)	118	104	121	260	129	1000
7.	TOTAL DISSOLVED SOLIDS (mg/l)	62.6	54.5	63.8	136.3	67.3	1000
8.	TURBIDITY (NTU)	1.4	2.1	1.8	2.4	1.2	5
9.	TOTAL SUSPENDED SOLIDS (mg/l)	0.3107	0.2422	0.1158	0.2631	0.2844	<10
B.	**CHEMICAL TEST RESULTS**						
10.	TOTAL HARDNESS (mg/l)	85.6.	85.6	102.72	136.96	119.84	NS
11.	MAGNESIUM (mg/l)	17.12	34.24	34.24	51.36	34.24	NS
12.	CALCIUM (mg/l)	68.48	51.36	68.48	85.6	85.60	NS

13.	TOTAL CHLORINE (mg/l)	0.013	0.015	0.018	0.019	0.011	0.2
14.	SULPHATE (mg/l)	110.0	110.0	100.0	100.0	130.0	500
15.	PHOSPHATE (mg/l)	1.152	1.382	1.101	1.203	1.102	5
16.	NITRATE AS NITROGEN (mg/l)	7.80	9.10	1.30	9.70	7.00	10
17.	NITRITE AS NITROGEN (mg/l)	0.273	0.449	0.517	0.811	0.391	1
18.	BIOCHEMICAL OXYGEN DEMAND (mg/l)	14.6	11.8	10.2	16.5	21.2	30
19.	CHEMICAL OXYGEN DEMAND (mg/l)	58.4	47.2	40.8	66.0	84.8	100
C	**HEAVY METALS**						
20.	LEAD (mg/l)	0.009	0.007	0.010	0.012	0.009	0.05
21.	CADMIUM (mg/l)	0.004	0.003	0.004	0.009	0.003	0.02
22.	MANGANESE (mg/l)	0.020	0.019	0.023	0.030	0.023	NS
24.	COPPER (mg/l)	0.004	0.005	0.006	0.009	0.010	0.1
25.	IRON TOTAL (mg/l)	3.203	2.075	1.501	1.345	3.045	0.2
26.	ZINC (mg/l)	0.420	0.575	0.405	0.345	0.315	1
D	BACTERIOLOGICAL ANALYSIS						
27.	TOTAL COLIFORM (MPN/100mL)	12.8×10^7	12.0×10^7	9.2×10^7	9.7×10^7	8.5×10^7	400

28	E-COLI (CFU/100mL)	3.9×10^4	3.3×10^4	3.4×10^4	3.8×10^4	3.6×10^4	0.0
29.	SALMONELLA (CFU/100mL)	3.5×10^6	3.5×10^6	3.7×10^6	3.6×10^6	3.5×10^6	0.0
30.	SHIGELLA (CFU/100mL)	2.2×10^4	2.1×10^4	2.2×10^4	2.4×10^4	2.1×10^4	0.0
31	YEAST/MOLD (CFU/100mL)	7.2×10^4	4.9×10^4	4.1×10^4	5.0×10^4	4.4×10^4	0.0
32.	STAPHYLOCOC CUS (CFU/100mL)	2.9×10^4	4.4×10^4	10.9×10^4	3.2×10^4	3.6×10^4	0.0
33.	KLEBSELLIA (CFU/100 ml)	2.3×10^4	ND	3.4×10^4	2.9×10^4	ND	0.0

ND = Not Detected NS = Not stated SW = **Ground Water** GIS=Gashua Irrigation Scheme

Source: Envicons Field Survey, 8th July, 2021

Table 4.32: PHYSICO-CHEMICAL ANALYSIS OF GROUND WATER SAMPLE

S/N	PARAMETERS	GW1 (GIS)	GW2 (GIS)	GW 3 control	FMEnv. STD
		733172.40 mE 1422190.62 mN	733338.15 mE 1419305.94 mN	734661.64 mE 1417134.88 mN	
A.	**PHYSICAL TEST**				
1.	ODOUR	UNOBJECTIONABLE	UNOBJECTION ABLE	UNOBJECTION ABLE	-
2	COLOUR	Colorless	Colorless	Colorless	-
3	TEMPERATURE (°C)	31.9	29.9	30.6	<40
4.	pH	7.2	7.1	7.1	6-9
5.	DISSOLVED OXYGEN (mg/l)	5.50	5.0	4.80	7.5
6.	ELECTRICAL CONDUCTIVITY (μS/cm)	120	234	281	1000
7.	TOTAL DISSOLVED SOLIDS (mg/l)	63	119	144	500
8.	TURBIDITY (NTU)	1.0	1.1	1.0	5
9.	TOTAL SUSPENDED SOLIDS (mg/l)	0.0477	0.0524	0.0512	10
B.	**CHEMICAL TEST**				
10.	TOTAL HARDNESS (mg/l)	136.96	85.6	119.84	200
11.	MAGNESIUM (mg/l)	34.24	34.24	34.24	50
12.	CALCIUM (mg/l)	102.72	51.36	85.60	150
13.	TOTAL CHLORINE (mg/l)	0.017	0.007	0.015	0.2
14.	SULPHATE (mg/l)	7.80	17.90	24.30	500
15.	PHOSPHATE (mg/l)	0.682	0.284	0.531	5
16.	NITRATE AS NITROGEN (mg/l)	4.470	7.190	10.00	20
17.	NITRITE AS NITROGEN (mg/l)	0.530	0.342	0.217	<1
18.	BIOCHEMICAL OXYGEN DEMAND (mg/l)	4.2	2.8	3.2	7.5
19.	CHEMICAL OXYGEN DEMAND (mg/l)	16.8	11.2	12.8	30
C	**HEAVY METALS**				
20.	LEAD (mg/l)	0.006	0.003	0.004	0.05
21.	CADMIUM (mg/l)	0.004	0.002	0.002	<1
22.	MANGANESE (mg/l)	0.028	0.022	0.023	0.2
24.	COPPER (mg/l)	0.008	0.003	0.004	0.1
25.	IRON TOTAL (mg/l)	1.150	1.045	1.031	1.5
26.	ZINC (mg/l)	0.438	0.675	0.345	1

D	BACTERIOLOGICAL ANALYSIS				
27.	TOTAL COLIFORM (MPN/100mL)	6.3×10^7	4.5×10^7	5.7×10^7	1.8
28	E-COLI (CFU/100mL)	1.2×10^2	1.4×10^2	1.4×10^2	0.0
29.	SALMONELLA (CFU/100mL)	3.0×10^4	2.2×10^4	2.4×10^4	0.0
30.	SHIGELLA (CFU/100mL)	2.6×10^4	2.4×10^4	2.4×10^4	0.0
31	YEAST/MOLD (CFU/100mL)	4.3×10^4	3.1×10^4	3.2×10^4	0.0
32.	STAPHYLOCOCCUS (CFU/100mL)	6.0×10^4	4.0×10^4	6.9×10^4	0.0
33.	KLEBSELLIA (CFU/100 ml)	ND	ND	ND	0.0

ND = Not detected NS = Not stated GW = Ground Water GIS=Gashua Irrigation Schemes

Source: Envicons Field Survey, 8th July, 2021

4.3.2.1 pH

pH refers to the hydrogen ion concentration in moles per litre. pH affects the availability of various forms of nutrients and metals and also affects the various processes of water treatment that contributes to the removal of viruses, bacteria and other harmful organisms. It influences the toxicity of pollutants. Abnormal values of pH cause bitter taste to water, affect mucous membranes and causes corrosion.

The pH value of the Ground Water (GW) from the study area ranged from 7.1-7.2 while the Surface Water (SW) ranges from 6.9-7.8 during the sampling period. This value falls within the recommended value compare to the FMEnv limits of 6-9, during the sampling periods.

4.3.2.2 Total Dissolved Solids/Conductivity

Total dissolved solid is the measure of mineral salts dissolved in water. It results from the interaction of water with the earth. Conductivity is a measure of the ability of an aqueous solution to carry electric current. It depends on the presence and concentration, mobility and valence of the ions, and the temperature of the medium. Conductivity of water is a direct function of its total dissolved salts. Hence it is an index to represent the total concentration of soluble salts and water. If drinking or domestic water has high conductivity, it indicates the presence of high amount of dissolved inorganic substances in ionized form.

The conductivity of the GW was found to be between the ranges of 120.0 - 281.0 (µS/cm) while the SW falls between the ranges of 104.0 -260.0 (µS/cm).

This value is within the 1000(µS/cm) thresholds for ground and surface water and it can be said to be within the standard when compare to the acceptable limit of 1000(µS/cm) set by FMEnv.

4.3.2.3 Dissolved Oxygen (DO)

Dissolved Oxygen is the amount of gaseous oxygen (O_2) dissolved in the water. Oxygen enters the water by direct absorption from the atmosphere, by rapid movement, or as a waste product of plant photosynthesis. Water temperature and the volume of moving water can affect dissolved oxygen levels. Oxygen dissolves easier in cooler water than warmer water. Adequate dissolved oxygen is important for good water quality and necessary to all forms of life. Dissolved oxygen levels that drop below 5.0 mg/l cause stress to aquatic life. Lower concentrations cause greater stress. Oxygen levels that go below 1-2 mg/L for a few hours may result in large fish kills. The **DO** of the ground water value gotten falls within 4.80mg/l - 5.50mg/l while the surface water falls between 1.10mg/l - 6.80mg/l which is within the acceptable limit of 7.5mg/l. From the surface water table 72, we saw that SW 4 D.O is low (1.10) which have negative effect on the living organisms in the river/stream because low oxygen causes greater stress.

4.3.2.4 Total Suspended Solids

Total suspended solids (TSS) are particles that are larger than 2 microns found in the water column. Anything smaller than 2 microns (average filter size) is considered a dissolved solid. Most suspended solids are made up of inorganic materials, through bacteria and algae can also contributes to the total solid's concentration. The measured TSS is 0.0477- 0.524 mg/l for the ground water and the surface water is 0.1158- 0.3107 mg/l for surface water.

4.3.2.5 Total Dissolved Solids

Total Dissolved Solids (TDS) are the total amount of mobile charged ions, including minerals, salts or metals dissolved in a given volume of water, expressed in units of mg per unit volume of water (mg/L), also referred to as parts per million (ppm). TDS is directly related to the purity of water and the quality of water purification systems and affects everything that consumes, lives in, or uses water, whether organic or inorganic, whether for better or for worse. The TDS of the ground water within the study area was found to be 63.0 144.0 mg/l while the surface water is between 54.5 - 136.3 mg/l this is within the FMEnv Recommended standard of 500 -1000 mg/l and within the acceptable recommendable standard by FMEnv.

4.3.2.6 Total hardness

Water hardness is the amount of dissolved calcium and magnesium in the water. Hard water is high in dissolved minerals, both calcium and magnesium. The total hardness of the Ground water found within the study area reads between 85.6 – 136.96 mg/l while the surface water falls at 85.6 – 136.96 mg/l during the time of analysis at the study area which is within the Federal Ministry

Environment Standard of 200mg/l for Ground water while for surface water is not stated.

4.3.2.7 Magnesium

Magnesium occurs in significant amounts in most lime stones and especially in dolomites. The dissolution of these rocks brings magnesium into water. Magnesium levels in the ground water analysed within the study area was found to be 34.24 mg/l for the three (3) ground water analysed while the surface water ranges from 17.12 -51.36 mg/l which are within the recommended standard set by FMEnv of 50mg/l for ground water while surface limit is not stated.

4.3.2.8 Calcium

Calcium occurs in water naturally. One of the main reasons for the abundance of calcium in water is its natural occurrence in the earth's crust. It may dissolve from rocks such as limestone, marble, calcite, dolomite, gypsum, fluorite and apatite. Calcium is determinant of water hardness. When taken in large amounts, calcium may negatively influence human health. The lethal close of oral uptake is about 5-50 mg/kg body weight. The ground water values were found to be within the ranges of 51.36 -102.72 mg/l analysed while the surface water ranges from 51.36 - 85.6 mg/l which fall within the threshold set by FMEnv.

4.3.2.9 Nitrate and Nitrite

Nitrates are products of oxidation of organic nitrogen by bacteria in the presence of sufficient oxygen. Sources of nitrates are domestic effluents, fertilizer use, decayed vegetable and animal matter, leachates from refuse dumps etc. Nitrate is toxic in drinking water when present in excessive amounts and in some cases methemoglobinemia in bottle fed infants.

The nitrate value of the study area municipal water sample analysed within the study area was found to be within 4.47 -10.0 mg/l in the study area for ground water while surface water falls between 1.30 -9.70 mg/l This is within the FMEnv acceptable limit of 20mg/l for ground water and 10mg/l for surface water. Nitrite ranges between 0.217mg/l -0.811mg/l for both ground and surface water which fall within recommended threshold of FMENV.

4.3.2.10 Phosphate and Sulphate

Phosphates are released into natural water by the weathering rocks.

Phosphate and Sulphate level of the water analysed within the study area fall at the values of 0.284-1.382 1mg/l for Phosphate for both ground and surface water within the study area including the control point and the ranges of 7.8 mg/l -130mg/l for Sulphate both surface and ground water analysed within the study area. Which is within The Federal Ministry of Environment recommended level of 5mg/l and 500mg/l respectively.

4.3.2.11 Metals and Heavy Metals

Water naturally contains certain metals some of which can adversely affect plants, animals and man. Metal tested for the ground water and surface water within the study area at Gashua Irrigation Schemes Yobe during sampling is discussed below.

4.3.2.12 Manganese

Manganese occurs naturally as a mineral from sediment and rocks or from mining and industrial wastes. It is relatively non-toxic to animals but toxic to plants at high level.

Manganese levels at the study area, for the ground water fall at the values of 0.022 0.28mg/l while for surface water is fall at the value of 0.19- 30mg/l the value gotten for ground water is above the recommended values of 0.20mg/l and Surface shows that it is above the recommended thresholds of 0.10mg/l recommended by Federal Ministry of Environment as at the time of the analysis.

4.3.2.13 Copper

The concentration of copper in the ground water samples analysed was found to be between the ranges of 0.003 – 0.008 mg/l this reads shows is within the permissible limit of 0.1mg/l while the surface water reads between 0.004-0.010 which is within the recommended standard.

Copper could cause stomach and intestinal distress, liver and kidney damage and anaemia in high doses. It imparts an adverse taste to water and causes significant stains on cloths and fixtures. Copper is an essential trace element but toxic to plants and algae at moderate levels.

4.3.2.14 Lead

Lead occurs naturally in the environment. However, most lead concentration that is found in the environment is a result of human activities. Due to the application of lead in gasoline an unnatural lead-cycle has consisted. The lead cycle caused by human production is much more extended than the natural lead-cycle. It has caused lead pollution worldwide issues. The groundwater and surface water analysed at the study area, shows that lead was found to be within the ranges of 0.003-0.012mg/l at the time of the analysis and this conform to the FMEnv recommended Standard of 0.05 mg/l.

4.3.2.15 Cadmium

Cadmium is an extremely toxic metal commonly found in industrial workplaces. Due to its low permissible exposure limit, overexposures may occur even in situations where trace quantities of cadmium are found. Cadmium is used extensively in electroplating, although the nature of the operation does not generally lead to overexposures. Cadmium is also found in some industrial paints and may represent a hazard when sprayed.

Cadmium was dictated in the ground water and surface water analysed; the value gotten falls between the ranges of 0.002 -0.009mg/l which is within the set limit set by Federal Ministry of Environment for ground and surface water as shown on the table above.

