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FINAL REPORT

REPORT ON WATER CANALIZATION INTO WAWA-ZANGE GRAZING RESERVE

WATER CANAL STRUCTURE ASSESSMENT REPORT

FEED THE FUTURE NIGERIA RURAL RESILIENCE ACTIVITY

OCTOBER 2022

GOMBE STATE
JEWEL IN THE SAVANNAH

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MERCY CORPS
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This report is made possible by the support of the American people through the United States Agency for International Development (USAID) under the Feed the Future initiative. The contents of this report are the responsibility of the authors and do not necessarily reflect the views of USAID or the United States Government.

ACKNOWLEDGEMENTS

This report is the result of close collaboration between Mercy Corps and the Gombe State Government. We are grateful to Mercy Corps for giving the opportunity to conduct this feasibility assessment and the Gombe State Government under the leadership of His Excellency, Alhaji Muhammadu Inuwa Yahaya, (Dan Majen Gombe), The Executive Governor of Gombe State for all the assistance, resources and creating an enabling environment for the conduct of the study.

The guidance and convening power of Mercy Corps team members is acknowledged particularly from the Chief of Party, Margarita Ravi Aswani; Deputy Chief of Party, John Rachkara; and the Senior Intervention Officer, Emeka Njoku.

We are grateful for the valuable contributions of Dr. Usman Bello Abubakar, Senior Special Assistant and Technical Team Leader of Gombe State Livestock Transformation Management Project (LTMP) for his tireless efforts in bringing the feasibility study into reality.

The consulting team would like to express its sincere appreciation to the members of the Gombe State LTMP team who were very instrumental in identifying and engaging the different stakeholders as well as communities around the potential canal path.

We equally thank Dr. Ishiyaku Mohammed, Special Adviser Budget, Planning and Development Partner Coordination for his efficient guidance and coordination.

Sincere appreciation to the stakeholders engaged: the Secretary to the State Government (SSG), Gombe State, Prof. Ibrahim Abubakar Njodi; the Honorable Commissioner of Agriculture and Animal Husbandry, Muhammad Magaji Gettado; the Honorable Commissioner of Finance and Economic Development, Muhammad Gambo Magaji; the Honorable Commissioner of Water Resources, Mijinyawa Yahaya; the Honorable Commissioner of Trade and Tourism, Nasiru Mohammed Aliyu; and the Honorable Commissioner of Science and Technology, Dr. Aishatu Usman Maigari.

We are thankful to Dr. Yunusa Ugya and the Dongrong Capital team for the immerse contribution towards the technical feasibility of this report and generally thankful to all those who have contributed in one way or another to make this document a reality.

Most importantly, we are thankful to the community leaders, community members and key informants for their contribution to this report and insightful knowledge on the lived realities of their day-to-day experiences in their individual communities.

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ADB	African Development Bank
ArcGIS	Arc Geographic Information System
BCR	Benefit Cost Ratio
CCA	Cultivable Command Area
EMP	Environmental Management Plan
ESIA	Environment Social Impact Assessment
ESIS	Environmental and Social Impact Statement
FAO	Food and Agriculture Organization
FGDs	Focus Group Discussions
GWAC	Gongola River Water Access Corridor
IBAT	International Biodiversity Assessment Tool
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IPM	Integrated Pest Management
ISRIC	International Soil Reference and Information Centre
KBA	Key Biodiversity Areas
KII	Key Informant Interviews
LGA	Local Government Area
LTMP	Livestock Transformation Management Project
MC	Mercy Corps
MOE	Myth of Empire
N	Naira
NEPC	Nigerian Export Promotion Council
NGSA	Nigeria Geological Survey Agency
NiMet	Nigerian Meteorological Agency
NIPC	Nigerian Investment Promotion Council
PSA	Poverty and Social Assessment
SAP	Social Action Plan
SEMA	State Emergency Management Agency
SEP	Stakeholder Engagement Plan
SES	Socioeconomic Survey
SIO	Senior Intervention Officer
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
WZGR	Wawa-Zange Grazing Reserve

EXECUTIVE SUMMARY

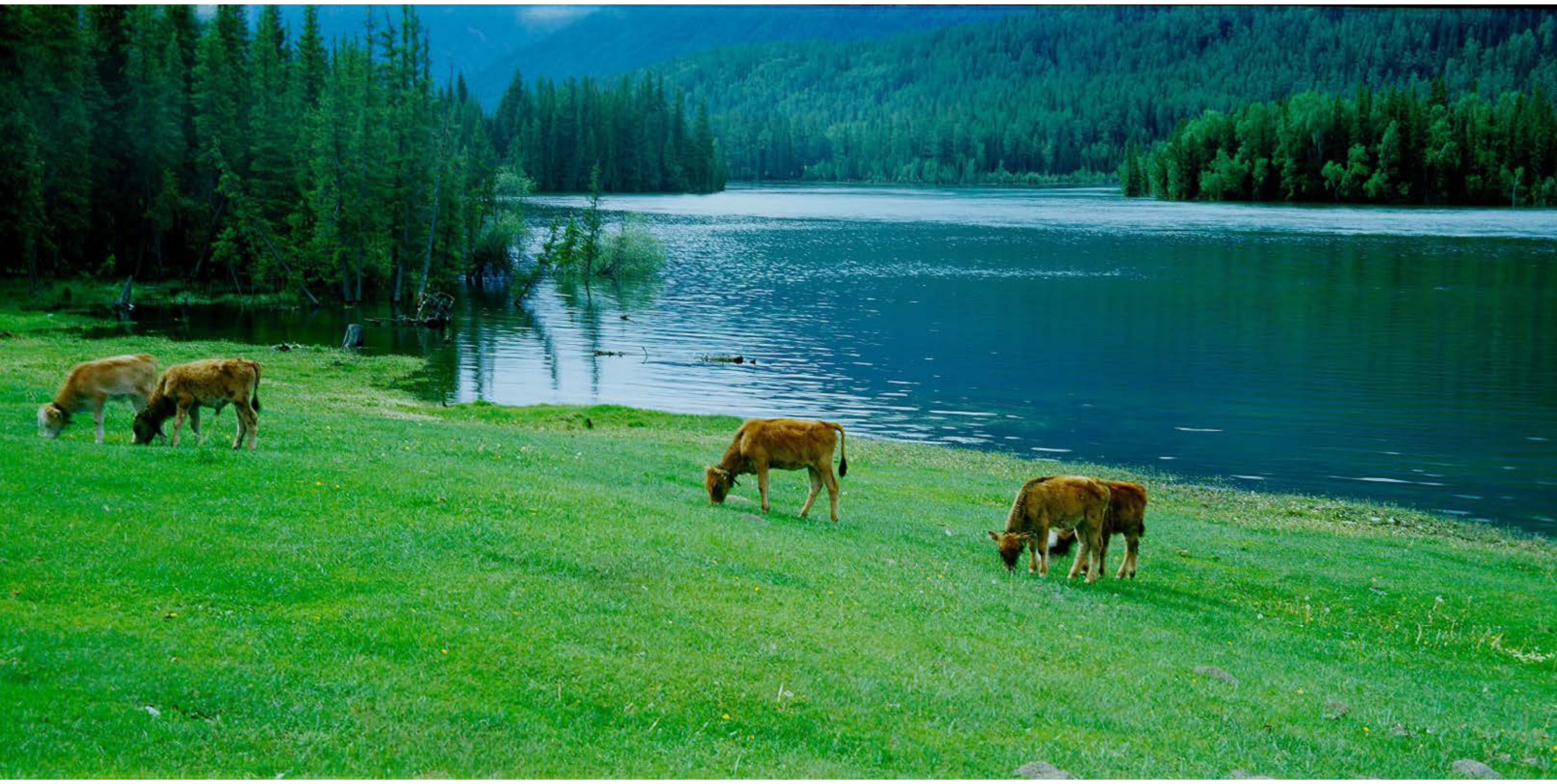
Wawa-Zange is a 146,000-hectre grazing reserve located in Gombe State, North-Eastern Nigeria. The State Government partnered with the Feed the Future Nigeria Rural Resilience Activity with the aim of transforming the dairy, beef, and breeding value chain for pastoralists through the creation of more jobs, increasing animal productivity, reducing environmental impact, and animal husbandry education.
However, the success of this transformation is highly dependent on sustainable water availability in Wawa-Zange. This report details a structure assessment for canalizing water into the grazing area, as well as debriefing findings, and reporting on stakeholder engagement.