4.3.2.16 Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD)

The standard method for indirect measurement of the amount of pollution (that cannot be oxidized biologically) in a sample of water. The chemical oxygen demand test procedure is based on the chemical decomposition of organic and inorganic contaminants, dissolved or suspended in water. The result of a chemical oxygen demand test indicates the amount of water-dissolved oxygen (expressed as parts per million or milligrams per litre of water) consumed by the contaminants, during two hours of decomposition from a solution of boiling potassium dichromate. The COD of the water analysed was found to be between 11.2-16.8mg/l for ground water while the surface water falls between the ranges of 47.2mg/l- 84.8mg/l which is within federal ministry of environment standard of 30.0mg/l and 100mg/l respectively indicating moderate organic input and oxygenation and BOD falls between the rages of 2.8-4.2mg/l for ground water and 40.8-84.8mg/l also indicating moderate organic input and oxygenation.

4.3.2.17 Microbiological studies

Water samples for microbiological studies were collected in 100ml plastic containers which were covered with aluminium foil and keep in ice-cool box prior to culturing in the laboratory. The water was then analysed for coliforms using the multiple tube fermentation technique.

The microbiological isolate; the water sample analysed, revealed that the *total Coliform Number* of bacteria is above the recommended for both ground and surface water analysed compared to the standard of 1.8 and 400 for ground water and surface water. While *Escherichia Coli (*1.2×10^2 -3.9×10^4*), salmonella (*2.2×10^4 -3.7×10^6*), shigella (*2.1×10^4 -2.6×10^4*) yeast/mold (*3.1×10^4 -7.2×10^4*), staphylococcus (*2.9×10^4 -10.9×10^4*)* and *klebsellia (*2.3×10^4 -3.4×10^4*)* were all present in surface water at different load except SW 2 and GW 1-3 that klebsellia was not **dictated** but the rest of the bacteriological analysis shows different level of their presence in the surface and ground water analysis.

Do not lump surface and groundwater studies together. They are separate aspects of baseline. Surface water characteristics usually indicate capability for sustaining aquatic life such as fisheries for which community members rely on for food, economic gains, drinking, washing, transport, etc. groundwater is often studied for potability, recharge/aquifer type, and potential direction of movement of contaminants.

4.3.3 Soil Characteristics

Soil sampling

Surface soil was investigated through visual observation and sampling. Soil sampling were obtained from designated sampling points in nine locations including control within the project site. At each sampling location, topsoil and subsoil samples were taken making it eighteen (18) soil samples in all. Hand Auger of uniform cross section was used to ensure that reproducible soil samples were collected from depths of 0-15cm (surface soil level) and 15-30cm (sub surface soil level). This ensured high quality representative data collection. Surface litter of un-decomposed plant materials were removed to ensure that uncontaminated soil samples were not collected. Soil samples were collected in appropriately labelled and sealed in polythene bags.

Samples for microbiological analysis were collected in sterile McCarthey bottles and kept under 4^0C in a refrigerated box (cooler). Samples for physio-chemical analysis were air-dried in a dust free environment while those for microbiological analysis were stored in ice-packed cooler in the field and transferred to the refrigerator at 4^0C. Physio-Chemical analysis of soil samples were carried out using the analytical methods recommended by FMEnv.

4.3.3.1 Land use Soil

The main use of land in the study area is for Agriculture purpose. Majorly agricultural practice exists in parts of the land around and its usually subsidence in nature. The crops grown in the area amongst others include rice, vegetable etc. Generally, the crops grown are greatly influenced by the climatic condition and the area.

4.3.3.2 Method of soil studies

The textural composite of Gashua Irrigation Schemes Yobe, the soil is clay-sandy with sand between ranges from 25.49% -36.77%, the clay content is 39.97% -54.03 while the silt was ranged from 15.52% - 34.54% in composition for top soil while the subsoil has the following content sand range from 20.33%-37.11%, clay falls between 41.80%-53.43% and silt is between 15.61%-37.87% for subsoil.

Nine (9) locations of Soil samples were taken both topsoil and subsoil making it eighteen (18) soil samples in nine locations this was collected within the study area and control was taken away from the project site radius of more than 500M away from the site, the samples were all taken to Zabson laboratory located at Masaka.

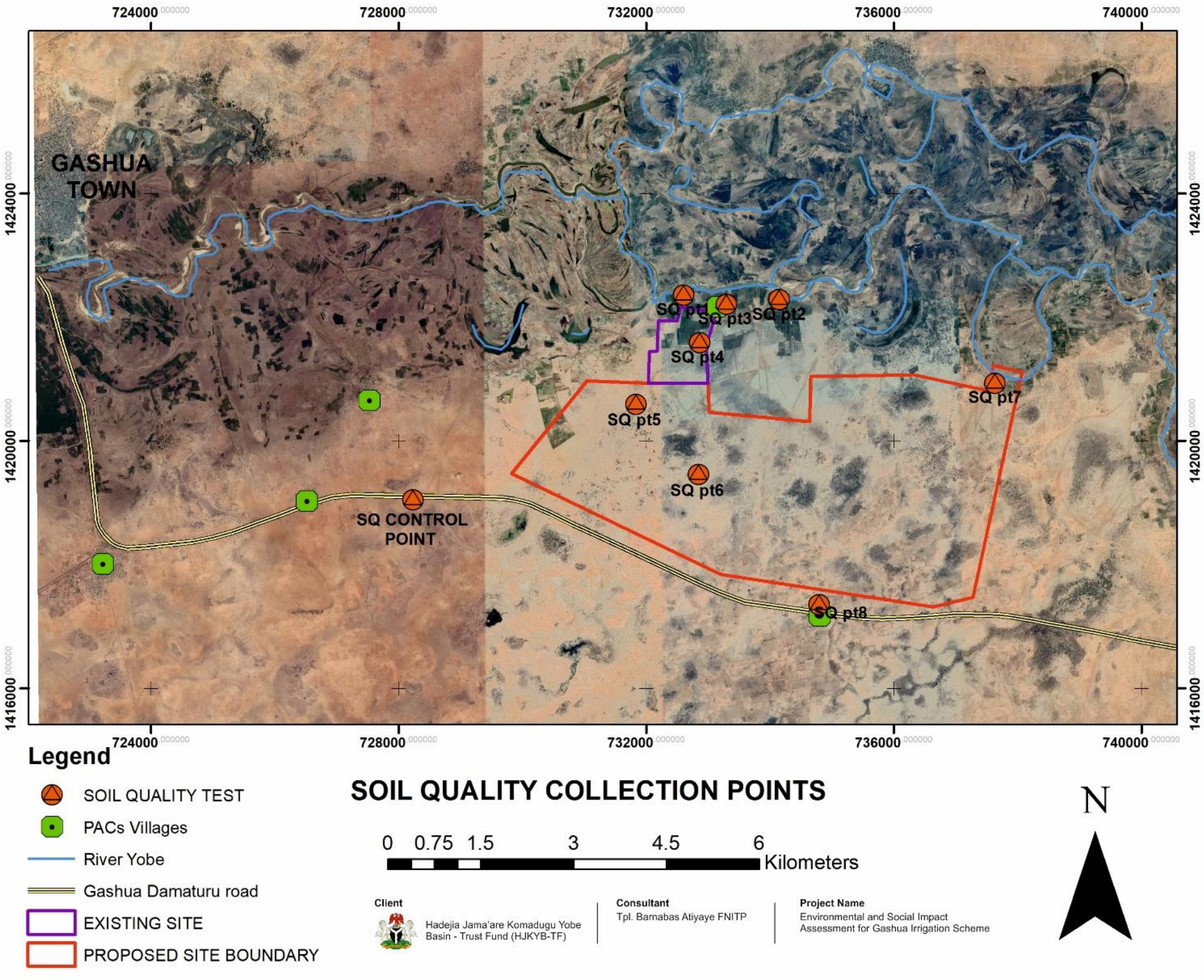

Figure 4.30: Distribution of collected soil samples

Plate 218: Collection of soil samples by lab scientist
Source: Envicons Field Survey, 8th July, 2021

Plate 4.19: Bagging of soil samples by lab scientist and his assistant
Source: Envicons Field Survey, 8th July, 2021

Table 4.33a: PHYSICAL/CHEMICAL ANALYSIS RESULTS OF SOIL SAMPLE. (Top Soil)

S/N	PARAMETER	GIS 1 (TS) (mg/kg)	GIS 2 (TS) (mg/kg)	GIS 3 (TS) (mg/kg)	GIS 4 (TS) (mg/kg)	GIS 5 (TS) (mg/kg)	FMEnv Limit
A.	**PHYSICAL TEST**	732604.87 mE 1422351.74 mN	734142.85 mE 1422280.56 mN	733172.40 mE 1422190.62 mN	732860.18 mE 1421582.15 mN	731829.71 mE 1420582.65 mN	
1.	pH	8.0	8.5	8.3	8.7	8.8	6-9
2.	TEMPERATURE (^{0}C)	34.9	36.0	35.9	35.7	35.8	<40
3.	ELECTRICAL CONDUCTIVITY (µS/cm)	232	260	244	223	285	1000
4.	PARTICLE SIZES/TEXTURE	SAND/SILT/ CLAY 29.12/23.78/ 47.10	SAND/SILT/ CLAY 33.37/22.20 /44.43	SAND/SILT/ CLAY 25.49/34.54 /39.97	SAND/SILT/ CLAY 36.77/15.52/ 47.71	SAND/SILT/ CLAY 30.99/26.07/4 2.92	NS
5.	POROSITY (%)	30.66	33.66	26.66	36.66	26.66	NS
6.	MOISTURE CONTENT	2.43	1.64	2.58	1.78	1.83	NS
7.	BULK DENSITY (g/dm^3)	1.68	1.57	1.78	1.68	1.77	NS
B.	**ORGANICS**						
9.	TOTAL ORGANIC CARBON	4.33	6.4	10.13	6.2	8.0	NS
C.	**EXCHANGEABLE IONS**						
12.	NITRATE	5.15	7.42	10.13	11.68	14.95	20
13.	NITRITE	0.101	0.150	0.100	0.100	0.290	10
14	SULPHATE	65.5	100.32	95.8	95.60	89.50	500
15.	MAGNESSIUM	17.12	34.24	34.24	34.24	17.12	NS
16.	CALCIUM	34.24	51.36	51.36	51.36	34.24	NS
D.	**HEAVY METALS**						
17.	LEAD	0.009	0.005	0.004	0.006	0.011	<1
18.	IRON	2.400	4.304	7.522	6.330	3.420	1.5
19.	COPPER	0.088	0.061	0.049	0.072	0.065	<1
20.	MANGANESE	0.047	0.053	0.032	0.042	0.063	1
21.	ZINC	1.260	1.112	1.008	1.142	1.090	1
22.	CADMIUM	0.004	0.011	0.005	0.007	0.006	1
23	NICKEL	0.006	0.002	0.003	0.004	0.004	1
E.	**BACTERIAL ISOLATE**						
24	PROTEUS	8.9×10^7	9.4×10^7	9.2×10^7	8.8×10^7	9.0×10^7	NS
26.	E-COLI (CFU/100mL)	1.1×10^1	1.0×10^1	1.0×10^1	1.2×10^1	1.1×10^1	NS
27.	YEAST/MOLD	1.3×10^2	1.2×10^2	1.2×10^2	1.2×10^2	1.3×10^2	NS
28	SHIGELLA	3.2×10^4	3.4×10^4	2.9×10^4	2.9×10^4	3.2×10^4	NS
29.	KLEBSILLA	6.4×10^4	5.9×10^4	6.2×10^4	6.7×10^4	5.9×10^4	NS
30.	STAPHILOCOC CUS	1.0×10^1	1.1×10^1	1.1×10^1	1.0×10^1	1.0×10^1	NS

ND = Not Detected, NS = Not stated, TS = Top Soil, GIS=Gashua Irrigation Schemes
Source: Envicons Field Survey, 8th July, 2021

Table 4.33b: PHYSICAL/CHEMICAL ANALYSIS RESULTS OF SOIL SAMPLE (Top soil)

S/N	PARAMETER	GIS 6 (TS) (mg/kg)	GIS 7 (TS) (mg/kg)	GIS 8 (TS) (mg/kg)	GIS Control (TS) (mg/kg)	FMEnv Limit
A.	**PHYSICAL TEST**	732840.92 mE 1419451.08 mN	737630.60mE 1420925.11 mN	734790.47mE 1417347.25 mN	728224.59mE 1419042.06 mN	
1.	Ph	8.4	8.3	8.0	8.2	6-9
2.	TEMPERATURE (^{0}C)	30.9	31.3	31.0	31.7	<40
3.	ELECTRICAL CONDUCTIVITY (µS/cm)	249	199	264	257	1000
4.	PARTICLE SIZES/TEXTURE	SAND/SILT/ CLAY 30.62/24.00/45.38	SAND/SILT/ CLAY 27.06/18.91/54.03	SAND/SILT/ CLAY 31.9/19.93/48.07	SAND/SILT/ CLAY 33.81/19.61/46.49	NS
5.	POROSITY (%)	26.66	33.33	30.66	26.66	NS
6.	MOISTURE CONTENT	2.64	2.67	1.72	2.59	NS
7.	BULK DENSITY (g/dm^3)	1.80	1.79	1.83	1.67	NS
8.	**ORGANICS**					
9.	TOTAL ORGANIC CARBON	2.90	3.60	3.20	3.40	NS
C.	**EXCHANGEABLE IONS**					
10.	NITRATE	10.19	6.44	8.16	11.68	20
11.	NITRITE	0.24	0.19	0.30	0.19	10
12	SULPHATE	78.65	72.82	100.05	97.40	500
13.	MAGNESSIUM	34.24	51.36	34.24	34.24	NS
14.	CALCIUM	34.24	51.36	51.36	51.36	NS
D.	**HEAVY METALS**					
15.	LEAD	0.009	0.004	0.005	0.004	<1
16.	IRON	5.230	7.314	6.512	5.480	1.5
17.	COPPER	0.080	0.670	0.345	0.670	<1
18.	MANGANESE	0.600	0.500	0.140	0.500	1
19.	ZINC	1.480	1.242	1.580	1.242	1
20.	CADMIUM	0.004	0.014	0.008	0.014	1
21	NICKEL	0.005	0.010	0.003	0.010	1
E.	**BACTERIAL ISOLATES**					
22	PROTEUS	8.8×10^7	8.7×10^7	9.0×10^7	8.7×10^7	NS
23.	_E-COLI (CFU/100mL)	1.0×10^1	1.1×10^1	1.1×10^1	1.0×10^1	NS
24.	YEAST/MOLD	1.2×10^2	1.1×10^2	1.1×10^2	1.1×10^2	NS
25	SHIGELLA	3.0×10^4	3.2×10^4	2.8×10^4	2.9×10^4	NS
26.	KLEBSILLA	6.4×10^4	5.7×10^4	5.9×10^4	6.0×10^4	NS
27.	STAPHILOCOCCUS	1.1×10^1	1.2×10^1	1.2×10^1	1.1×10^1	NS

ND = Not Detected, NS = Not stated, TS = Top Soil, GIS=Gashua Irrigation Schemes
Source: Envicons Field Survey, 8th July, 2021

Table 4.34a: PHYSICAL/CHEMICAL ANALYSIS RESULTS OF SOIL SAMPLE (Sub soil)