The primary data used in the hydrologic studies are rainfall, evaporation, and stream flow which were obtained from the Nigerian Meteorological Agency (NiMet). The soil map of Nigeria was collected from FAO, UNESCO and ISRIC while geologic data was collected from NGSA. The soil and geology data collected were digitized as polygon, other visible features such as local government boundaries were also digitized and overlaid on the two generated soils and geology maps. The clip sub module of the ArcGIS was used to define each of the local governments in both maps as well as the soil and geology. The area in square kilometers of the soils and geology units in the entire state and each LGA was obtained using the area calculation module of the ArcGIS. Sandstones were mainly found around the potential pathways for the canal on both plains. A straight path starting from Kupto through Bodor into Wawa-Zange Grazing Reserve (WZGR), with an estimate length of 35.95km, was identified as the most economically viable option for canalization water into the reserve.

Based on the findings from stakeholder engagement, water source options, the alignment of the proposed canal, geological analysis, and topographic survey, the report concludes that canalizing water from the western plain of the Gongola River into WZGR may not be the most viable option. The most feasible option based on the above criteria is to canalize from the eastern plain of the Gongola River into the grazing reserve. The 35.95km canal project is estimated at N1.5billion and has the potential to directly impact the lives of over 100,000 people and indirectly impact another 600,000 people. Those indirectly impacted are living in the four LGAs around the canal path; all of whom are facing water challenges for farming and domestic use. The opportunity cost of doing a similar project to reach 600,000 people is N2,500/human. Based on the costing, economic and financial analysis, the report concludes that this is a minimal amount to move 600,000 people out of poverty and towards agricultural productivity, security, water, and sanitation security.

The report recommends that all participating agencies work together, and to reduce the risk of flooding, a control point should be built at the main canal which should be closed during rainy season. In addition, it is crucial to conduct an IEE (Initial Environmental Examination), develop an EMP (Environmental Management Plan), and engage competent contractors who can follow mitigation and monitoring guidelines in the EMP. Furthermore, the work plan and schedules for the canalization initiative should be approved by the relevant traditional and State councils and developed in consultation with residents considering the need for access during harvesting and planting periods.

1.0 INTRODUCTION



Wawa-Zange is a 146,000-hectre grazing reserve located in Gombe State, North-Eastern Nigeria. The State Government partnered with the Feed the Future Nigeria Rural Resilience Activity with the aim of transforming the dairy, beef, and breeding value chain for pastoralists through the creation of more jobs, increasing animal productivity, reducing environmental impact, and animal husbandry education However, the success of this transformation is highly dependent on sustainable water availability in Wawa-Zange. This report details a structure assessment report for canalizing water into the grazing area, and provides a debrief of findings and stakeholder engagement.

The volume of the water was determined by the evaluation of the net inflow from both catchment areas. Considering that the proposed canal will have several important functions, such as irrigation, domestic usage, livestock management, and storage, it is proposed that the canal be constructed to distribute irrigation water during the dry season. This will reduce the amount of unirrigated wastelands leading to an increase in the quantity of biomass in the area. The primary data used in the hydrologic studies are rainfall, evaporation, and stream flow which were obtained from NiMet. The soil map of Nigeria was collected from FAO, UNESCO, and ISRIC while geologic data was collected from the Nigerian Geological Survey Agency (NGSA). The soil and geology data collected were digitized as polygon, other visible features such as local government boundaries were also digitized and overlaid on the two generated soils and geology maps. The clip sub module of the ArcGIS was used to define each of the local governments in both maps and the soil and geology. The area in square kilometers of the soils and geology units in the entire state and in each LGA was obtained using the area calculation module of the ArcGIS. Sandstones were mainly found around the different potential path for the canal on both plains.

The last type of soil that is found in Nafada, Funakaye and Kwami LGAs that bond the eastern Gongola River is luvisol. This type of soil is widely used for agricultural activities because it has argic horizon criteria. The formation of this type of soil in this location does not have any negative implication to the canalization of water in the proposed site within the eastern plain of Gongola River as water sources.

The elevation of the canal construction was found to be on the highland plain of altitude, between 409-498 meters, though local government favors the western plain Gongola River as a potential water source for the canalization. However, the lack of year-round water supply rules this location out as a potential source for the canal. The area within the eastern plain of the Gongola River falls within the low plain of altitude, between 324-409 meters, thereby making it difficult for the canalization of water into the proposed project site as a water source. However, increasing the depth of the canal to counteract the effect of the slope and the creation of a pump house would eradicate this difficulty.

The question of water availability in WZGR relates to the amount of water resources and the delivery of that water. The hydrological analysis undertaken for the feasibility study concluded that there is sufficient water available at the eastern plain of River Gongola year-round from a combination of inflow from tributaries in Yobe and Borno state. The findings also show the Dandi Kowa dam and Kiri dam as another reason why the eastern plain of River Gongola is best to be used a water source. However, the delivery of water to WZGR travels from lower elevation to higher elevation. This can be controlled using pump stations to increase the water velocity and difference in depth to counteract the effect of the slope.

Since the canal will be used for irrigation and grazing purposes, the current study suggests the division of the canal into a main canal, lateral and sub-lateral canals, and tertiary units. The main canal was recommended for conveying water from River Gongola into the grazing reserve in the most economical way. The main canal is planned to originate from the eastern plain where water resources are year-round. The lateral and sub-lateral canals are responsible for the delivery of water from the main canal to the tertiary units where the water is utilized for irrigation and grazing purposes within the grazing reserve.

- Based on the availability of water sources, the western plain of the River Gongola has a seasonal recharge and cannot be considered as a water source for the canal construction. The eastern plain of River Gongola which is the most feasible source of water can adhere to the initial planning.
- The alignment of the proposed canal can be in a straight line and short distance, but a pump house is needed because the topographic data of the eastern plain is lower than the topography of the WZGR.
- The geologic data also shows that there is a basalt rock that will hinder the construction of the proposed canal from the eastern plain as a water source, but a point was discovered at Bodor community were the problem can be solved.
- The topographic survey of the route and cross-sectional survey along the lateral canal and tertiary units show high feasibility.
- The construction of the proposed canal will also boost the economic development of the area by avoiding dangerous droughts and total dependence on rainfall.

Based on the findings from stakeholder engagement, water source options, the alignment of the proposed canal, geological analysis, and topographic survey, the report concludes that canalizing water from the western plain of the Gongola River into Wawa-Zange Grazing Reserve may not be the most viable option. The most feasible option based on the above criteria is to canalize from the eastern plain of the Gongola River into the grazing reserve.

A concrete lined canal is recommended for sustainable canalization mainly because of the nature of the terrain which sips water into the aquifer. The canal is estimated to cost N1.5 billion with 89% of this attributed to the main canal and associated structures. The irrigation area and distributaries in WZGR will help increase forage production to 115 million pounds at 400 pounds/acre. Assuming cultivable command area is divided in the following ration: 35% forage area, 50% future health of plant, 15% wildlife use.

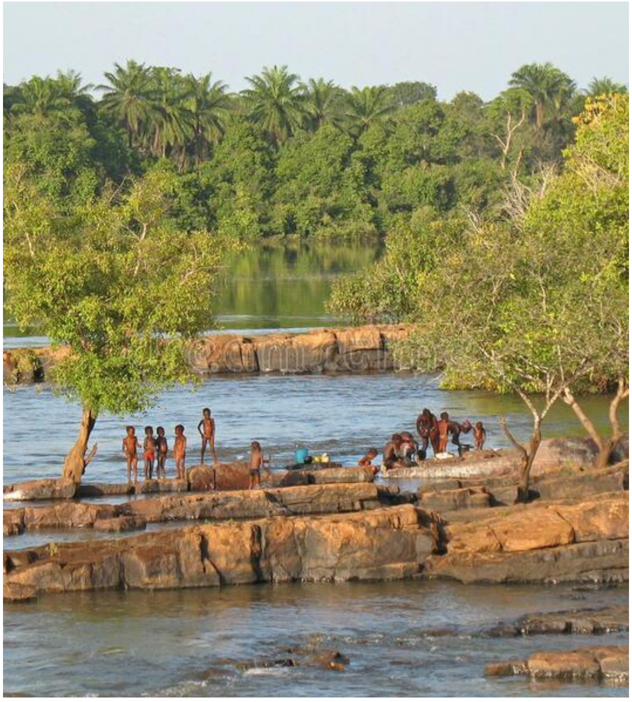
The total of serviceable cows can be at least 50,498 cows (1,000-pound cows) per month and over 150,000 cows per annum. These estimates are of lower bounds. Similarly, the impact rate of the canal can be calculated based on the crop production along the path of the canal before the grazing reserve. Using maize as an example, the total land on the canal path is estimated as 200 x 35.950 = 7190 hectares. Therefore, total wealth generated for maize farming on the canal path = 7190 x 2,368,000 = N17,025,920,000. The national average monthly salary is currently N42500; the average salary in 4 months is N170,000. Total impact on the canal path = 17, 025, 920 000/ 170000 = 100, 152.47. With Gombe taking the 3rd position in poverty headcount at 86%, 100,152 lives will benefit from the canal construction along the path.

1.1 Background of WZGR Canalization Project

The Feed the Future Nigeria Rural Resilience Activity (RRA) is a 5-year USAID funded program being implemented by a consortium led by Mercy Corps with support from IFDC and Save the Children across the states of Adamawa, Borno, Gombe and Yobe in North-East Nigeria. The RRA will facilitate economic recovery and growth in vulnerable, conflict-affected areas by promoting systemic change in market systems. This will ensure long-term improvements to markets that will sustainably move over 600,000 individuals out of chronic poverty.

According to available data, Nigeria has the highest number of livestock in West Africa, with the number of cattle estimated at 19.5 million. This official figure must be taken as a rough approximation, because it has been many years since a comprehensive livestock survey was carried out in Nigeria, but it does suggest a much larger cattle population than any other ECOWAS country.

The entire Nigerian Livestock industry is still rudimentary, with little modernization in key areas, such as animal husbandry, cross breeding technology, dairy and beef processing, packaging, and marketing for socio-economic benefits.



In Nigeria (especially in the North) the practice of preserving land for grazing existed prior to colonial times. Allocation of land to pastoralist, particularly during cultivation season and around towns and villages, was socially endorsed since then. Today, however, these pastoralists face a new problem that they cannot overcome alone - climate change. The pastoralist’s way of life is in danger especially as the rainy seasons are growing shorter, and the dry seasons are longer, sometimes lasting up to nine months. Each year, in mid-November, the first signs of drought appear as rivers start to dry up and pastures become scarce. Many of these families, often in small groups, begin months-journey in search of water and pasture land.

More so, changes to pastoral mobility and production have significant effects on zoonotic disease transmission. For example, in 2020, Nigerien and North Nigerian pastoralists driven south by desertification were implicated in the introduction of anthrax in Nigeria. Water has become increasingly scarce for these pastoralists. At the same time, farmers are expanding their fields with the growing population’s demand for food, encroaching on pastoral regions and transhumance corridors. This situation has seriously disrupted traditional herd management methods which manifest in low livestock productivity, and result in more frequent and potentially more severe conflicts. The World Bank argued that providing pastoralists with social infrastructure around water points, schools , skill acquisition as well as control of animal disease through effective veterinary services would make it easier to encourage pastoralist to adopt a more sedentary system, mitigate conflicts, facilitate access to markets, and ensure crisis preparedness and response and improve natural resource management and animal health.

The welfare of pastoralist communities is largely dependent on the environment, as livestock production is highly dependent on the availability of water and pasture. Due to the reliance on natural resources, these communities are extremely vulnerable to climate shocks, threatening their security, food and livestock. Sedentary practice can help increase the resilience of pastoral families by enabling them to express their needs more coherently, providing them with essential services and infrastructure, and giving them the tools and knowledge they need to manage this grazing land themselves on a sustainable basis.

The general idea behind the program is that better management practices through sedentary livestock practice would provide conditions favorable to cattle production and reproduction. Facilities such as fodder, feed supplements, regular water supply, and veterinary services would be readily available to enhance cattle health, production, and productivity. With the provision of all these facilities, it was hoped that pastoralists would be introduced to sedentary and improved management practices of cattle husbandry.