S/N	PARAMETER	GIS 1 (SS) (mg/kg) EXCEPT STATED	GIS 2 (SS) (mg/kg) EXCEPT STATED	GIS 3 (SS) (mg/kg) EXCEPT STATED	GIS 4 (SS) (mg/kg) EXCEPT STATED	GIS 5 (SS) (mg/kg) EXCEPT STATED	FMEnv Limit
A.	**PHYSICAL TEST**	732604.87 mE 1422351.74 mN	734142.85 mE 1422280.56 mN	733172.40 mE 1422190.62 mN	732860.18 mE 1421582.15 mN	731829.71 mE 1420582.65 mN	
1.	pH	7.6	8.3	7.0	8.4	8.8	6-9
2.	TEMPERATURE (^{0}C)	34.4	35.7	35.3	35.0	34.8	<40
3.	ELECTRICAL CONDUCTIVITY (µS/cm)	239	248	224	240	269	1000
4.	PARTICLE SIZES/TEXTURE	SAND/SILT/ CLAY 30.32/20.18/49.50	SAND/SILT/ CLAY 29.47/21.65/48.88	SAND/SILT/ CLAY 20.33/37.87/41.80	SAND/SILT/ CLAY 31.92/17.76/50.32	SAND/SILT / CLAY 32.08/18.77/49.15	NS
5.	POROSITY (%)	30.10	33.00	26.66	26.66	26.66	NS
6.	MOISTURE CONTENT	1.23	2.11	1.66	2.00	2.49	NS
7.	BULK DENSITY (g/dm^3)	1.72	1.44	1.76	1.59	1.63	NS
8.	**ORGANICS**						
9.	TOTAL ORGANIC CARBON	7.6	6.0	6.8	5.7	6.0	NS
C.	**EXCHANGEABLE IONS**						
12.	NITRATE	9.70	7.04	8.23	12.18	19.73	20
13.	NITRITE	0.091	0.053	0.054	0.070	0.096	10
14	SULPHATE	65.5	100.63	100.0	99.60	110.00	500
15.	MAGNESSIUM	8.90	8.68	17.12	17.12	8.59	NS
16.	CALCIUM	17.12	34.24	34.24	34.24	17.12	NS
D.	**HEAVY METALS**						
17.	LEAD	0.006	0.003	0.004	0.004	0.013	<1
18.	IRON	2.270	3.403	5.029	3.520	1.820	1.5
19.	COPPER	0.032	0.042	0.021	0.022	0.028	<1
20.	MANGANESE	0.024	0.013	0.020	0.018	0.025	1
21.	ZINC	0.467	0.672	0.683	1.024	0.840	1
22.	CADMIUM	0.002	0.008	0.007	0.003	0.003	1
23	NICKEL	0.004	0.002	0.001	0.003	0.002	1
E.	**BACTERIAL ISOLATE**						
24	PROTEUS	6.9 X 10^6	5.4 X 10^6	6.2 X 10^6	5.4 X 10^6	5.0 X 10^6	NS
26.	_E-COLI (CFU/100mL)	1.0 X 10^1	ND	1.0 X 10^1	1.1 X 10^1	ND	NS
27.	YEAST/MOLD	1.3 X 10^2	1.2 X 10^2	1.2 X 10^2	1.1X 10^2	1.2 X 10^2	NS
28	SHIGELLA	3.0 X 10^4	3.0 X 10^4	2.6 X 10^4	2.4 X 10^4	2.9 X 10^4	NS
29.	KLEBSILLA	6.2 X 10^4	5.3 X 10^4	5.7 X 10^4	6.5X 10^4	5.2 X 10^4	NS
30.	STAPHILOCOCCUS	ND	1.0 X 10^1	1.0X 10^1	ND	ND	NS

ND = Not Detected, NS = Not stated, TS = Top Soil, GIS=Gashua Irrigation Schemes . SS=Sub Soil
Source: Envicons Field Survey, 8th July, 2021

SAMPLE TYPE – SOIL; QUANTITY - 100G EACH; PRESERVATION METHOD - AIR DRYING

Table 4.34b: PHYSICAL/CHEMICAL ANALYSIS RESULTS OF SOIL SAMPLE (Sub Soil).

S/N	PARAMETER	GIS 6 (SS) (mg/kg) EXCEPT STATED	GIS 7 (SS) (mg/kg) EXCEPT STATED	GIS 8 (SS) (mg/kg) EXCEPT STATED	GIS Control (SS) (mg/kg) EXCEPT STATED	FMEnv Limit
A.	**PHYSICAL TEST**	732840.92 mE 1419451.08 mN	737630.60mE 1420925.11 mN	734790.47mE 1417347.25 mN	728224.59mE 1419042.06 mN	
1.	pH	8.6	8.8	8.0	7.9	6-9
2.	TEMPERATURE (^{0}C)	30.2	31.0	30.9	31.5	<40
3.	ELECTRICAL CONDUCTIVITY (µS/cm)	212	176	279	269	1000
4.	PARTICLE SIZES/TEXTURE	SAND/SILT/CLAY 37.11/15.75/47.14	SAND/SILT/CLAY 29.42/20.61/49.97	SAND/SILT/CLAY 33.0/23.50/43.5	SAND/SILT/CLAY 30.96/15.61/53.43	NS
5.	POROSITY (%)	26.66	33.30	30.00	30.66	NS
6.	MOISTURE CONTENT	1.84	2.57	2.30	1.64	NS
7.	BULK DENSITY (g/dm^3)	1.80	1.74	1.83	1.71	NS
B.	**ORGANICS**					
9.	TOTAL ORGANIC CARBON	2.06	2.90	2.99	3.08	NS
C.	**EXCHANGEABLE IONS**					
10.	NITRATE	7.86	6.96	7.02	9.34	20
11.	NITRITE	0.16	0.31	0.16	0.21	10
12	SULPHATE	100.00	60.98	105.25	85.80	500
13.	MAGNESSIUM	17.12	34.24	17.12	17.12	NS
14.	CALCIUM	17.12	34.24	34.24	34.24	NS
D.	**HEAVY METALS**					
15.	LEAD	0.004	0.002	0.002	0.002	<1
16.	IRON	3.320	1.113	3.072	2.110	1.5
17.	COPPER	0.031	0.240	0.095	0.023	<1
18.	MANGANESE	0.016	0.020	0.014	0.019	1
19.	ZINC	0.880	1.042	0.610	1.034	1
20.	CADMIUM	0.005	0.010	0.005	0.008	1
21	NICKEL	0.002	0.003	0.003	0.005	1
E.	**BACTERIAL ISOLATE**					
22	PROTEUS	7.4 X 10^6	7.4 X 10^6	8.1 X 10^6	7.7 X 10^6	NS
23.	E-COLI (CFU/100mL)	ND	1.0 X 10^1	ND	ND	NS
24.	YEAST/MOLD	1.1 X 10^2	1.2 X 10^2	ND	1.1 X 10^2	NS
25	SHIGELLA	2.7 X 10^4	2.5 X 10^4	2.4 X 10^4	2.6 X 10^4	NS
26.	KLEBSILLA	5.8 X 10^4	5.2 X 10^4	4.9 X 10^4	5.3X 10^4	NS
27.	STAPHILOCOCCUS	1.0 X 10^1	1.1 X 10^1	1.2 X 10^1	1.1 X 10^1	NS

ND = Not Detected, NS = Not stated, TS = Top Soil, GIS=Gashua Irrigation Schemes
Source: Envicons Field Survey, 8th – 9th July, 2021

4.3.3.3 Soil pH

pH is the acidity or basicity of a medium. It is basically the concentration of the hydrogen ion. pH is a major factor in all chemical reactions associated with the formation, alteration and dissolution of minerals. It yields useful information about the availabilities of exchangeable cautions (Ca, Mg, K, etc) in soils. High pH can induce trace elements (Fe, Zn, Mn, and Cu). Microbial activity and plant sensitivity are strongly pH dependent and very active at pH of 6.0

Soil pH value is a measure of the free hydrogen ion (H+) and Hydroxyl ion (OH-) concentration of soil solution. The pH provides a variety of useful information about soil including the relative's availability of plant nutrients amongst others. pH between 7 and 8 is suitable for garden/commercial vegetable /grasses and most forage corps. pH determines the potential of soil aggressiveness on structures.

The pH of project site soils was found to fall between the ranges of 8.0 to 8.8 for the nine soil samples for top soil while the subsoil ranges from 7.0 to 8.8, the result shows an alkalinity conducive for the availability of plant nutrient; nitrates, potassium, phosphates, magnesium, sulphur, copper and boron required for growth. General, the pH is typically of the North East Nigeria soils. Plants on soils with pH greater than 9 usually have reduced growth or even die.

4.3.3.4 Moisture Content

This is the percentage of water held in soil by strong cumulative forces of hydrogen bonds that are between water and oxygen atoms. Soil moisture content has an effect on soil formation, erosion and structure stability, but primarily the availability of water for plant growth. Moisture is the major constituent of plant protoplasm (85-95%), it is essentially for photosynthesis and conversion of starches to sugars, solvent in which nutrients moves, provides plant turgidity –maintains proper form and position of plant parts to capture light.

The moisture content of the project area soil was found to be between 1.64% - 2.67% for top soil and 1.23% - 2.57% for subsoil. The soils are sandy/clay/silt so will hold enough water (as indicated in the moisture content value) required for plant metabolic processes.

Bulk Density The bulk density of the study area varies from the ranges of 1.57 g/dm^3 to 1.83g/dm^3 for the topsoil sample while subsoil bulk density ranges from 1.44 g/dm^3 to 1.83g/dm^3 at the time the analysis was carry out.

Nitrate, Nitrite and Phosphate The most important nutrient for plant growth is inorganic nitrogen in the form of nitrate and phosphates. Nitrates are products of the oxidation of organic nitrogen by bacteria in the presence of sufficient oxygen. Sources of nitrates are domestic effluents, fertilizer use, decayed vegetable and animal matter, leachates from refuse dumps etc. phosphate results from weathering of rocks. Soils have low total plants available phosphate supplies because minerals phosphates forms are readily not soluble.

The nitrate concentration of soil sample from the project site was found to be from the ranges of 5.15mg/kg -14.95mg/kg for the top soil while the subsoil ranges from 6.96mg/kg -19.73mg/kg.

Nitrite was found between the ranges of 0.100mg/kg – 0.300mg/kg for the top soil within the study area and the subsoil falls between the ranges of 0.053mg/kg – 0.31mg/kg. Nitrogen is absorbed in plants in the form of nitrates. Nitrates constitutes plant proteins, chlorophyll and nucleic acids. Adequate nitrogen often produces thinners cell walls which results in more tender, more succulent plants-larger plants and greater crop yield which deficiency in plants is indicated by stunted growth (with small leaves and weak steams) and progressively yellowing of leaves in colour.

Phosphorus is available for plants uptake in the form of phosphate. Phosphorus is an essential part of nucleoproteins, which controls cell division in stimulation of early root growth, hastening plant maturity, is energy transformations within the cells and fruiting and seed production while deficiency is indicated by the purple or dark blue coloration on leaves and roots.

4.3.3.5 Heavy Metals

These are metals with mass numbers greater than twenty and specific gravity greater than 5.0g/cm^3. The usually occur naturally in the environment at low concentration; however heavy metal pollution may occur when concentration becomes higher than recommended threshold.
Heavy metals a large class of inorganic and organic chemicals, which are both essential and toxic to human and ecological health. The metals exist in several oxidation states, each with different reactive, ecological physiological and bio concentration potentials. Many heavy metals such as Pd, Cd, Cu, Fe, Mn, Zn and Ni are toxic in their cationic form, while other requires biochemical transformation to organic metallic compounds. The concentrations of Pb, Cd, Cu, Fe, Mn, Zn and Ni are as follows from the soil samples analysed for both topsoil and subsoil:

Copper (Cu); Copper ranks 25th in abundance among the elements present in the earth’s crust. It is a borderlines metal and therefore capable of forming complexes with a number of ligands but ligands with nitrogen donor atoms are generally favoured. Copper is an essential element for plants, animals and humans. It is also a component of many metallo-enzymes and respiratory pigments. However excess concentration of copper in an environment at a given time may cause chronic toxicity. The concentration of analysed copper in the top soil samples from the study area was found to fall between

0.049kg/mg -0.670kg/mg while the subsoil falls between 0.021kg/mg - 0.240kg/mg.

Lead (Pd); Topsoil falls between 0.004kg/mg - 0.011kg/mg while Subsoil ranges from 0.002kg/mg - 0.013kg/mg,

Cadmium (Cd); Top soil reads 0.004kg/mg -0.014kg/mg while subsoil falls between 0.002kg/mg -0.010kg/mg,

Iron (Fe); Fe falls between 2.400kg/mg -7.522kg/mg while subsoil is between 1.113kg/mg -5.027kg/mg.

Manganese (Mn); Topsoil values reads 0.032kg/mg-0.600kg/mg and subsoil read 0.013kg/mg -0.024kg/mg,

Zinc (Zn); 1.008kg/mg-1.580mg/l for topsoil while the subsoil falls between 0.467kg/mg -1.042kg/mg

Nickel (Ni); Topsoil ranges from 0.002kg/mg – 0.010kg/mg while subsoil ranges from 0.001kg/mg -0.005kg/mg.
They were all found to be within the acceptable level of no more than 1kg/mg except for Iron and some few points of zinc which values were above recommended values of 1kg/mg as shown on the table while some of the parameters of soil do not yet have the stated Federal Ministry of Environment Recommended value.

4.3.3.6 Exchangeable Cation

Calcium (Ca), Potassium (P) and Magnesium (Mg) are very abundant elements in the earth's crust and are very important nutrients required to ensure plants growth. K facilitates many plant actions and enzyme transformations while Ca is a part of the plant cell walls and is needed for cell division. **Calcium** values reads 17.12mg/kg to 51.36kg/mg for the top soil and subsoil analysed within the study area.

Magnesium is a chlorophyll component and is supplied to plants mostly from exchangeable forms.
The magnesium, levels in soils of the project site ranges between 8.59kg/mg - 51.36 kg/mg for both topsoil and subsoil analyse within the Gashua Irrigation Schemes Project site.

The microbiological isolates for soil; the soil sample analysed both for top and subsoil revealed the different level of bacteriology present in the soil within the project area. *Escherichia Coli* ranges from *(*5.0×10^6 -9.4×10^7*)* at some few point it wasn't detected , *Proteus (*2.2×10^4 -3.7×10^6*), shigella (*2.4×10^4 -3.4×10^4*), yeast/mold (*1.1×10^2 -1.3×10^2*)* at point 8 subsoil it wasn't detected*, staphylococcus (*1.0×10^1 -1.2×10^1*)* few point of subsoil *staphylococcus* was not detected and *klebsellia* falls between the ranges of *(*4.9 x 10^4 -6.7 x 10^4*)* different loads of bacteria was found in the soil samples analyse except for few organisms that wasn't detected at the time of the analysis. The bacteriological analysis table shows different level of their present in the topsoil and subsoil analysis

Note Please:
The baseline data should also include the reviewed secondary data. The outstanding baseline data yet to be provided in the report include: the Climatic conditions of the project area, the local geology of the Gashua area, Agricultural practises, fisheries and aquatic resources (Planktons and Benthic micro flora and fauna), Sediment physical and microbial characteristics, Green growth and Climate Adaptation.

The relevant baseline data provided in the project description from the SMEC report can be brought to this chapter of **Description of Project Environment**.