To date, pastoralists in Nigeria have struggled to effectively engage in commercial value chains and their participation has been marred by their limited access to inputs and their exposure to climate-related risks. However, there is an increasing demand for meat in the country and a growing middle-class is increasingly concerned with food safety and is interested in higher-value products.

The key question for Nigeria is whether it is possible to modernize and improve productivity in the livestock sector in a way that enables the million pastoralists to participate and benefit from the sector. The cultural way of life for pastoralists is already starting to change – and as a result, there is a growing opportunity for pastoralists to engage in the livestock industry on a more commercial basis.

Gombe State is in the most northeastern part of northern Nigeria and lies between latitude 9°30' and 12°30N and longitude 8°45' and I l°45'E. It is on an altitude of 540m above sea level. Gombe State covers an estimated land mass of 20.26km2 and has an estimated population of over 3.2 million people as of 2019. The state has a mean annual rainfall of 818.5mm, a mean maximum monthly temperature of 37°C, and relative humidity of 94% in August and 10% in December. The climatic factors are favorable for crop and livestock agriculture.

Known as The Jewel in the Savannah, Gombe State was formed in October 1996 by the Abacha military government. The state shares common borders with Borno, Yobe, Taraba, Adamawa and Bauchi states. The state is currently headed by the Executive Governor Alhaji Muhammadu Inuwa Yahaya and has 24 State House Assembly members. Gombe has 11 local government areas (LGAs), 117 political wards, and 14 emirates/chiefdoms. It has three senators and six members in the National Assembly.

Gombe State is blessed with natural resources. Rearing of indigenous livestock is one of the primary activities due to the increasing demand and favorable conditions for livestock farming compared to other states in the country.

The Gombe State Government partnered with the Feed the Future Nigeria Rural Resilience

Activity to develop three to four investable projects in Wawa-Zange, a 146000-hectare grazing reserve. The state has demonstrated commitment and ability to catalyze livestock sector competitiveness and investments by revamping the grazing reserve. Both the Federal and the Gombe State governments have made deliberate and conscious efforts to bolster livestock production by prioritizing the Wawa-Zange Grazing Reserve.

The success of the overall intervention is highly dependent on the availability of water. Therefore, the assignment at this stage is on Objective I: Canalizing Water into WZGR. This report contains a structure assessment report for canalizing water into the grazing area, as well as a debrief of findings and stakeholder engagement details.

Section 2 of the report summarizes the stakeholder engagement process and outcomes. In Section 3, the report details the findings. Section 4 details the feasibility with a structure assessment report of the canal. In Section 5, the report describes the potential canal planning and design. The report is summarized with recommendations in Section 6 and an investment plan structure roadmap in the appendices.

2 Stakeholder Engagement Summary

2.1 Scope and Objectives

The stakeholder engagement process for the feasibility study for the canalization of water into WZGR was conducted in line with Environmental Impact Assessment (EIA) guidelines and with international best practice, such as the USAID, World Bank, and International Finance Corporation (IFC) safeguards (USAID 2022; World Bank 2017; IFC 2012). Key principles of international best practice include beginning implementation early in the project lifecycle; avoiding manipulation, interference, coercion, or intimidation from external parties when applicable; enabling meaningful community participation should be conducted based on timely, relevant, and understandable factors; and information is presented in a culturally appropriate format.

The main objectives of stakeholder engagement as part of the feasibility study were to:

1. Involve stakeholders in the assessment based on the important role they play in providing local knowledge to inform the impact assessment and the identification of culturally appropriate mitigation measures.
2. Facilitate understanding with an open, inclusive, and transparent process of culturally appropriate engagement and communication to make sure stakeholders are kept abreast of the proposed canal.
3. Enhance relationships with open dialogue and engagement processes that help to establish and maintain a productive relationship between all parties and the Environment Social Impact Assessment (ESIA) team (comprising of Livestock Transformation Management Project (LTMP) team and Mercy Corps delegate).
4. Engage vulnerable groups by adopting different strategies and approaches such as focus group discussions (FGDs) to ensure that the perspectives of vulnerable stakeholders are heard and considered.
5. Manage stakeholder expectations to ensure that the canalization benefits are understood to avoid the creation of unrealistic expectations about potential opportunities. The engagement process should help to

provide a mechanism for understanding and managing stakeholder and community expectations and share reliable project information in an accessible way.

6. Incorporating findings from the consultation process in the ESIA to inform the mitigation of impacts and to identify opportunities to enhance positive impacts of the canal.

2.2 Approach and Methods

Stakeholder engagement in each stage of the feasibility study for the canalization of Wawa-Zange comprised the following activities articulated below. Figure 1 provides a graphical representation of the different steps in the stakeholder engagement process. These consist of five parts - Parts 1 – 3 of the stakeholder engagement process have been completed. Part 4 of the process is currently ongoing, and Part 5, Record of Decision (RoD) will be initiated upon completion of Part 4.

A key informant standing in the middle of a paddy field that would otherwise be part of the River

Figure 1: Stakeholder engagement components

PART 1	• Preparation of a Stakeholder Engagement Plan (SEP) • Preliminary identification of stakeholders
PART 2	• Sensitization meetings were held with state authorities with a direct or likely interest in the canalization project as well as its potential impacts • Sensitization meetings were held with district authorities and traditional leaders from communities around the corridors of WZGR canal
PART 3	• Community/village meetings were held in pre-identified village clusters along the WZGR canal • FGDs with men, women, and youth to obtain social data were held, and provided a forum for community members to raise additional issues and concerns, and suggestions • Key Informant Interviews (KII) held with relevant stakeholders who live and/or work around the potential sources of the canal to obtain social data, to inform the social impact assessment and to provide an avenue for concerns and suggestions
PART 4	• Full disclosure of the feasibility study was done by notifying relevant stakeholders of the availability of Environmental and Social Impact Statement (ESIS), EMP and supporting reports • MC in collaboration with the Livestock Transformation Management Project can coordinate a workshop to present these findings and Objective II assignment components
PART 5	• Disclosure of the RoD will require notifying state, district, and traditional authorities in English and Hausa by email and/or letter and advertise in two newspapers the disclosure

2.3 Process Timelines

Stakeholder engagements were undertaken from the 4th to 6th October 2022 and included participation by the various ministries and key informants from the four local governments around the canal corridor mainly Dukku, Funakaye, Kwami and Nafada. Sites visited included Jurara, Malleri and Kupto on the Eastern plain and Hashidu, Malala and Gombe Abba on the western plain.

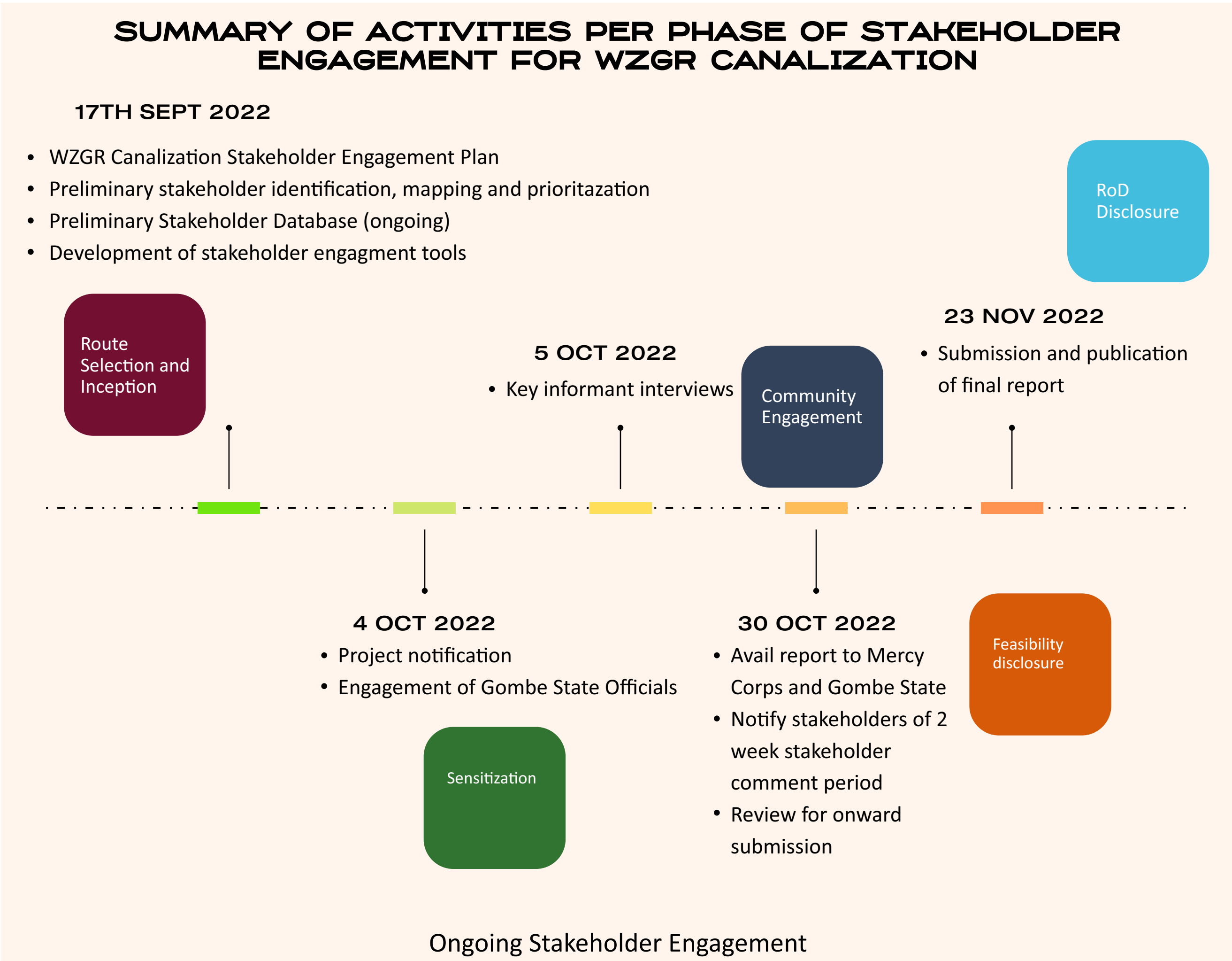


Figure 2: Stakeholder engagement process timelines

2.4 Key Findings and Issues Raised by Stakeholders

All issues raised by stakeholders were recorded and logged. They are summarized below:

2.4.1 District and State Authorities

Sensitization meetings were held with district and state authorities. This was in anticipation and arrangement for the future community level meetings. The meetings were facilitated by the LTMP team, these meetings were attended by the Senior Intervention Officer (SIO) and representatives of the consultant. The meetings provided an overview of Objective I: Canalizing Water into WZGR - the studies that were to be undertaken and potential opportunities for participation.

Issues raised by district and state authorities regarding Objective I was related to:

- Resource Conflict
- Employment and access to livestock and water related economic opportunities
- Environmental impact
- Revive investments opportunities
- Improve life of rural dwellers, women empowerment, and feed production
- Role of technology in mapping of WZGR and livestock
- Demystifying livestock production
- Pedologic and geologic concerns

2.4.1. State Authorities

Initial introduction and individual meetings with relevant state authorities were held prior to feasibility study to present an overview, discuss the potential for obtaining relevant data, and issues of concern to further inform the scope of work. Meetings were held with the Directors, Permanent Secretaries, Commissioner of Trade and Tourism, Commissioner of Science and Technology, Commissioner of Finance and Economic Development, Commissioner of Water Resources, Special Adviser Budget and Planning, and Development Partner Coordination Office.

Issues raised by the state authorities regarding Objective I was related to:

- Concern about farmer/herder conflict due to competition for water resources
- Potential establishments of commercial hubs including schools, processing plants, hospitals, etc.
- Potential impact of flooding, erosion, and carbon emission
- Revamping the livestock industry in Gombe State
- Water availability for domestic use among vulnerable communities in the corridor
- Livestock production is not unique to an ethnic group, as it is a potential source of wealth creation for all tribes i.e., Fulani's and non-Fulani's included
- Rock formations and slope of terrain along the canal path into WZGR

2.4.2 Community members

Several key informants in the districts along the Gongola River Water Access Corridor (GWAC), including the Eastern plain (Jurara, Malleri, Kupto) and Western plain (Hashidu, Malala and Gombe Abba), were identified to provide baseline information and insights on the canalization initiative. Generally, the key informants expressed very high expectations that their quality of life would improve drastically. Although communities closer to the Gongola River have access to water, their concerns revolved around the quality of water for domestic uses. Even though boreholes are available in the LGAs, community members still lacked access to clean water either because the boreholes were either moribund or too far (access could be as far as 7km). Generally, in the dry season, the situation was described as worse because water levels deplete. Community members expressed high expectations that the canal would reduce incidence of herders/farmers conflict, provide economic opportunities through job creation, improve access to markets to sell produce, and increase access to social, health, and agricultural extension services. There were no indications of unrealistically high expectations about the canal. In addition, a district head at Kupto described how a foreigner had advised the community to migrate into the grazing reserve 60 years ago because their community was prone to flood. Many of these communities around currently face this potential risk and look forward to the canal project.

Potentially negative issues raised by community members include:

- Loss of arable minimal farmland, (see Figure 10 of the feasibility study)
- Injury and property damage from rocks, (see Figure 6 of this report)
- Loss of fuelwood, medicinal plants, and other natural resources
- Construction disturbance from noise, dust, etc.

2.5 Key Findings and Issues Raised by Sectors

Several informants in the districts were identified to provide baseline information and insights on the potential positive and negative impacts of the canalization initiative. Individual meetings were held with key informants in the agriculture, trade, finance, science and technology, and water resource sectors primarily. Nearly all the project benefits will accrue from increased agricultural productivity within the corridor of the eastern plain of the Gongola River into WZGR. They potentially include increased cropping intensity, increased yields, and crop diversification in addition to benefits for cattle in the grazing reserve itself. The benefits are anticipated to increase to their full potential over a long-term period.