Table 4.35: TOP SOIL PARTICLE SIZE DISTRIBUTION

PARAMETER	GIS 1(TS)	GIS 2(TS)	GIS 3(TS)	GIS 4(TS)	GIS 5(TS)	GIS 6(TS)	GIS 7(TS)	GIS 8(TS)	GIS 9(TS) Control	Soil Type
MESH SIZE/100g	**SOIL RETAINED**	**SOIL RETAINED**	**SOIL RETAINED**	**SOIL RETAINED**	**SOIL RETAINED**	**SOIL RETAINED**	**SOIL RETAINED**	**SOIL RETAINED**	**SOIL RETAINED**	**Soil Type**
2.0mm	10.90	8.59	7.95	8.12	12.17	8.22	5.39	7.99	10.85	**Cs**
1.18mm	5.60	10.45	17.54	15.39	14.82	16.40	7.90	13.96	11.96	**Cs**
600µm	8.00	14.33	19.21	13.26	13.94	15.77	12.37	11.95	14.95	**Ms**
425µm	4.38	6.45	8.25	7.42	5.71	6.26	6.83	7.42	7.42	**Ms**
300µm	5.45	7.28	6.08	8.10	6.42	5.97	8.08	6.51	6.39	**Ms**
212µm	11.95	8.47	5.58	7.99	7.37	15.06	10.71	11.89	5.09	**Ms**
150µm	16.34	12.34	8.16	12.63	10.48	10.60	17.06	13.08	12.98	**Fs**
63µm	28.64	26.87	24.83	24.39	22.97	19.68	26.26	23.10	22.42	**C silt**

Source: Envicons Field Survey, 8th – 9th July, 2021

USING BRITISH STANDARD 410;

C=coarse, M=medium, F=fine, S=sand GIS= Gashua Irrigation Schemes

Table 4.36: SUB SOIL PARTICLE SIZE DISTRIBUTION

PARAMETER	GIS 1 (SS)	GIS 2 (SS)	GIS 3 (SS)	GIS 4 (SS)	GIS 5 (SS)	GIS 6 (SS)	GIS 7 (SS)	GIS 8 (SS)	GIS 9 (SS) Control	Soil Type
MESH SIZE/100g	**SOIL RETAINED**	**SOIL RETAINED**	**SOIL RETAINED**	**SOIL RETAINED**	**SOIL RETAINED**	**SOIL RETAINED**	**SOIL RETAINED**	**SOIL RETAINED**	**SOIL RETAINED**	**Soil Type**
2.0mm	9.22	10.13	11.65	10.82	12.56	6.99	9.19	9.39	12.05	**Cs**
1.18mm	5.91	8.37	15.23	13.78	14.92	18.13	8.28	12.94	10.11	**Cs**
600µm	7.68	13.93	16.81	12.46	10.94	12.82	13.14	13.83	13.62	**Ms**
425µm	10.18	9.45	9.32	8.92	9.94	8.22	8.83	8.05	8.85	**Ms**
300µm	7.15	6.28	7.00	6.45	7.82	6.52	6.08	5.81	7.36	**Ms**
212µm	13.95	5.47	4.98	8.00	8.37	15.06	12.21	14.52	9.99	**Ms**
150µm	16.34	13.74	6.49	14.23	13.98	13.60	19.06	15.02	14.98	**Fs**
63µm	26.94	30.27	27.83	23.39	21.11	18.68	23.12	19.94	23.00	**C silt**

Source: Envicons Field Survey, 8th – 9th July, 2021

USING BRITISH STANDARD 410;

C=coarse, M=medium, F=fine, S=sand GIS= Gashua Irrigation Schemes

CHAPTER FIVE

5.0 ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACTS POTENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS

This chapter describes the potential environmental and social impact likely to be experienced during and after the project; having considered its impact on the Biological and human environment. This chapter also assessed and estimated the duration of these impacts through Social and Environmental researches and literature reviews.

The sole aim of irrigation project is to boost agricultural production, which is a conscious effort in achieving the targets of the SDG 2 which seeks to end hunger, improve food security and nutrition; and at the same time promote sustainable agriculture. The proposed Gashua irrigation scheme in its totality satisfies the conditions to achieve the laid down targets of the SDG 2. However, for every action and development on land, there is an expected repercussion which could be positive, negative or both.

5.1 Impact Prediction Methodology

- Review of relevant literatures regarding irrigation projects.
- Examination of results from questionnaire survey and Focused Group Discussions (FGDs) to draw out inference.
- Determination of anticipated environmental and social impact likely to emanate from the proposed project haven reviewed the technical report.

5.2 Significant positive impacts

5.2.1 Significant Positive Impact during project Construction phase

i. ***Job creation:*** The significant positive impact accruing to the project at this stage is the employment opportunities for the residents living around the project area, as the construction of the irrigation project will offer room for both skilled and unskilled labour, which these community residents can key into.

ii. ***Improving local economy:*** The impact of this project will improve local economy within the areas at proximity to the project site as residents who sell food and other items required by construction workers would be patronized.

iii. ***Capacity Building:*** The project will also provide an opportunity for technology transfer through training in some specialized areas for the skilled workers and for acquiring new skills by the local people.

5.2.2 Significant Positive Impact during project operation phase

i. ***Positive impact in combating Desertification***: Given the fact that the project falls within the Sudan savannah region of Nigeria which is highly prone to desert encroachment, having an irrigation project within the designated area will improve the vegetal cover of the region, improve agricultural productivity and reduce the susceptibility of the area to drought.

ii. ***Positive impact in Improving Food Security***: The benefits of the project include food security and increase economic opportunities which will result to poverty alleviation. More so, the project will attract people and development around the project area. This will in turn result to provision of facilities which were lacking to satisfy the growing population. Developing irrigation farms in such a large scale would increase crop production significantly.

iii. ***Positive impact in improving soil quality***: Implementing modern irrigation farms with appropriate environmental Management will improve soil fertility of the area through addition of organic matter and other fertilizers into the soil. hence, developing the proposed irrigation farm will enable the use of available water and land resources of the area efficiently and effectively.

iv. ***Positive impact in Climate Change Adaptation:*** The irrigation project is a way of increasing Climate Change Adaptation amongst farmers within the region as it is more resilient option in tackling the issue of Climate Change.

5.3 Significant negative impacts

5.3.1 Negative impacts during the construction phase

i. ***Impact on terrestrial and aquatic ecosystem and biodiversity:*** The impact of the irrigation project will disturb the existing ecosystem within the project area, besides dislodging people living within the project area, the project will have a negative impact on terrestrial life forms as terrestrial animals would be displaced from their habitat due to disturbance and human interference with their environment, animals like birds, insects and reptiles will likely be affected. Based on the negative impact on aquatic life forms, the disturbance of the irrigation river by mechanical pumps can increase sedimentation in the river thereby reducing water quality which might affect aquatic life. Also, the increased traffic volume and operation of heavy machineries with the accompanying noise pollution will disturb the wild birds adapted to use of those habitats. Fish and other aquatic organisms can be negatively affected by the construction activities or the irrigation structures.

Construction debris and soil contaminate the downstream water and increase turbidity in the river.

ii. ***Impact from camp sites, access roads and air/noise pollution:*** Borrow areas, camp sites and access roads would cause environmental problems like land deformation, erosion, creation of mosquito breeding, anaesthetic view, loss of vegetation and productive land. Nuisance Impacts from excessive noise levels and vibrations will arise during construction from operating heavy equipment and vehicles, as Well as aggregate production. Increase in Suspended particles from excavation, and movement of heavy machineries and other Vehicles over unpaved or dusty access roads will create local air pollution impacts.

iii. ***Impact of Settlement areas, farms and grazing land:*** The land use of the proposed irrigation command areas is mainly farming and grazing. The local people are farmers and pastoralists who depend mainly on crop production and cattle rearing. Therefore, the expansion of irrigation farms on 2,000 ha land would significantly reduce their grazing land. There are houses in the proposed irrigation command area. Most of the houses are made of wood, mud and grass. Other loss of land will occur due to camp site and borrow areas and workshops etc.

iv. ***Disruption of livelihoods***: The main source of livelihood within the area is crop farming and this could be impacted if farmers are unable to continue farming during the project construction phase.

v. ***Health Impacts:*** During Construction phase, communicable diseases primarily associated with population influx into the project area would result to a major health problem. Health risks like malaria and schistosomiasis are expected to increase as the construction activities create conducive environment for the breeding of mosquito and molluscs.

vi. ***Greenhouse gas (GHG) emission impacts of the reservoir pond:*** Creation of reservoirs can contribute to GHG emissions when a large biomass is flooded during impoundment. The flooded biomass particularly when decomposed at the ambient physicochemical conditions may promote anoxic conditions and formation of methane, which has a greater warming potential. In order to reduce GHG emission to the environment, clearance of vegetation form the reservoir pond should be done before impoundment takes place.

More so, emissions from vehicles and machinery brought to the project area will air quality by means of air pollution from the continuous emission of Carbon monoxide from the exhaust of these vehicles and machinery.

5.3.2 Negative impact during operation phase

i. ***Impact on downstream and wildlife habitat:*** Removal of the vegetation and grassland from the irrigation Command area would adversely affect wildlife species dwelling in within the project area. The pumping of water from the Yobe River will affect water flowing downstream to the Lake Chad and might impact the ecology downstream.

ii. ***Deterioration of water quality:*** The major pollution sources that are anticipated to cause deterioration of surface and ground water quality of the project area and its downstream include use of fertilizers and pesticides to boost agricultural produce and protect them from ravaging pest, increased levels of dissolved solids and turbidity, domestic waste from camp sites and settlement areas, as well as discharge of organic waste from processing crops. These will have negative impact in the aquatic ecosystem and downstream users.

iii. ***Barrier/impediment to movement:*** the main irrigation canals could create a barrier to the movement of people, livestock and wild animals especially those from the "Laba" settlement area behind the designated project area, as this proposed project would be situated between the community and the closest access road. In addition to this the canal may pose hazard to livestock when they try to cross it. Other components of the proposed project could also be an obstacle to the free movement of wildlife.

iv. ***Human-animal conflict:*** Wildlife in the Dagona bird sanctuary and cattle could eat crop that will be produced by the irrigated agriculture. This Crop damage could cause human-animal around the designated project area and such conflict could threaten the existence of some of these animal species.

v. ***Impact on soil salinity:*** Unwise use or water in the irrigation field or local losses of irrigation water could cause water logging and associated salinity problems. This is peculiar to irrigation within flat lands like the proposed project area. Over use of water or leakage from canals may raise saline ground water reservoir and could contribute for the increase of salt at the root zone or the crops and may affect crop production.

vi. ***Siltation of the reservoir pond:*** The immediate irrigation area will be degraded. The soil around the reservoir pond is sandy and sensitive to erosion. Though there are trees on the immediate catchment, the undercover is sent and exposed to erosion.

5.3.3 Site preparation and construction impacts

i. ***Noise pollution:*** The anticipated impacts to be experienced within this phase of the project primarily is the nuisance pollution in the form of noise and vibration which would be generated as a result of the site clearing activity.

ii. ***Disturbance to Flora and Fauna:*** this also will result the removal of some existing vegetation that will hinder the proposed development of the area. Additionally, the removal of topsoil and modification to the topographical nature of the area to suit the purpose of irrigation will dislodge existing terrestrial animals like insects and reptiles living within designated project area.

iii. ***Risk of injuries and accidents:*** Construction workers may likely be exposed to injuries and accidents during this stage.

iv. ***Soil Pollution:*** Soil pollution may also emanate due to excavation that might loosen the soil and also a potential contamination of the soil from engine oil and fuels from the heavy machinery and vehicles coming to the construction site.

v. ***Waste generation:*** this would result from workers' camps and also around the project site as nylon and plastic waste containing food for contractors might be indiscriminately disposed, more so. The waste from machines during maintenance of machinery might further pollute the environment.

However, the beneficial impact would include employment opportunities for those who would carry out these activities.

5.3.4 Transportation impacts

i. ***Noise Pollution***: The anticipated impacts based on transportation would include increased noise from transportation vehicles which would transport workers to and fro during the preparation and construction phase of the project area.

ii. ***Air Pollution***: In addition to this, air quality within area would be affected owing carbon emission and raising of dust particles by constantly moving vehicles within the designated project area.

iii. ***Disturbance to Flow of Traffic***: Additionally, impairment of the flow of traffic may arise on the access road bordering the site during the construction phase of the project.

However, beneficial impact of this would include improvement of local economy for the local transportation workers as the project is anticipated to attract population who would require transportation to the area.

5.3.5 Raw materials impact

This project is likely to have minimal impact on the extraction and use of raw materials on site, unless at the workers' camp which would temporary be constructed to harbour distant workers within the project period. Raw materials such as irrigation pipes, cement, blocks, wood, roofing sheets for the construction of a pump station and booster station would be transported to the site. Additionally, pumps and machines for the irrigation would be brought to site and installed the anticipated impact will be associated with the process of transportation to the irrigation site.

5.3.6 Process impacts

The process impacts include; impact from land acquisition, impacts from project implementation and impacts from project. The processes involved in the implementation of the irrigation project includes the acquisition of land for the project, which will entail the resettlement of the people who live within the designated area, the associated impact with this is a compulsory migration.

The project implementation which would have a lot of impact which is both adverse and beneficial. The beneficial impact includes employment opportunities, training opportunities and improvement of local economy within the area. On the other hand, adverse impact of the project during the implementation includes: Impact on terrestrial and aquatic life forms which would be dislodged; Impact of Settlement areas; farms and grazing land; Disruption of livelihoods, Health Impacts, Transportation Impact, Greenhouse Gas (GHG) emission from vehicular movements, noise pollution and vibration.

During the project operation stage impacts will include: Impact on downstream and wildlife habitat; Deterioration of water quality; Barrier/impediment to movement; Human-animal conflict Impact on soil salinity and; Siltation of the reservoir pond.

5.3.7 Health Impact Assessment (HIA)

In carrying out the health impact assessment. The stakeholder communities to be affected by the irrigation project were identified, which were; Jurgwaya, Renakunu, Laba and Mari, which are the communities at close proximity to the project area. The irrigation project though with its numerous benefits, might likely pose health risk to the stakeholders within these communities as health hazards which includes injury, communicable and non-communicable diseases might emanate during the project implementation and operation stage. Specifically, disease such as malaria and typhoid are very prevalent around irrigation areas and this has been backed up by numerous HIA studies within irrigation area.

A visit to these four aforementioned communities in which questionnaire survey was carried out. The result revealed that Typhoid and Malaria were the most prevalent diseases within these four communities having the frequency of 250 and 221 responses respectively out of the 311 administered questionnaires across the four communities. It is worthy to note that this prevalent disease is most likely to be a result of the first irrigation project of 200 hectares close to the proposed irrigation area.

The implementation and operation of the proposed project will therefore increase the susceptibility of these stakeholder communities to health risk, as cases of Malaria and Typhoid is expected to be exacerbated. Furthermore, the influx of people who would migrate and interact with these stakeholder communities as a result of the irrigation project would make them vulnerable to communicable disease. (Mutero, 2018)

It is therefore recommended that residents living within the project take preventive measures by means of using mosquito nets, mosquito repellant cream, appropriate water treatment before use such as boiling. In addition to this, as part of social responsibility, a small hospital or clinic facility could be built at proximity to these communities especially Laba and Mari communities which do not have access to healthcare facility.

5.4 Project specific incremental environmental changes

Project specific incremental change related to the irrigation project will translate in gradual transformation of the existing vacant field to agricultural features in conjunction with cultivation i.e., change in land use. As a result of the proposed irrigation, the soil water content within the area will experience a gradual increase. More, so small-scale individual agricultural fields at the northern parts will be agglomerated into a complex agricultural system as a result of the cumulative actions of individual famers. In other words, farming methods will graduate from a simple to a modern complex form. More so there would an anticipated increase in soil organic matter and soil salinity due to constant irrigation activities.

5.5 Project specific Cumulative Effects

The anticipated cumulative effect of the socio-economic terms would reflect a population increase around the project area as people might migrate to settle closer to their farms. In addition to these irrigation activities would improve local economy and improve food security and increase climate change adaptation in the agricultural Context. The specific effect of the project in negative terms is the exacerbation of the prevailing Malaria and typhoid disease; and also, water logging within the irrigation areas.