2.5.1 Agriculture

A representative from the Ministry of Agriculture (also on the LTMP team) was interviewed and believes the canalization of water into WZGR would enable productivity of livestock farmers. Beside access to seed and fertilizer uses, crop farmers would have the opportunity to sell grains and crops as feed for livestock. In addition, it was highlighted that the incidence of livestock theft will reduce as pastoralists avoid uncharted territory and maintain grazing within the boundary of WZGR. They also indicated that livestock theft would decrease as police could respond more promptly.

The main issues of immediate concern revolved around productivity of farmers, i.e., farmers who get jobs during construction of the canal would not be available to farm. The counterpoint was raised that farmers who do get jobs are very likely to employ replacement workers on their farms.

Additional concerns around poor collaboration between farmers and business owners/buyers were raised. The expectation is that collaboration would improve and expand due to increased access and engagement. It was also thought that farmers would attend training workshops and for extension officers would be deployed to advise farmers along the route.

Mitigation measures suggested by agricultural sector representatives are below:

- Residents are mostly farmers and have limited livelihood opportunities and skills, therefore, farmers should receive support on how to use compensation money that is paid

for affected fields, and that the Ministry of Agriculture should be involved.
- LTMP could assist with construction of accommodation for ministry field staff when working in the districts, a hall for training workshops, and financial support with a trip for livestock farmers to observe a rotational grazing pilot programme in WZGR.

2.5.2 Trade

In the meeting with the Gombe State Ministry of Trade and Tourism, led by the Honorable Commissioner, the following key issues were raised:

- Issues and concerns
  - Herders/farmers conflict
  - Rudimentary livestock sector and the need to scale
  - Contribution of women towards state development
  - Profitability of the water canal and its multiplier effect on the state's development
- Anticipated benefit of the canal
  - Irrigation for agriculture
  - Improvement in animal husbandry
  - Potential water availability for industrial use
  - Water availability for domestic usage
  - Empowering women economically
- Suggestions for mitigation/enhancement
  - Investment awareness
  - Partnering with Mercy Corps and other potential investment partners like Nigerian Investment Promotion Council (NIPC), Nigerian Export Promotion Council (NEPC) etc.
  - Support from Ministry of Trade and Tourism

The Ministry of Trade and Tourism indicated that they anticipated that the canal would improve livelihoods and commercial activities in the communities around the Wawa-Zange corridor. They recommended that the LTMP with MC should build on previous conversations to support sustainable investment ideas and plans around the canal.

2.5.3 Finance

Some of the issues raised by the Honorable Commissioner of Finance were similar to those raised under agriculture and trade (as summarized above). In relation to finance issues, the Honorable Commissioner indicated that the canal would improve delivery of water to communities in which it was previously unavailable. Access to water remains a serious challenge in Gombe State and this is made worse in rural communities where there are no boreholes. Often drilling for water could prove expensive and impractical as boreholes could go as far as 400 meters deep without contact with water. Furthermore, issues around the economic and social benefits of the canal were raised especially regarding the availability of drinking water. Clean water access seemed to be a pervasive problem among several rural dwellers. With MC already taking responsibility for the feasibility study, the state government is willing to assist where necessary, but investors are highly dependent on the availability of water in WZGR.
The Honorable Commissioner emphasized the need to put the ministry in the forefront of water investment policy.

2.5.4 Water Resources

In the session with the Ministry of Water Resources, similar issues were raised as outlined in the agriculture section above. In addition, the Honorable Commissioner of Water Resources emphasized the importance of the feasibility study while highlighting that the study is overdue. They also maintained the sustainability of the project requires harmonization between the water, agriculture, and environmental functions in the state.

Main concerns were:

- Soil composition and rock formations in the path of the proposed canal
- Elevation of the canal into WZGR
- Year-round water supply around the WZGR axis

2.5.5 Science and Technology

During the engagement with the representatives of the Ministry of Science and Technology, the

Honorable Commissioner raised a similar set of issues as above. One important emphasis was the need to demystify the livestock business which is perceived by the general public to be conducted solely done by Fulani's. Though the herders are typically Fulani, this means of livelihood is primarily connected to their culture, even though the practice is rudimentary.

However, since the government has made provision from grazing with WZGR, it is crucial to conduct a survey around canalizing water into the reserve. To conduct a survey, science and technology is crucial especially for the map and geospatial analysis. In addition, tech can help track livestock and monitor their progress and well-being.

Other issues raised were the benefit of the project to women in the surrounding areas. Access to clean water is crucial not only for farming activities but also for women as they mostly engage in domestic activities in comparison to the men. A total of 300 women are already engaged in the production of feed. Getting water into WZGR is more likely to be beneficial for women already engaged in feed production as it can create better access to market. The canal can enhance the resilience of vulnerable groups around the WZGR corridor as previous activities leverage on the availability of water to scale up, hence improving these previous efforts' ability to resist potential shocks and stress in the future.

A moribund water facility

3

Debrief Meeting Report

Date of Debrief: 6th October 2022
Chaired By: Dr. Usman Bello Abubakar, Senior Special Assistant Technical / Team Leader Gombe State Livestock Transformation Management Project
Also in attendance: Special Adviser Budget, Planning and Development Partner Coordination Office, **Dr. Ishiyaku Mohammed**
Date of Release: 30th October 2022

3.1 Summary of Project

Based on the stakeholder engagement and field visit undertaken between 4th and 6th, October 2022, it was crucial to avail the details of some of the findings to determine the viability of canalizing water into WZGR (subject to further feasibility analysis). Specifically, the study required a visit to four LGAs: Dukku, Funakaye, Kwami and Nafada based on their proximity to WZGR and availability of water source. Other factors for choosing these LGAs include the alignment of the proposed canal, geological analysis, and topographic survey to determine the feasibility of the project.

3.2 Summary of Feasibility Issues/Schedule

Prior to the stakeholder engagement and field visit, a Field Survey Protocol for Canalizing Water into WZGR was availed to the LTMP team and MC team to conduct a robust exercise and a succinct report. The LTMP was very helpful in facilitating meetings with various external stakeholders including the State Government. The SIO from MC was also very helpful in coordinating with the LTMP, thus little time was wasted as schedules were timely. While sensitizing and meeting with state officials and key informants from the local communities, there were no signs of unrealistic expectations of the proposed canal project. All stakeholders engaged expressed optimism on the potential outcome of the canal. Informants seemed in tune with the realities of the current water challenges and were willing to share their experiences with these challenges. In some places, water access was far and or often the quality was poor, even if nearby. Often many locals manage or resort to buying from water vendors.

Apart from the availability of water, other feasibility issues were mainly around meteorological and hydrological threshold (i.e., rainfall and evaporation levels), pedologic and geologic formation and the elevation terrain. Any of the aforementioned could pose a threat to the success of canalizing water into WZGR. However, with precise mapping, these risks can be mitigated.