5.6 Project specific long/short term effects

The "long term" effects of the project will majorly be experienced during the operational phase, estimated to go beyond 10 years; some of the likely long-term effects include disruption of free flow of water which would be disturbed by mechanical pumps within the area, this disruption can also affect aquatic life within the area. More so, continuous pumping is likely to affect water quantity and quality especially during the dry season. Fishing activities within that part of the river; if it existed, would be greatly reduced due to increase in water consumption to sustain the irrigation project. Soil content and composition is likely to change as a result of the irrigation which is expected to change the soil composition especially in the event of using fertilizer and pesticides, this would increase the soil salinity. If the water used in irrigation is polluted from an external source is untreated before use, it would lead to concentration of heavy metals in both the soil and cultivated crops which would have a long-term effect. More so, the Irrigation project would likely elevate the cases of water borne disease such as malaria and typhoid and this would last as long as the project does. The project would likely attract migrants to the location thereby yielding an increased population that would be there for a long time. Lastly, the boosting of agricultural produce, improvement of local economy and averting chances of drought within the region is expected to be some of the benefit of the long-term effect of this project.

The" short term" effects of this project would be mostly experienced during Construction Phase of this project which is estimated to be between 1 to 6 Months. Some of the short-term effect would include increased noise and vibrations during excavation using heavy machines during the excavation of land and installation of mechanical pumps. Employment opportunities. In terms of socio-economic effect, the employment opportunities which comes up during the project construction phase would be temporal as workers would be laid off at the completion of the project. More so, disturbance to traffic as a result of the project construction would end when the project is completed.

5.7 Project specific reversible/irreversible effects

Project specific reversable effect on the biophysical environment would include the replenishment of water table/ aquifer even though it would be used excessively. In the event where the project becomes terminated, the environmental dignity can be regained overtime as trees and shrub might grow back. More so, the water flow would be returned to normalcy in the event where the pumps are turned off. In addition, sedimentation as a result of disturbance to the river can be reversed as water particles would be settled at the bottom, aquatic life can also return to the area in the event that the project becomes terminated.

Project Specific irreversible effect may include the loss of terrestrial ecosystems which once existed in the area of the proposed project, such as reptiles, birds and insects would never return due to the disturbance in their habitat. Also, the people who have been compensated to leave the project area may never return. Most importantly, the soil composition in terms of salinity as a result of irrigation and application of fertilizer and pesticides would never be the way it was before the project.

5.8 Project specific adverse/beneficial effects

5.8.1 Adverse effects

The adverse effect peculiar to this project would be increased incidence of water borne diseases such as typhoid as affirmed by the stakeholder respondents who participated in the questionnaire survey. More so, there would be an expected increase of malaria disease which poses a health risk to the residents around the project area. On the part of physiological composition, the irrigation project might lead to waterlogging and salinity of soils and inadequate leaching.

5.8.2 Beneficial effects

The beneficial effect of the project is the improvement of food security, improvement of local economy for both farmers and the State Government; reduction of vulnerability to drought, improving climate change adaptation and the advancement in technological or technical aspect in modern day agriculture.

5.9 Project specific risk and hazard assessments

The potential risk that may emanate from the irrigation project are health risk in terms of malaria, typhoid and related water-borne disease that would affect the stakeholder community being very close to the irrigation area. Additionally, environmental hazards likely to emanate from the project is the risk of flooding and erosion which is most likely to affect the Laba Community situated in between the project area and the river Yobe where the project site would be irrigated from. The health risk could be averted through preventive measures such as the use of Mosquito net and mosquito repellent cream; and also, the provision of a mini health care facility to provide treatments to those who have these diseases. On the other hand, flood risk can be averted through the creation of abatement at the riverbanks to either direct or repel rapid water flow towards these communities.

Cumulative Effects

Note Please

The potential Environmental and Social Impacts (beneficial and adverse) should be presented in a sequential manner under the various project phases thus:

-Mobilization/Preconstruction Phase
- Construction activities phase
- Operational Phase
- Decommissioning Phase

CHAPTER SIX

6.0 MITIGATION MEASURES

There are numerous mitigation measures and alternatives that shall be implemented to curb the negative impact that are most likely to emanate from the proposed irrigation project and maintain its sustainability, these mitigation measures have been explained in the following sections

6.1 Best available control technology

There are variety of technologies that are best suited for irrigation systems, most of these technologies have to do with the regulation of water use so as to prevent over pumping of water and water logging of irrigation fields through the use of soil moisture sensor, water level sensor and GSM controller in which the regulator can control the functions of the irrigation system from a remote location. A very good example is the PLC based sprinkler irrigation system. The contemporary way of irrigation if not given full attention, has the potential of water wastage which would result in negative impact on the environment as a result of waterlogging.

Additionally, researches have shown that the best way of managing irrigation projects in order to optimize crop yields and minimize negative environmental impact, is the incorporation of modern agricultural technologies that monitor the environment affecting crop yields through the use of sensors and chips, in essence, automated agricultural systems. These sensors help in monitoring water levels, soil contents and salinity which are very much peculiar to irrigation projects. The project shall consider the use of modern available technologies that are easy to use in the nearest future, so as to enhance monitoring of environmental parameters which will decrease the chances of adverse environmental impact happening.

6.2 Liability Compensation

All Project Affected Communities fall outside the perimeter of the project site. Consequently, therefore, there are no encumbrances on the project site.

6.3 Summary of Proposed Mitigation Measures

Table 6.1: Impacts with corresponding mitigation measures

S/N	PROJECT ACTIVITY	ENVIRONMENTAL ASPECT	ASSOCIATED AND POTENTIAL IMPACT	IMPACT CHARACTERIZATION	OVERALL IMPACT RATING	MITIGATION MEASURE(S)	RESIDUAL IMPACT RATING (IMPACT AFTER MITIGATION)
1.	**Site Preparation**	Flora, Fauna	Loss of habitat for fauna, loss of native species of flora	Direct, adverse, long-term	Medium	HJKY_TF shall restrict Land Clearing to work areas	Negligible
		Air quality and Noise	Increase in noise levels and gaseous emissions from equipment used in clearing	Direct, reversible, short-term	Medium	HJKY_TF shall use equipment in optimal condition to reduce emissions and noise	negligible
		Socio-economic	Attraction of labour and commerce	Direct, beneficial, short-term	Beneficial	Enhancement of the Local Economy and livelihood of people	Beneficial
		Geology and Soil	Erosion as a result of change in surface morphology	Direct, adverse, short-term, reversible	High	Limit clearing to the canal, channels and pump station areas; limit clearing to dry season	Low
		Health	Risk of accident and injuries, exposure to dust, effluents and emissions from equipment	Direct, adverse, long-term	Medium	Ensure proper use of Personal Protective Equipment by workers, engagement of professionals, have first aid kit on-site	Low

		Waste management and Climate Change	Indiscriminate dumping of waste within project site, felling of trees.	Direct, adverse, long-term	Medium	Plant trees along the perimeter and buffer zones of the site to prevent desertification, provide waste bins for proper disposal of waste	Low
		Traffic	Increase in traffic along the Gashua-Damaturu road and PACs resulting in accident and increase in noise	Direct, adverse, reversible	Low	HJKY_TF shall apply speed limitation around the project site, install speed breakers/bumps, mount appropriate traffic signs, train drivers on defence driving.	Negligible
		Ground and Surface Water	Water quality	Groundwater contamination from seepage and eutrophication, runoff onto Yobe river through canals and channels	Medium	HJKY_TF shall use impervious membrane during mixing of concrete, anc control runoff water.	Low
2.	**Construction**	Flora, Fauna	Loss of habitat for fauna, loss of native species of flora	Direct, adverse, long-term	Medium	HJKY_TF shall restrict construction to work areas	Negligible
		Air quality and Noise	Increase in noise levels and gaseous emissions from equipment used during construction	Direct, reversible, short-term	Medium	HJKY_TF shall use equipment in optimal condition to reduce emissions and noise	negligible

		Socio-economic	Employment opportunities and commerce	Direct, beneficial, short-term	Beneficial	Job creation, Enhancement of the Local Economy and livelihood of people	Beneficial
		Geology and Soil	Erosion as a result of change in surface morphology, seepage from concrete mixing on soil; ground and surface water contamination	Direct, adverse, short-term, reversible	High	Limit clearing to the canal, channels and pump station areas; limit clearing to dry season, mixing at designated spots on site, spread of impervious membrane at designated points of mixing	Low
		Health	Risk of accident and injuries, exposure to dust, effluents and emissions from equipment, Open defaecation	Direct, adverse, long-term	Medium	HJKY_TF shall ensure proper use of Personal Protective Equipment by workers, engagement of professionals, have first aid kit on-site, provide mobile toilet facilities for workers on site	Low
		Waste management and Climate Change	Indiscriminate dumping of waste within project site, felling of trees,	Direct, adverse, long-term	Medium	HJKY_TF shall plant trees along the perimeter and buffer zones of the site to prevent	Low

			spillage of fuel and oil from equipment and fuel dump			desertification, provide waste bins for proper disposal of waste, refuelling and change of oil shall be done at designated service station, fuel dump shall have bund wall	
		Traffic	Increase in traffic along the Gashua-Damaturu road and PACs resulting in accident and increase in noise	Direct, adverse, reversible	Low	HJKY_TF shall apply speed limitation around the project site, install speed breakers/bumps, mount appropriate traffic signs, train drivers on defence driving.	Negligible
		Pumping and booster Station	Loss of topsoil, seepage from concrete mixing on soil; ground and surface water contamination	Direct, adverse, short-term	Medium	mixing at designated spots on site, spread of impervious membrane at designated points of mixing	Negligible
		Ground and Surface Water	Water quality	Groundwater contamination from seepage and eutrophication, runoff onto Yobe river through canals and channels	Medium	HJKY_TF shall use impervious membrane during mixing of concrete, anc control runoff water.	Low

3.	**Operation**	Flora, Fauna	Loss of habitat for fauna, loss of native species of flora	Direct, adverse, long-term	Low	HJKY_TF shall restrict cultivation to designated lots	Negligible
		Air quality and Noise	Increase in noise levels and gaseous emissions from equipment used during farming	Direct, reversible, short-term	Low	HJKY_TF shall use equipment in optimal condition to reduce emissions and noise	negligible
		Socio-economic	Employment opportunities and commerce	Direct, beneficial, short-term	Beneficial	Job creation, Enhancement of Household Income and Local Economy and livelihood of people, Food Security	Beneficial
		Geology and Soil	Seepage of excess phosphorus and nitrogen content in soil from use of agro-chemical fertilizers and herbicides into ground and surface water	Direct, adverse, short-term, reversible	Medium	HJKY_FJ shall regulate the use of inorganic manure as fertilizer within the scheme. HJKY_FJ shall train and sensitize farmers on the best practices of the use of agro-chemical fertilizers and herbicides to reduce their impact on the soil	Low

		Health	Increased breeding of mosquitoes and other vectors, within the project site	Direct, adverse, long-term	Medium	HJKY_TF shall provide mosquito nets for its resident staff and maintain proper waste and sanitation conditions within the project area	Low
		Waste management and Climate Change	Indiscriminate dumping of waste within project site, spillage of fuel and oil from equipment and fuel dump	Direct, adverse, long-term	Medium	HJKY_TF shall plant trees along the perimeter and buffer zones of the site to prevent desertification, provide waste bins for proper disposal of waste, refuelling and change of oil shall be done at designated service station, fuel dump shall have bund wall	Low
		Traffic	Increase in traffic along the Gashua-Damaturu road and PACs resulting in accident and increase in noise	Direct, adverse, reversible	Low	HJKY_TF shall apply speed limitation around the project site, install speed breakers/bumps, mount appropriate traffic signs, train drivers on defence driving.	Negligible
		Farmers/herders clash	Invasion of animal herds on farmlands, Loss	Direct, adverse, long-term	High	HJKY_TF shall in conjunction with the state	Low

			of crops to animal grazing, Injuries and loss of life(s), displacement of farming settlement(s)			government clearly delineate cattle grazing routes to avoid encroachment on farming lands. Conversely farmers shall be confined to not cultivating the grazing routes.	
		Pump and Booster station	Waterlogging due to over-supply of water to canals; Open defaecation around the pump station	Direct, mild, short-term	Medium	HKJY_TF shall regulate the volume of water pumped into the scheme per time. The toilets at the pump station shall be kept functional at all times	Low
		Fire outbreak	Loss of farm produce, human life, farm assets	Direct, adverse, long term	High	Fuelling and associated activities shall be done outside the farm area.	Low
		Ground and Surface Water	Water quality	Groundwater contamination from seepage and eutrophication, runoff onto Yobe river through canals and channels	Medium	HJKY_TF shall use impervious membrane during mixing of concrete, regulate the use of non-organic manure.	Low
4.	**Decommissioning**	All stakeholders shall be adequately involved during the decommissioning phase of the project.					

Table 6.2: Impact Receptors amd Proposed Mitigation Measures

S/N	Potential Negative Impact of the proposed irrigation scheme	Receptors	Proposed Mitigation Measures
1.	*Impact on terrestrial and aquatic ecosystem and biodiversity*	Terrestrial and aquatic life forms within the site.	• Confine clearing of vegetation to what is absolutely necessary. Preserve trees as much as possible. • Avoid locating camp site and borrow pits in vegetated areas. • Promote enrichment tree plantation in the buffer zone. • Utilize field borders to conserve natural vegetation and to provide wildlife corridors around fields used for crop production. • Maintain the river channel and its associated riverine woodland. • Selective cutting should be adopted during the clearance. • Prohibit clearing of vegetation cover at least from 100-150 m buffer zone centred on river channel on the sides of the river in irrigation command area. conserving this area would also provide corridor for the movement of wildlife. • Avoid dumping of solid and liquid wastes from the construction camps and spoils. • Avoid washing construction equipment in to and river. • Do not dispose chemicals, fuel and lubricants into river or the irrigation area.
2.	*Impact from camp sites, access roads and air/noise pollution*	The surrounding environment of the Project area.	• Select camp and borrow sites far from Settlement, forest and environmentally sensitive areas. if possible, locate them away from the proposed area. • Preserve top soils for reuse to refill borrow Sites
3.	*Impact on Settlement areas, farms and grazing land*	Stakeholder communities close to the project.	• Compensations paid for the loss of property based on the Country's compensation policy. • Relocation of the resident famers and pastoralists away from the command areas. • Give consideration to compensation for other losses Such as opportunity loss and psychological trauma. • Consider allocation of irrigation land for farmers displaced from the irrigation command area. • Include pasture production as cattle in the irrigation plan.