3.3 Summary of Resource/Staffing

Staffing for the key activities was right and all milestones were achieved on time. Some difficulties did result from trying to cover the entire field visit in one day; this was however resolved by splitting the teams into two groups.

3.4 Safety

With support from the LTMP team and the SIO, safety was elevated. Most of the LTMP members were either members or conversant with the communities around the Wawa-Zange corridor.
Using a soil map of Nigeria, collected from FAO, UNESCO, International Soil Reference, and Information Centre (ISRIC) as well as geologic data from NGSA, the soil and geology data was digitized as polygon. The other visible features such as local government boundaries were also digitized and overlaid on the two generated soils and geology maps. The clip sub module of the ArcGIS was also used to define each of the local government in both maps and the soil and geology.

The potential shifting of soil is limited to the canal path. Apart from this, the formation of luvisol in this location does not constitute major negative material implication to the canalization in the proposed site within the eastern plain of Gongola River (see figure 6 and 10). Although there may be dust from excavation for the canal path, communities need support during construction to reduce the chances of physical harm or damage to property.

3.5 Water Facility and Other Key Issues Raised

Generally, water facilities are limited in rural areas in Gombe State and the four LGAs around the canal path are not any different. A 25-litre keg of water is 5 times more expensive in rural communities than in Gombe town. This can even be higher in dry season. The current administration under His Excellency, Alhaji Muhammadu Inuwa Yahaya, is already implementing efforts to address water needs with projects like the Dadin Kowa water harvesting project and the SURWASH partnership between the Gombe State, Federal Government, and World Bank.

Such activities like this indicate commitment from the state and encourage future water projects in the state. Several decentralized water projects like boreholes and storage tanks have always existed around the state; some are now moribund, and the functional ones are inaccessible to the majority of the population. Other key issues raised during the debriefing include other potential sources around the eastern plain of the Gongola River, previous attempts to channel water and relocate pastoralist to Wawa-Zange, data availability, and potential for rainwater harvesting.

3.6 Success Criteria

Some of the factors identified as key success criteria for the canal include a robust Poverty and Social Inclusion Assessment (PSA), conducting an Initial Environmental Examination (IEE), developing an Environmental Management Plan (EMP), continuous management and communication with relevant stakeholders, use of technology, favorable government policies, adequate financing and identifying the right investors.

Low water level on the western plain of the Gongola River

4 Feasibility Report on Canalization of Wawa-Zange Forest Reserve

4.1 Introduction

A man-made or enhanced waterway known as an irrigation canal is used to transport water for agricultural purposes from a lake, river, or stream to a specific location. Irrigation canals are vital elements of any agricultural activities and have been identified in archaeological digs as early as 4,000 BCE and have frequently spelled the difference between subsistence and starvation. Due to its tendency to have an impact on the community's social, economic, and environmental well-being, irrigation canals are often referred to as the most crucial tool required for sustainable development.

The most basic form of an irrigation canal is a trench filled with water. It can be constructed by digging a hole in the earth and filling it with water, or it can be constructed by "canalizing," or widening an existing stream and diverting it where necessary to achieve optimal effectiveness. A canal can also be formed by first constructing its walls and using the dry earth as its foundation before connecting it to a water source.

Providing a continuous flow of water for irrigation canals is one of the main challenges for canalization. The water supply is consistent when the canal is directly connected to a water source, such as a lake or river, but caution must be taken to prevent utilizing so much water that neighboring areas suffer. Other methods must be used when an irrigation canal must go a long distance or deal with elevation variations. For instance, it's typical to construct a reservoir to store water for irrigation and to fill irrigation canals with dam and lock systems. Another approach involves creating locks or dams to separate water supply sources from irrigation canals, opening them when water is needed in the irrigation canal, and closing them when it is no longer needed.

Water from irrigation canals must frequently be transported from the canal to the agricultural land via alternative methods because the water is not always supplied directly to the land being utilized for the agricultural activities. One typical method for accomplishing this is to direct water from the canal into lateral irrigation canals that have been dug close to the crop rows. Sometimes complex systems are created to transport water upward from an irrigation canal when utilized on slopes.

The proposed canal will be located at Wawa-Zange Grazing Reserve, which is located between latitude 10 49’ 22.7" N and longitude 10 46’ 23.7" E. The grazing reserve is in a high plain at an altitude of between 409 and 498 meters. The grazing reserve is situated in Dukku, Nafada, Funakaye, and Kwami Local Government Areas (LGAs) of Gombe State. These LGAs are all located in the valley of River Gongola which is the largest and most significant river for the present study. The river passes through Gombe state via the north-west from Bauchi State and flows eastward via Dukku, and Nafada local government. The river Gongola bends in a loop southward forming natural boundary between Gombe, Borno and Adamawa states in the eastern parts before it joins River Benue at Numan in Adamawa State.

The proposed canal covers a length to 35.95km from its start point into Wawa-Zange Grazing Reserve in Gombe state with a gross command area of 146,000 hectares (ha). The main canal and associated structures of the WZGR canalization project has five components related to the WZGR canal: (i) main canal; (ii) service road (iii) sector turnouts, (iv) pumping station, and (v) storage reservoir. The WZGR canalization project also includes development of the irrigated agriculture project preparation facility, which will prepare subsequent projects under Objective 2 of the project. The main canal base costs are approximately N1.3 billion for the five components directly related to the canalization and will be financed from a consortium comprising development partners, government, and the private sector. The irrigated agriculture project has a base cost of N58.29 million. Together with contingencies and taxes, this is estimated at N143 million.

The most economically viable type of canal is a permanent canal characterized as a Concrete Line Canal which is fed from the Gongola River year-round. In addition to the main canal is the irrigation canal which will carry water to the agricultural field. The canal will receive water from the eastern plain with a flow rate along the plain to about 21 cubic meters per second.

4.1.1 Proposed benefits of canalization

The proposed canalization project will enrich the people of Dukku, Nafada and Kwami LGA due to the increase in cropping area and yields, which result in higher incomes for farmers, include lower overall use of agricultural chemicals, the adoption of water conservation practices, and improving water availability. These benefits will accrue from the combination of civil works to rehabilitate and expand the irrigation infrastructure and capacity building.

4.2 Water Availability Analysis

4.2.1 River system and catchment areas

As shown in Figure 3 the potential water source for the canal construction is River Gongola which flows via the western plain of Dukku LGA and the eastern plain via Nafada, Funakaye and Kwami LGAs. The potential source of the water supply between the western and eastern plain of River Gongola was assessed based on water availability and volume. The volume of the water was determined by the evaluation of the net inflow from both catchment areas.

The result obtained shows the water from the eastern plain to be the best source of water supply to the proposed canal construction. This is because the western plains of River Gongola depends on recharge from runoff during rainy season and as such have low water level and flow rate during the dry season. The mean the flow rate in dry season is around 5.7 cubic meters per second (201 cu ft/s).