			• Minimize land areas required for each component during the irrigation construction.
4.	*Disruption of livelihoods*	Stakeholder communities close to the project.	• Give consideration to compensation for other losses Such as opportunity loss and psychological trauma. • Allocate irrigation land for those who were displaced from their irrigation command area as compensation.
5.	*Health Impacts*	Stakeholder communities close to the project.	• Do not induce malaria outbreak by creating temporary and permanent water holding areas which favour mosquito breeding. • Use mosquito nets and insect repellent cream in times of malaria out beak; and provide a clinic or medical facilities at the construction camp. • Strengthen the capacity of health institutions and provide a clinic at the construction camp. • Provide Safe water supply and appropriate waste disposal facilities including the provision of sanitary latrines in the construction camp.
6.	*Greenhouse gas (GH) emission impacts of the reservoir pond*	Immediate environment of the project	• Clearance of vegetation from the reservoir pond should be done before impoundment takes place. • Preservation of existing trees and planting of drought resistant trees around the site boundary.
7.	*Impact on downstream and wildlife habitat*	Aquatic and terrestrial life forms	• Optimize crop yield while conserving the quality and quantity of water. • Conserve irrigation water by reducing evapotranspiration by avoiding midday irrigation and reducing seepage losses in canals by lining them or using close conduits • Monitor the river level draw down and water quality of the Yobe River from time to time.
8.	*Deterioration of water quality*	River Yobe bordering the site.	• Collect and treat irrigation farm drainage water before discharging to the river • Control direct discharge of crop waste into the river

			• Composting crop waste into organic manure. • Reduce the number of pesticides and fertilizers applied in the irrigation farms. • Do not dispose fuel and lubricants into the river. Servicing of plants, equipment and vehicles should be carried out at a workshop area. • Avoid dumping of solid and liquid wastes from the project camps and spoils from construction sites into the river • Promote watershed management work to control soil erosion, nutrient wash and associated water quality deterioration. • Encourage the use of manure over fertilizer as it is like has lesser potential to pollute the environment.
9.	*Barrier/impediment to movement*	Stakeholder Community, especially Laba settlement	• Selection of appropriate location with consultation of the local people prior to construction of crossing structures. • Construction of crossing structures/bridges on the canal at appropriate distance interval. • Fence along the canal in areas where there are many livestock are present. • Establishment of wildlife corridor. • A wild life corridor is an area of habitat that provides passage for wildlife across artificial obstacles such as a canal and road. • Provide convenient routes to access the Gashua-Damaturu road.
10.	*Human-Animal conflict*	Terrestrial life forms (Man, birds and Herbivore's animals)	• Enhance community awareness by Educating rural villagers in practical skills that would help them deal with bird species and acquire or develop new tools like the scarecrow and deterrents for defending their crops and livestock. • Fences made of thorned bush can be almost completely effective in preventing conflict between people and birds and cattle, Fences are used to protect crops and to protect people and Livestock. • The use of alternative crops such as ginger and chili around the boundary of the site to deter animals from coming to the area.

11.	*Impact on soil salinity and Soil Pollution*	Soil within the proposed irrigation area	• Avoid over use of water in the irrigation filed. • Avoid excessive application of fertilizers and pesticides. • Drain water logging areas of the farm. • Classify irrigation field according to soil salinity class and grow salt tolerant crops on saline plots. • Apply periodic leaching of saline soils. • Properly designed spillway to direct water back to natural course • Avoid unnecessary movement of machinery beyond the excavation area
12.	*Impact from crop residue, solid waste and pesticides*	The proposed irrigation area.	• Recycle crop residues and other organic materials by leaving the materials in the fields; Ploughing, and/or composing • Clean and dispose of (through crushing. shredding, or return to suppliers) pesticide packaging and containers to ensure that they are not subsequently used as containers for food or drinking water. • Manage expired and unwanted pesticides as hazardous Wastes in accordance with the general NASRA and FAO guidelines. • Protect natural enemies of pests by providing a favourable habitat such as bushes for nesting sites.
13.	*Siltation of the reservoir pond*	Surface and underground water	• Conserve buffer zone around the reservoir pond (10-50m) • Conduct integrated watershed management activities such as area closure, terracing, planting trees etc. • Construct sediment retention points where more sediment load flow to the reservoir pond. • Provide sluice gets or other structures in the reservoir pond design to selectively discharge the sediment from the reservoir.
14.	*Disturbance to Flora and Fauna*	Flora and Fauna within the site	• Preserve as much trees as possible and plant more trees. • The disturbance to both flora and fauna as a result of the construction is inevitable. Therefore, ensure that alternative

			habitat is not tempered with. Limit clearing to the designated area.
15.	*Risk of injuries and accidents*	Workers and residents of stakeholder communities	• Provide workers with relevant working gears to protect them from accidents. • Have a health/safety personnel with who can oversee that safety measures are in place. • have a traffic warden to oversee vehicular movement are not obstructed
16.	*Waste generation*	Surrounding environment of the project impact. And workers camp/borrow pit	• Provide temporary or permanent public convenience for workers for the duration of the project. • Provide waste bins and waste collection points. • Sensitive sellers on the need to keep the environment clean and carefully the waste that emanates from what they sell such as wraps, nylon and plastics.
17.	*Noise Pollution*	Surrounding environment of the project impact.	• Provide and encourage the use of protective gears for workers such as ear muffs.
18.	*Air Pollution*	Surrounding environment of the project impact.	• Reduce dust by watering the access road surface. • Avoid incineration of materials such as tyre's, plastic, rubber products or other materials that can create heavy smoke or unpleasant odour. • Ensure that workers wear facemask to protect them from inhaling smoke and dust
19.	*Disturbance to Flow of Traffic*	Surrounding environment of the project impact.	• Have a traffic warden to oversee vehicular movement are not obstructed. • Use traffic signs and construction work notice along the express ways. • Create speed bumps if necessary to slow down vehicles.

CHAPTER SEVEN

7.0 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

This chapter updates ESMP of the Gashua irrigation project. In Updating the ESMP, consideration has been given to current experience in ESMP implementation. Measures have been proposed to strengthen implementation of the ESMP for the overall irrigation project. The review follows a site visit to ensure that ESMP is current an address any changes.

Generally, this ESMP provides a roadmap for implementation of enhancement and mitigation measures of the impacts identified under this project. The details for implementation of Environmental and Social Enhancement Measures as well as Impact Mitigation measures are provided in Tables 81 and 82. The basis for the development of ESMP comes from the findings of environmental and social impacts that are likely to be generated from the project development phases. The plan indicates the impacts, their proposed mitigation and enhancement measures, responsible institutions, and appropriate time for taking action.

ESMP provide instructions to relevant project personnel regarding procedures for protecting the environment and minimizing environmental effects, thereby supporting the project goal of minimal or zero incidents. Therefore, the developer is ought to be pro-active in ensuring voluntary compliance by adopting the proposed mitigation and enhancement measures prescribed in this Environmental and Social Impact Assessment Report.

7.1 Project Management and Responsibilities

In order to ensure the effective implementation of the ESMP, the management structure which will include health, safety and environmental personnel will be formed so as to ensure the environmental management measures identified are implemented. The roles and responsibilities of the various persons and organizations involved in the project are as defined in

Table 7.1.

Table 7.1: Project Organization and Responsibilities

Unit	Responsibilities for environment
Project Manager (PM)	- Responsible for overseeing the contract from initiation to completion of construction on the site; - Appoint a team of contractors, which will be responsible for the construction of the entire project; - Responsible for ensuring that the site development is implemented according to the requirements as set out in the ESMP; - Ensure that sufficient resources are available to the other role players to efficiently perform their tasks in terms of the ESMP; - Management of overall project activities; - Receive and supervise the environmental report from the consultant; - Cooperate with Consultant to periodically supervise contractors' activities; and - In case of any violations or arising works that were submitted by the Environmental Control Officer, PM will request contractors to amend and correct them.
Consultant (Design Engineer)	- Responsible for design; - Receive and supervise the environmental report from the environmental officer, reporting to PM on a weekly basis. The environmental officer will be in charge of reviewing the environmental report and recommend further actions. - Cooperate with PM to periodically supervise contractors' activities. Scheduled meetings (e.g weekly meetings) will be held between the contractor, PM and consultants. - Include, among its staff, an environmental officer who will oversee the implementation of the ESMP and report to PM
Environmental Control Officer (ECO)	- ECO should be nominated from within the CBDA team before the start of the construction phase. This role should be managed by the person who has the mandate as the Environmental and Social Safeguard Officer. - ECO shall be assisted in his/her tasks by a social safeguard's expert. - Ensure that all Contractor, subcontractors, employees and the beneficiaries are fully aware of their environmental responsibilities. This will take the form of an initial environmental awareness-training program in which requirements of the ESMP will be explained. - Undertake on-going training of the workforce; - The ECO shall monitor the developer's actions to ensure that the developer's staff and/or contractor are adhering to all the stipulations of the ESMP;

	- The ECO shall be responsible for monitoring the construction activities throughout the project by means of undertaking site visits and meetings. These visits should be documented as part of the site meeting minutes; - The ECO must sign off that the PM certifies the developer's compliance in ensuring all clean-up and rehabilitation or any remedial action required shall take place, and be completed prior to transfer of properties; - Ensure that a post construction environmental audit is to be conducted to ensure that all conditions in the ESMP have been adhered to. - Make reference and prepare site specific plans in accordance with ESMP. The respective contractor will be required to formally commit to requirements of the site-specific Management Plans. - Establish environmental procedure and notify and obtain formal commitment from the contractor; - Observe directly the performance of the environmental works, report mitigation measures of the environmental impact resulting from contractor's activities; - Review weekly/monthly environmental reports prepared by the Contractor; - Report to the Consultant and PM the performance of the contractors, and recommend countermeasures if any.
Community Liaison Officer (CLO)	- Representing the community and managing all communication between the ECO, the Contractor and the public. (The details of the CLO are to be forwarded to the relevant representative) - The CLO will be the contact person where all grievances or complaints are lodged by the public
Contractor	- After receiving and committing to the environmental procedures and Management Plans, Contractors shall prepare/update a Contractor's ESMP, and ensure that the measures related to environmental and social safeguards are fully carried out. as indicated; - Preparing/Updating the project's Environmental Health and Safety Management Plan - Appointing a full-time Environmental, Health and Safety Officer - Reporting any violations or arising works that either detected by Environmental officer to Consultant and PM for further actions.

Unit	**Responsibility for Health and Safety**
Project Manager (PM)	- Select the health and safety/safeguard officer - Receive and supervise the environmental report from the consultant. - Cooperate with the Consultant to periodically supervise contractor's activities

Health and Safety Officer	- Make reference and propose additional site-specific plans in accordance with ESMP; - Establish health and safety procedures and notify the contractors; - Periodically inspect the performance of the construction activities, health and safety management at construction site; - Analyse and issue health and safety reports periodically; - In case health and safety officers detect violations at construction site related to health and safety management, they must promptly report to the Consultant and PM, and recommend measures if any.
Consultant (Design Engineer)	- Receive and supervise the construction and inspection report from the contractor, weekly reporting to PM; - Cooperate with PM to periodically supervise contractors' activities; - In case of any violations or arising works detected and submitted by the technical consultant, Consultant will request contractors to amend and correct the violations.
Contractor	- After receiving health and safety procedure, Contractors must be informed to fully carry out the measurement of the health and safety protection as indicated; - Contractors must assign at site personnel in charge of health and safety procedure. Any changes related to health and safety procedures must be communicated to Health and Safety Officer, Consultant and PM for approval; - In case of any violations or arising works that was either detected by Health and Safety Officer or proposed by contractors, they must be reported to the Consultant and PM for further actions; - If contractors decides not to follow instructions from the consultant, health and safety officer and PM, construction activities will be halted until necessary actions are taken. - To allocate the responsibility of overseeing day-today compliance with the ESMP to a senior member of his/ her staff. - Responsible for the implementation of all measures included in the ESMP for all activities undertaken in terms of the construction contract (including work undertaken by sub-contractors if any). - Keep monthly records of all incidents occurring on site

7.2 Training

The ESIA involves training which require the appointment of an ECO as the one responsible to ensure ESMP is implemented. The appointed ECO will require environmental, health and safety training for construction sites, and specific training on his/her expected roles and responsibilities, as outlined above.

The ideal candidate for the ECO would have experience on construction sites, experience of regulating Environmental, Health and Safety compliance, local knowledge and a strong interest in environmental issues.

Training of the appointed ECO would ideally involve one week of onsite training by an experienced environmental manager during the construction period. The aim of the training will be to establish good auditing procedures, identify ways in which to successfully implement the ESMP and continually improve environmental performance. The scope of the training would include:

- Weekly EHS toolbox talks;
- Environmental auditing;
- Non-conformance awareness and emergency response procedures;
- Continual performance review and improvement;
- Document control;

Also, all persons responsible for undertaking work during the life of the project must be trained on the contents of the ESMP. Ensure that all site personnel have a basic level of environmental awareness training. Topics covered should include:

- Meaning of "Environment" and coverage;
- Why the environment needs to be protected and conserved;
- How construction activities can impact on the environment;
- Proposed mitigation against impacts; and
- Social responsibility during construction e.g., being considerate to local residents.

7.3 Implementation of ESMP

The environmental and social mitigation measures incorporated in this report shall be implemented by an Environmental Expert with at least 10 years' experience in projects of similar nature. The expert will be familiar with the scientific measurement of environmental and social impacts; and remedies and enhancement.

The selected contractor for the construction of the irrigation scheme shall be supervised by a selected consulting firm (Resident Engineer). One of the team members of the supervision team will be the Environmental Specialist who is an expert in Environmental Management issues especially on construction project (with at least 10 years' experience in projects of similar nature). One of his tasks shall be to oversee the contractor in implementing the mitigation measures proposed by the ESMP during the construction phase. His other duties will be to assist the contractor in the implementation of the Environmental Monitoring Plan during construction period.

During operational phase the Implementation of the ESMP shall be mainly the responsibility of CBDA.

7.4 Environmental Cost

A number of assumptions regarding the costs were also made, for instance that some costs will be covered by the contractors' standard practices. The costs are therefore indicative and should be reviewed prior to commencement of the project.

In view of the updated ESIA, the principal environmental cost includes the cost for implementing the mitigation measures proposed and that for carrying out monitor of specific environmental parameters. These costs for mitigation measures are indicated in Table 7.2.

Table 7.2: Environmental and Social Management Plan for proposed Project

S/N	PROJECT ACTIVITY	ENVIRONMENTAL ASPECT	MONITORING PARAMETERS	ASSOCIATED AND POTENTIAL IMPACT	RATING BEFORE MITIGATION	MITIGATION MEASURE(S)	RATING AFTER MITIGATION	TIMELINES/ FREQUENCY	RESPONSIBLE PARTIES	COST (₦)
1.	**Site Preparation**	Flora, Fauna	Changes in biodiversity	Loss of habitat for fauna, loss of native species of flora	Medium	HJKY_TF shall restrict Land Clearing to work areas	Negligible	Weekly	HJKY_TF, CBDA, Regulators (Federal, State and Local Governments)	15,000,000.00
		Air quality and Noise	Changes in levels of oxides of sulphur (SOx)and nitrogen (NOx), decibel levels	Increase in noise levels and gaseous emissions from equipment used in clearing	Medium	HJKY_TF shall use equipment in optimal condition to reduce emissions and noise	negligible	Monthly	HJKY_TF, CBDA, Regulators (Federal, State and Local Governments)	22,500,000.00
		Socio-economic	Change in taste and lifestyle	Attraction of labour and commerce	Beneficial	Enhancement of the Local Economy and livelihood of people	Beneficial	Bi-annual	HJKY_TF, CBDA	15,000,000.00

		Geology and Soil	Soil integrity test	Erosion as a result of change in surface morphology	High	Limit clearing to the canal, channels and pump station areas; limit clearing to dry season	Low	One-off	HJKY_TF, CBDA	7,500,000.00
		Health	Prevalent ailment within the PACs.	Risk of accident and injuries, exposure to dust, effluents and emissions from equipment	Medium	Ensure proper use of Personal Protective Equipment by workers, engagement of professionals, have first aid kit on-site	Low	One-off	HJKY_TF, CBDA	7,500,000.00
		Waste manageme nt and Climate Change	Aesthetics, Number of waste bins on project site	Indiscriminate dumping of waste within project site, felling of trees.	Medium	Plant trees along the perimeter and buffer zones of the site to prevent desertification, provide waste bins for proper disposal of waste	Low	One-off	HJKY_TF, CBDA	7,500,000.00
		Traffic	Traffic flow, reduced/ zero accident rate	Increase in traffic along the Gashua-Damaturu road and PACs resulting in accident and	Low	HJKY_TF shall apply speed limitation around the project site, install speed breakers/bumps	Negligibl e	Weekly	HJKY_TF, CBDA	15,000,000.00

				increase in noise		, mount appropriate traffic signs, train drivers on defence driving.				
		Ground and Surface Water	Water quality	Groundwater contamination from seepage and eutrophication, runoff onto Yobe river through canals and channels	Medium	HJKY_TF shall use impervious membrane during mixing of concrete, anc control runoff water.	Low	Weekly	HJKY_TF, CBDA	15,000,000.00
2.	**Construction**	Flora, Fauna	Changes in biodiversity	Loss of habitat for fauna, loss of native species of flora	Medium	HJKY_TF shall restrict construction to work areas	Negligibl e	Weekly	HJKY_TF, CBDA, Regulators (Federal, State and Local Governme nts)	18,000,000.00
		Air quality and Noise	Changes in levels of oxides of sulphur (SOx)and nitrogen (NOx), decibel levels	Increase in noise levels and gaseous emissions from equipment used during construction	Medium	HJKY_TF shall use equipment in optimal condition to reduce emissions and noise	negligible	Monthly	HJKY_TF, CBDA, Regulators (Federal, State and Local Governme nts)	27,000,000.00
		Socio-economic	Change in taste and lifestyle	Employment opportunities	Beneficial	Job creation, Enhancement of the Local	Beneficial	Bi-annual	HJKY_TF, CBDA	18,000,000.00

				and commerce		Economy and livelihood of people				
		Geology and Soil	Soil integrity test	Erosion as a result of change in surface morphology, seepage from concrete mixing on soil; ground and surface water contamination	High	Limit clearing to the canal, channels and pump station areas; limit clearing to dry season, mixing at designated spots on site, spread of impervious membrane at designated points of mixing	Low	One-off	HJKY_TF, CBDA	9,000,000.00
		Health	Prevalent ailment within the PACs.	Risk of accident and injuries, exposure to dust, effluents and emissions from equipment, Open defaecation	Medium	HJKY_TF shall ensure proper use of Personal Protective Equipment by workers, engagement of professionals, have first aid kit on-site, provide mobile toilet facilities for workers on site	Low	One-off	HJKY_TF, CBDA	9,000,000.00
		Waste manageme nt and	Aesthetics, Number of waste bins	Indiscriminate dumping of waste within project site,	Medium	HJKY_TF shall plant trees along the perimeter and	Low	One-off	HJKY_TF, CBDA, Regulators (Federal,	15,000,000.00

		Climate Change	on project site	felling of trees, spillage of fuel and oil from equipment and fuel dump		buffer zones of the site to prevent desertification, provide waste bins for proper disposal of waste, refuelling and change of oil shall be done at designated service station, fuel dump shall have bund wall			State and Local Governme nts)	
		Traffic	Traffic flow, reduced/ zero accident rate	Increase in traffic along the Gashua-Damaturu road and PACs resulting in accident and increase in noise	Low	HJKY_TF shall apply speed limitation around the project site, install speed breakers/bumps , mount appropriate traffic signs, train drivers on defence driving.	Negligibl e	Weekly	HJKY_TF, CBDA	18,000,000.00
		Pumping and booster Station	Functionality and efficiency	Loss of topsoil, seepage from concrete mixing on soil; ground and surface water contamination	Medium	mixing at designated spots on site, spread of impervious membrane at designated points of mixing	Negligibl e	Quarter ly	HJKY_TF, CBDA	9,000,000.00

		Ground and Surface Water	Water quality	Groundwater contamination from seepage and eutrophication, runoff onto Yobe river through canals and channels	Medium	HJKY_TF shall use impervious membrane during mixing of concrete, anc control runoff water.	Low	Weekly	HJKY_TF, CBDA	15,000,000.00
3.	**Operation**	Flora, Fauna	Changes in biodiversity	Loss of habitat for fauna, loss of native species of flora	Low	HJKY_TF shall restrict cultivation to designated lots	Negligibl e	Bi-annual	HJKY_TF, CBDA, Regulators (Federal, State and Local Governme nts)	6,000,000.00
		Air quality and Noise	Changes in levels of oxides of sulphur (SOx)and nitrogen (NOx), decibel levels	Increase in noise levels and gaseous emissions from equipment used during farming	Low	HJKY_TF shall use equipment in optimal condition to reduce emissions and noise	negligible	Quarter ly	HJKY_TF, CBDA, Regulators (Federal, State and Local Governme nts)	15,000,000.00
		Socio-economic	Change in taste and lifestyle	Employment opportunities and commerce	Beneficial	Job creation, Enhancement of Household Income and Local Economy and livelihood of people, Food Security	Beneficial	Annual	HJKY_TF, CBDA, Regulators (Federal, State and Local Governme nts)	9,000,000.00

		Geology and Soil	Soil fertility	Seepage of excess phosphorus and nitrogen content in soil from use of inorganic manure into ground and surface water	Medium	HJKy_FJ shall regulate the use of inorganic manure as fertilizer within the scheme	Low	Annually	HJKY_TF, CBDA, Regulators (Federal, State and Local Governments)	9,000,000.00
		Health	Prevalent ailment within the PACs.	Increased breeding of mosquitoes and other vectors, within the project site	Medium	HJKY_TF shall provide mosquito nets for its resident staff and maintain proper waste and sanitation conditions within the project area	Low	Annually	HJKY_TF, CBDA, Regulators (Federal, State and Local Governments)	9,000,000.00
		Waste management and Climate Change	Aesthetics, Number of waste bins on project site	Indiscriminate dumping of waste within project site, spillage of fuel and oil from equipment and fuel dump	Medium	HJKY_TF shall plant trees along the perimeter and buffer zones of the site to prevent desertification, provide waste bins for proper disposal of waste, refuelling and change of	Low	Quarterly	HJKY_TF, CBDA, Regulators (Federal, State and Local Governments)	30,000,000.00

						oil shall be done at designated service station, fuel dump shall have bund wall				
		Traffic	Traffic flow, reduced/ zero accident rate	Increase in traffic along the Gashua-Damaturu road and PACs resulting in accident and increase in noise	Low	HJKY_TF shall apply speed limitation around the project site, install speed breakers/bumps, mount appropriate traffic signs, train drivers on defence driving.	Negligible	Bi-annually	HJKY_TF, CBDA, Regulators (Federal, State and Local Governments)	18,000,000.00
		Farmers/herders clash	Peaceful coexistence	Invasion of animal herds on farmlands, Loss of crops to animal grazing, Injuries and loss of life(s), displacement of farming settlement(s)	High	HJKY_TF shall in conjunction with the state government clearly delineate cattle grazing routes to avoid encroachment on farming lands. Conversely farmers shall be confined to not cultivating the grazing routes.	Low	Annually	HJKY_TF, CBDA, Regulators (Federal, State and Local Governments)	18,000,000.00

		Pump and Booster station	Efficiency and Functionality	Waterlogging due to over-supply of water to canals; Open defaecation around the pump station	Medium	HKJY_TF shall regulate the volume of water pumped into the scheme per time. The toilets at the pump station shall be kept functional at all times	Low	Bi-annually	HJKY_TF, CBDA, Regulators (Federal, State and Local Governments)	27,000,000.00
		Fire outbreak	fire free incidence	Loss of farm produce, human life, farm assets	High	Fuelling and associated activities shall be done outside the farm area.	Low	Annually	HJKY_TF, CBDA, Regulators (Federal, State and Local Governments)	18,000,000.00
		Ground and Surface Water	Water quality	Groundwater contamination from seepage and eutrophication, runoff onto Yobe river through canals and channels	Medium	HJKY_TF shall use impervious membrane during mixing of concrete, regulate the use of non-organic manure.	Low	Quarterly	HJKY_TF, CBDA	15,000,000.00
									TOTAL	**417,000,000.00**

The total cost of implementing the ESMP is estimated to be **Four Hundred and Seventeen Million Naira (₦417,000,000.00) only** with a US Dollar equivalent of **One Million, Twelve Thousand, Nine Hundred and Forty Seven Thousand Dollars, Twenty-Six Cents ($1012947.26)** only, using an exchange rate of **$1=411.67** as at Friday, 20th August, 2021

7.5 Environmental Health and Safety Management Plan

7.5.1 Introduction

An Environmental Health and Safety Management Plan embraces the challenges necessary to proactively manage environmental, health and safety issues and obligations. The aim of the EHS Plan is to set out the Organization and Arrangements for the Principal Contractor for achieving the health and safety objectives for the construction phase of this project, as required by the regulations and HSE Policy.

The main purpose of the HSE Policy is that the project health, safety and environment regime is practicable within the regulations, codes, guidelines and practices as directed by directorate of occupational health and safety and the Ministry of Environment. The EHS Management system is designed so as to be able to adapt and respond to evolving circumstances so that predicted and actual effects are managed effectively. The primary components of the EHS Management System are:

- An organizational structure and defined EHS responsibilities and accountabilities for personnel;
- A safety performance objective system that provides a mechanism to measure and improve safety and recognize achievements in safety performance;
- A management plan to ensure compliance with regulations, goals and objectives;
- Safe work practices and procedures documentation that establish basic precautions for preventing accidents, injuries or illnesses in the performance of work;
- Environmental practices and procedures that establish minimum standards for all operations that have a potential to cause environmental problems;
- Safety trainings established to ensure that all personnel are aware of potential hazards and know safe work practices/emergency procedures;
- A medical and occupational health management program that will foster the maintenance and preservation of employees' good health and welfare;
- An accident/incident reporting system that standardizes prompt reporting of all injuries, property damage, environmental incidents and near misses;
- A procedure to carry out formal safety and environmental audits for operations controlled by Health and Safety Officer and Contractor to verify compliance with approved plans, procedures, system specifications and/or other applicable contract requirements;

- A procedure for periodic operational safety and environmental inspections conducted to verify all activities conform to health and safety requirements and are being conducted in a safe, efficient, and environmentally responsible manner;
- Identification of potentially hazardous materials and exposures;
- Procedures to initiate an organized response to an emergency or potential emergency situation, including periodic exercises; and
- A safety information management system that provides the ability to record safety information, analyse data and produce timely and relevant reports.

7.5.1 Implementation of HSE Policy

The main issues to look at, in the implementation of HSE policy at the construction site are:

i. Site Safety and Performance
    - Ensuring no harm to people
    - Compliance with all legal requirements
    - Implementation of the HSE standards and codes
    - Lessons learnt

ii. Environmental Performance

The Contractor shall comply with THE HSE Policy and all relevant provisions of the Environmental Management Act through the implementation of its ESMPs developed while carrying out Environmental and Social Impact Assessment of the proposed irrigation project. The major environmental issue in this phase will be construction debris, wastewater management, liquid waste, recyclable or reusable items, dust emissions and other hazardous wastes generated during the construction activities.

7.6 Environmental Protection and Compliance

The Contractor and any supplier must confirm and ensure compliance with all relevant environmental, health and safety legal requirements. It is recommended that a legal register be developed and compliance against the requirements be audited as part of the environmental, health and safety management system. All applicable standards and guidelines relating to environmental, health and safety must be considered during the development of environmental legal register.

7.6.1 Health and Safety Legal Compliance

The health and safety legal register must be developed to consider all applicable legalization relating to occupational health and safety for workers, community health, safety and security.

7.6.2 Occupational Health and Safety
The contractor shall identify potential hazards and develop responses (including design, testing, choice, substitution, installation, arrangement, use and maintenance of workplaces, working environment and work processes) to eliminate sources of risk or minimize workers' exposure to hazards.

Where hazards are inherent to the project activity, or it is otherwise not feasible to completely eliminate the hazard, residual risks shall be managed through appropriate protective measures, such as controlling the hazard at source through protective solutions and by providing adequate personal protective equipment at no cost to the worker.

The appointed contractor must document and report occupational injuries, illnesses and fatalities. It is recommended that a process for reporting near misses and unsafe behaviours be developed as a proactive approach to occupational health and safety risk management. Adequate access to first aid and medical assistance in cases of work-related accidents or injuries must be provided. The overall site management system must be designed with adequate capacity for oversight of occupational health and safety matters.

7.6.3 Training
Training must be provided to all workers on all relevant aspects of occupational health and safety associated with their daily work, including emergency arrangements. Third parties (visitors and external service providers) must be briefed on the relevant aspects of health and safety and emergency response when accessing the site.

7.7 HJKY_TF's Safety Guidelines and Management
General guidelines for the Contractors to follow are:

- All works should be carried out in accordance with all relevant health, safety and environment (HSE) legislation, codes of practice, standards and guidance notes issued in relevance to the laws.
- Contractors should adhere to site specific policies and procedures, the requirements outlined in this document, all statutory requirements as well as their own HSE policies and procedures.
- Provide appropriate training and supervision of the employees.
- Meeting the necessary qualification requirements and providing the necessary documentation prior to the commencement of work.
- Identify health and safety hazards associated with the specific work being undertaken and to identify and implement appropriate control measures.

7.7.1 Site Induction Procedures

Prior to commencement of site activities at construction site, all workers and other persons working within the site shall attend a site induction which may include information on the following:

- Review and explanation of the HSE requirements as directed in this document or its associated HSE manuals of operations.
- Details on relevant HSE policies, procedures and requirements for specific parts of the construction activities.
- Site emergency procedures.
- Hazard and incident reporting procedures.
- First aid procedures.
- Hazards associated with the task and with the location of the task.
- Location of hazardous materials.
- Security and access.
- Site specific risks.
- Site Specific hazards and requirements.

7.7.2 Nature of the Construction Site

The irrigation site is relatively flat and free from any settlement. The site has minimal human activities as most settlers around the site are farmers. The Contractor should clearly earmark the working area using warning tapes. The Contractor should also clearly earmark the work area and carry out a pre-entry risk assessment prior to entering the work area by considering the following:

- The work required to be done, including the need to enter the work perimeter.
- The range of methods by which the work can be done.
- The hazards involved and the associated risks involved with the actual method selected and equipment proposed to be used.
- Emergency response procedures.
- The competence of persons to undertake the work, and
- Selection of appropriate control measures to be taken prior to entry into the work area.

7.7.3 Contractor Vehicles

Vehicles onto the construction site should observe all site speed limits where they are imposed, right of way, timings, and avoid blocking any access points to and from the project work areas. All loads on construction vehicles must be properly secured and covered. This will help to avoid risks such as accidents and chaos to pedestrians.

7.7.4 HSE Performance Monitoring

Contractor health and safety performance may be monitored by the following means:

- Inspection of the work area to ensure compliance with HSE documentation
- Submission of reports detailing hazards, incidents and injuries occurring on the work site
- Review of contractor insurances and licenses

Such monitoring may be undertaken by an HSE Officer at any time. The HSE Officer is required to report to the project management in view of a non-compliance by an individual or a contractor.

7.7.5 Construction Materials and Waste Management

Contractors shall maintain their materials, tools and other equipment in an orderly manner on site. All debris and waste resulting from contractor activity on site shall be removed by the responsible contractor. All materials and debris must be dumped into a selected dump site approved by the state government.

7.7.5.1 Hazardous Materials

In case of use of hazardous material, the contractor shall ensure that all relevant details, location and condition of such materials are documented and managed. Any work on hazardous materials shall only be undertaken by an appropriately licensed and qualified contractor and in compliance with statutory requirements.

7.7.6 Safety Gears

7.7.6.1 Personal Protective Equipment (PPE)

The contractor shall:

- Assess the suitability of the PPE, prior to the commencement of works, required to allow them to undertake the works safely
- Supply PPE appropriate for the hazards identified
- Supervise the use and maintenance of the PPE
- Ensure that PPE is worn in accordance with contractor's health and safety procedures or signage throughout the property.

7.7.6.2 First Aid kit

Prior to the commencement of work, the contractor shall ensure that provisions are available for prompt treatment in the event of an injury. First aid equipment should always be available on site.

7.8 Communication, Training and Awareness Programs

The contractor shall be responsible for ensuring both internal and external communications with the workers and stakeholders which include information disclosure, updates with the progress of the implementation of the project and community-oriented emergency. The Contractor's HSE Officer should ensure that workers have received appropriate "in-house" training before being mobilized to the project. Training to be conducted by professionals should contain the following aspects:

i. New employee orientation
ii. Personal Protective Equipment
iii. Accident Prevention Signs and Tags
iv. Accident/Incident reporting

7.8.1 Emergency Response

The contractor's management shall be responsible for ensuring some rapid emergency response communications with relevant authorities which will include: Police, Hospital etc.

7.9 Equipment Control and Site Maintenance

The contractor shall be responsible for the safe and efficient operations of the construction equipment and ensuring the safety of the personnel. Equipment Inspections and preventative maintenance shall be under the responsibility of the operations contractor. The equipment to be used shall meet with statutory and client requirements, together with additional safe operating standards. Any known hazard or risk related deficiency shall be reported immediately. The inspections at the construction site include the following:

i. Carrying out regular checks of the site and document the inspections
ii. Periodic inspections of the contractor's equipment and safety equipment
iii. Making regular inspections of the waste water facilities
iv. Making regular inspection of the construction activities and equipment

7.10 HSE Audits & Reviews

The HSE Management System shall be carried out or adopted in accordance with the following standard risk control:

i. Eliminate or reduce risks using prevention and mitigation measures.
ii. Prevent risks by engineering controls and giving collective protective measures.
iii. Minimize risk by the design of suitable systems, and ensure all employees are properly trained to handle all relevant types of hazards and risks associated with the construction activities.
iv. Eliminate risks, by means of physical engineering controls and safeguards that can be more reliably maintained.

7.11 Community Health and Safety

The Client shall, during the project life, continue to seek opportunities to improve environmental conditions which affect the surrounding communities.

7.12 Community Diseases

The Contractor will be responsible for putting in place adequate surveillance programs to screen the health of workers, which may include documenting and reporting on existing diseases to avoid the introduction of new or highly resistant diseases into host communities. Any health information obtained as part of these efforts may not be used for exclusion from employment or any other form of discrimination. Specific education and training programs for contractors must be developed and implemented to prevent the transmission of communicable diseases. Surveillance, active screening and treatment must be provided to workers in order to prevent the spread of illnesses in local communities by:

- Undertaking health awareness and education initiatives;
- Training health workers in disease treatment;
- Conducting immunization programs for workers in local communities to improve health and guard against infection;
- Providing health services (treatment through standard case management in on-site or community health clinics); and
- Promoting collaboration with local authorities to enhance access of workers families and the community to public health services and promote immunization facilities.

The health and safeguard officer shall identify all health risks to affected communities (such as air and water quality impacts) and take the appropriate steps to avoid, minimize and mitigate such impacts via the provisions of the site-specific Environmental Management Plans which support this ESMP.

7.11.2 Safety and Security

Measures to reduce safety and security risk must include (but is not limited to) the following:

- Access to construction sites must be restricted;
- Trespassing on neighbouring properties (by workers) must be prohibited and the appropriate disciplinary action must be taken in the event of transgression;
- The appropriate signage must be placed on the boundary or at the entrance to all construction sites, warning against entering the site and highlighting the health and safety risks; and
- Public awareness programmes must be developed to identify areas of particular risk and approaches to reduce risk. This may be expanded to include programs at residential, schools, along the road in order to advise children of the dangers of traffic and risks at construction site.

Institutional Capacities and Strengthening Plan

Provide the information on institutional capacities and strengthening plan in the revised report.

CHAPTER EIGHT

8.0 CONCLUSION

The Gashua Irrigation Scheme Rehabilitation and Expansion Project, one of four priority projects selected as part of the Strategic Action Plan with the primary aim of achieving food security and boosting the local economy of the farming communities and Nigeria at large is geared towards sustainable development. Having studied the project and analysed collected site information and socio-economic data from the Project Affected Community, the consultant has highlighted the positive and negative impacts and recommended mitigation measures to significantly reduce or eliminate negative impacts. The study has also developed a robust Economic and Social Management Plan that will ensure the Environmental, Social and Economic Sustainability of the scheme as proposed.

It was observed during the course of this study, that the existing and proposed irrigation scheme are located on just the southern side of the Yobe River, given the benefits of the project to the livelihood of the people of Gashua and National Food Security, it is recommended that the northern side of the project be developed for the same purpose as there are already small-scale private irrigation efforts ongoing in the area. Further to this, the consultant recommends the consideration of alternative irrigation methods to surface irrigation in the event of further expansion of the project.

Specify in the revised report if the environmental and social acceptability of the project.

Annexes

Include the following in the Annexes:

- List of the professionals and organizations having contributed to the preparation of the ESIA Report.
- List of consulted documents, including project-related reports.
- Baseline data referred to in this report.

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APPENDICES

Appendix 1

Letter of Authorisation for Disclosure of the ESIA by the Federal Ministry of Environment.

FEDERAL MINISTRY OF ENVIRONMENT

Environment House

Independence Way South, Central Business District, Abuja - FCT.

Email: info@ead.gov.ng, eia@ead.gov.ng www.ead.gov.ng

ENVIRONMENTAL ASSESSMENT DEPARTMENT

Ref: FMEnv/EA/EIA/5992/Vol.1/X

Date: 30th May, 2023

The Director-General,
African Development Bank,
1521 Cadastral Zone AO,
Off Memorial Close,
Beside Silverbird Galleria,
CBD, Abuja

Attention: Dr. M. Bakia

AUTHORITY TO DISCLOSE

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) OF GASHUA IRRIGATION SCHEME, REHABILITATION AND EXPANSION PROJECT

I am directed to inform you that Hadejia Jama'are Komadugo Yobe Basin Trust Fund has registered the above-mentioned project with the Federal Ministry of Environment for an EIA permit.

2. The ESIA process is on-going, the draft ESIA Report has been submitted and shall soon be displayed for stakeholder's comments. You are kindly requested by this to proceed with your internal disclosure controls and to give the project all necessary assistance.

3. Please note that the Federal Ministry of Environment shall ensure that the Approval process leading to ESIA certification and monitoring is concluded.

4. Thank you for your cooperation.

Dr. Abbas .O. Suleiman, fnes
Director, Environmental Assessment Department
For: Honourable Minister.

Appendix 2: Guiding Documents

In undertaking the preparation of the ESIA, Mitigation Measures and the Environmental and Social Management Plan (ESMP), the consultant followed the guidelines below:

A. FORMAT OF ESIA REPORT FOR AFDB

EXECUTIVE SUMMARY

This section shall present in a non-technical language a concise summary of the ESIA Report including the baseline conditions; the alternatives considered; mitigation/ enhancement measures; monitoring program; consultations with stakeholders; capabilities of environmental and social units and actions to strengthen those capacities; and cost implications.

Introduction

The Introduction shall indicate the purpose of the ESIA, present an overview of the proposed project to be assessed, as well as the project's purpose and needs. It shall also briefly mention the contents of the ESIA Report and the methods adopted to complete the assessment.

Policy, Legal and administrative framework

This chapter contains the policy, legal and administrative framework within which the ESIA is carried out. It presents the relevant environmental, climate change and social policies of the Bank, co-financiers and borrowing country, as well as the national legal requirements and related constraints relevant to the project.

Description of project and justification

The first part of this chapter shall describe the proposed project, its area of influence (including map showing the project's location) and it's geographic, ecological, social, economic, and temporal context, various project components, capacity, construction activities, facilities, staffing, working conditions, availability and source of raw materials, production methods, products, schedule of works, land tenure, land use system, potential beneficiaries, affected groups (directly and indirectly) and offsite investments that may be required.

This section shall determine and characterize the anticipated impacts. It shall also indicate the need for any resettlement plan or vulnerable groups development plan. The project justification should be based on combined economic, environmental and social assessments. To this end, this chapter shall describe the current situation in the sector, explain the problems or the needs to be satisfied by the project and present the constraints associated with the project implementation.

Description of the project environment

This chapter shall first determine the limits of the study area that shall be defined in order to encompass all project direct and indirect impacts. The description and analysis of the physical and biological components shall address relevant environmental, social and climate change issues within this area, including any changes anticipated before project implementation. The description shall also integrate human conditions including population characteristics and trends, revenue disparities, gender differences, health problems, natural resource access and ownership, land use patterns and civil society organization level.

It shall also address the interrelations between the environmental and social components and the importance (value)that the society and local populations attach to these components. A particular attention shall be given to the rare, threatened, sensitive or valorized environmental ands social components. Maps, figures and tables shall be included in this chapter to better illustrate the various environmental and social components.

Presentation of the Alternatives Considered
This part of the ESIA Report consists in analyzing the various feasible alternatives of the project, including the "without project" option. It normally comprises two sections. The first section identifies and describes the potential feasible alternatives that would allow to reach the project objectives. The second section presents a comparison of the potential alternatives on the basis of technical, economic, environmental and social criteria, as well as of public views and concerns.

Results of the comparison alternatives
The alternative comparison shall address the proposed project site, technology, design, and operation, in terms of their potential environmental and social impacts and feasibility of mitigating these impacts. For each of the alternatives, the environmental and social impacts shall be quantified as possible, including their economic values where feasible. The selected alternatives shall be the most environmentally and socially sustainable, taking into the account the technical and economic feasibility.

Potential Environmental and Social Impacts
This chapter presents a detailed analysis of beneficial and adverse impacts of various components of the selected project alternative on the physical, biological and human (social, cultural and economic) environments. The methodology of assessment, based on a rigorous scientific method shall be first presented. Then all environmental and social direct, and indirect, short and long term, temporary and permanent impacts shall be described and assessed, indicating their importance, level, level and their probability of occurrence. The importance level may be assessed on the basis of the nature, extent, intensity, and duration of the impact, as well as on the sensitivity of the concerned environmental and social components and perceptions of the public. Irreversible or unavoidable impacts shall be clearly identified. Cumulative effects shall also be addressed taking into account other projects or actions planned in the study area.

Mitigation/Enhancement Measures and Complementary Initiatives
Appropriate mitigation measures shall be identified to prevent, minimize, mitigate, or compensate for adverse environmental and/or social impacts. Moreover, enhancement measures shall be developed in order to improve project environmental and social performance. Roles and responsibilities to implement measures shall be clearly defined.

The cost of each mitigation and enhancement measure shall be estimated including the cost for environmental and social capacity building. This cost shall be estimated for each identified measure and shall be integrated into the overall project cost.

Whenever applicable this section shall present initiatives proposed to complement the enhancement and mitigation measures previously described. For example, resettlement plans shall be summarized in this section, briefly presenting the number of displaced people, compensation and re-insertion measures, legal status, public consultations, implementation schedule as well as monitoring and evaluation procedures.

Expected residual effects and environmental hazard management
Residual impacts shall be presented. Wherever relevant, this chapter shall also describe the security measures and propose a preliminary contingency plan for the construction and operation phases of the project (possible contingency situations, major actions to properly react to accidents, responsibilities and means of communications).

For projects that may cause major technological accidents whose consequences may exceed the project site, the ESIA shall include an analysis of the technological accident risk; identification of hazard and potential consequences, estimation of the consequences, magnitude and frequency, and risk estimation and evaluation.

Monitoring Program
This section shall summarize the surveillance and monitoring activities proposed in the Environmental and Social Management Plan prepared for the project. It shall identify the roles and responsibilities of stakeholders in the implementation as well as the estimated cost of the activities.

Summary of public consultations and the opinions expressed
This chapter shall summarize the actions undertaken to consult the groups affected by the project, as well as other concerned key stakeholders including Civil Society Organizations. The detailed record of the consultation meetings shall be presented in annex to the ESIA Report. The consultation shall be free, prior and informed with communities likely to be affected by the environmental and social impacts, and with local stakeholders, and also for ensuring the satisfaction of Broad Community Support (BCS), especially for Category 1 projects and for projects affecting indigenous peoples. Consultation shall be undertaken with reference to Guidance Notes on informed Consultation Participation and BCS.

The results of such consultation shall be adequately reflected in the project design as well as in the preparation of project documentation. In all cases, consultation should be carried out in conjunction with the release of environmental and social information.

Environmental and Social Management Plan (ESMP)
This section shall present management measures including actions, roles and responsibilities, timeframes, monitoring and cost implementation.

Institutional Capacities and Strengthening Plan
This section shall outline the adequacy of the institutional capacity within the project implementation agency to oversee the implementation of the ESMP. This institutional capacity shall be strengthened to improve the implementing agency's function with regard to environmental and social management.

Conclusion
The conclusion shall specify the environmental and social acceptability of the project, taking into account the impacts and measures identified during the assessment process. It shall also identify any other condition or external requirement for ensuring the success of the project.

Annexes
This shall include:

- List of the professionals and the organizations having contributed to the preparation of the ESIA Report.
- List of consulted documents, including project-related reports

- Baseline data referred to in the report
- Record of consultation meetings with primary and secondary stakeholders.

B. Format of Environmental and Social Management Plan for AfDB

The ESMP defines the mitigation/enhancement, monitoring, consultative and institutional-strengthening measures to be undertaken during project implementation, as agreed with the borrower. The ESMP should be incorporated in the loan documents and should be flexible and integrate any initiatives, such as a RAP, to enhance project performance. It should allow for adjustments and revisions to reflect developments during project implementation.

General information: State the project number, project implementation start date, project completion date, date of
operation, period covered.

Objectives:

1. To outline the mitigating/enhancing, monitoring, consultative and institutional-strengthening measures required to prevent, minimise, mitigate or compensate for adverse environmental and social impacts or enhance benefits.
2. To formulate capacity-building measures to strengthen the borrower's capacities if necessary.

Context: Briefly describe project activities and major environmental and social components likely to be positively or
negatively affected by the project.

Beneficial and adverse impacts: Describe positive impacts that could improve the project's environmental and social
performance as well as adverse impacts that require mitigation or compensation.

Enhancement and mitigation program: Propose feasible, cost effective measures to augment benefits (enhancement measures) or reduce potentially adverse impacts (mitigation measures).
Include technical information.

Monitoring program: Describe the monitoring system envisaged. Ensure that the mitigation and enhancement measures proposed are implemented during the construction phase.
Define monitoring indicators. Measure and evaluate the project's impacts on environmental and social components of concern and implement remedial measures, if necessary.

Consultations: Identify measures for stakeholder consultations during the environmental and social assessment and during implementation; identify outputs and expected outcomes. Specify target groups, an appropriate consultative process, the frequency of consultations, reporting methods and result disclosure procedures.

Complementary initiatives: Integrate or at least refer to initiatives to improve the project's environmental and social
performance, especially for Category 1 projects.

Responsibilities and institutional arrangements: Identify the responsibilities of the SD, the borrower, the implementing agencies, and other stakeholders, and propose actions to strengthen capacity.

Cost estimates: Estimate the capital and recurrent costs of the enhancement and mitigation measures, the monitoring program, the consultations, complementary initiatives and institutional arrangements.

Implementation schedule and reporting: Provide a schedule for implementing the enhancement and mitigation measures, the monitoring program, the consultations, complementary initiatives and institutional arrangements.

Source: **Invalid source specified.**

Appendix 2: Attendance List for the Project Scoping Workshop

FEDERAL MINSTRY OF ENVIRONMENT
ENVIRONMENTAL IMPACT ASSESSMENT DEPARTMENT
EIA SITE VERIFICATION ATTENDANCE

PROJECT PROPONENT: HADEJIA JAMA'ARE KOMADUGU YOBE BASIN TRUST FUND

PROJECT TITLE: GASHUA IRRIGATION SCHEME

LOCATION: GASHUA

DATE: 8 / 7 /2021.

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FEDERAL MINISTRY OF ENVIRONMENT

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