The results show that the eastern plain received water from tributaries in neighboring states such as Hawul and Gungeru streams. The presence of the Dadin Kowa and Kiri dam along its path increases the flow rate along this plain to about 21 cubic meters per second (741.6 cu ft/s). The proposed canal will have several important functions, such as irrigation, domestic usage, livestock management and storage. It will be constructed to distribute irrigation water during the dry season thereby reducing the amount of un-irrigated wastelands leading to increase in the quantity of biomass in the area. The construction of the proposed canal will also boost the economic development of the area by avoiding dangerous droughts and total dependence on rainfall. The multi-purpose function of the proposed canal will include irrigation, domestic usage and livestock development. The development of the proposed canal can increase the ground water recharge and increase access to wells because it does not involve the utilization of ground water.

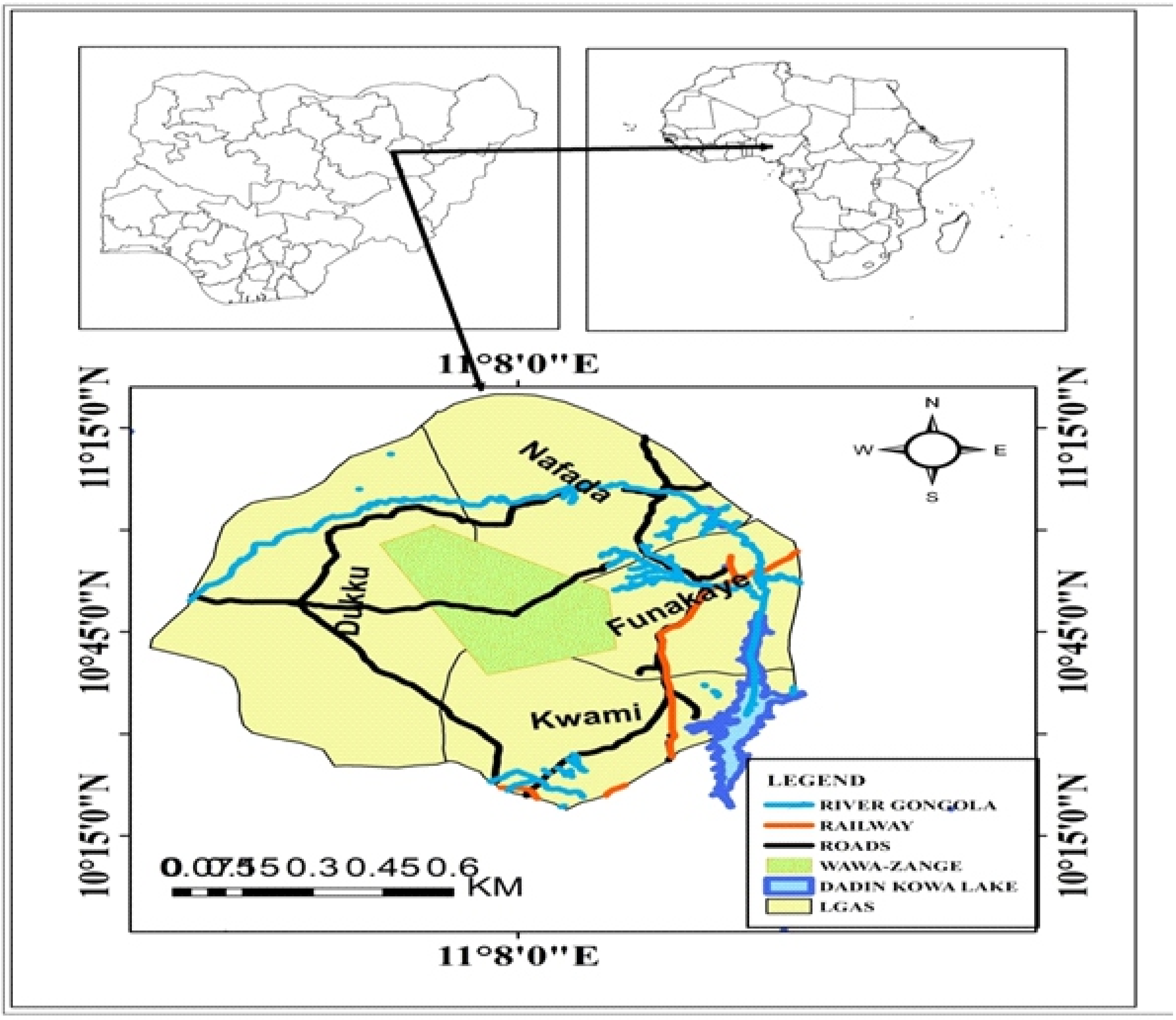


Figure 3: Study area

4.3 Meteorological and Hydrological Analysis

The primary data used in the hydrologic studies are rainfall, evaporation, and stream flow. These data were observations and measurements taken from the hydrology and meteorology stations operated and maintained by NiMet. Climate data available from the nearest meteorology station at NiMet are rainfall, temperature, relative humidity, sunshine hours, wind speed, and evaporation.

4.3.1 Rainfall data

The rainfall trend of Gombe State is represented in Figure 4. This rainfall data for the proposed project site shows a seasonal pattern, with the wet season covering the period, May to October, and the dry season usually occurring from late November to April. The flood season months generally occur from July to early November. The result presented in Figure 4 also show higher rainfall in the proposed site of the canal construction.

Heavy rainfall does not necessarily mean the total amount of precipitation at a proposed canal construction site will increase, but that the incidence of rainfall can occur with more intense events. However, changes in the intensity of rainfall, when combined with changes in the interval between rainfall events, can also lead to changes in overall rainfall. The potential impacts of this heavy rainfall include crop damage, soil erosion, and an increase in flood risk due to heavy rains which in turn can lead to injuries, drowning, and other flooding-related effects on health. In addition, runoff from precipitation can impair water quality as pollutants deposited on land wash into water bodies.

In the 2019 wet season, a heavy downpour accompanied by a strong thunderstorm wreaked havoc on communities in Dukku and Nafada LGAs of Gombe State which is the site of the proposed canal construction. These heavy downpours destroyed farmlands, rendering hundreds of residents homeless. A total of about 15 villages were affected by the flooding resulting from the heavy rainfall, which washed away farmlands and destroyed several houses. In 2019, an assessment conducted by the Gombe State Emergency Management Agency (SEMA), indicated that about 1,379 houses were partially or completely destroyed and about 116 farmlands were either submerged or washed away by the floods in Dukku LGA alone (Thisday, 2019). The affected communities were Dokoro, Burari, Hashidu, Malala, Wuro-Tale and Zaune.

In Nafada LGA, the flood affected Nafada town, the headquarters of the LGA, where numerous farmlands were either submerged or washed away by the flood, while several houses were destroyed. The construction of the proposed canal will increase the risk of flooding in the Dukku, Funakaye, Nafada and Kwami local government unless a control point is built at the main canal which should be closed during rainy season.

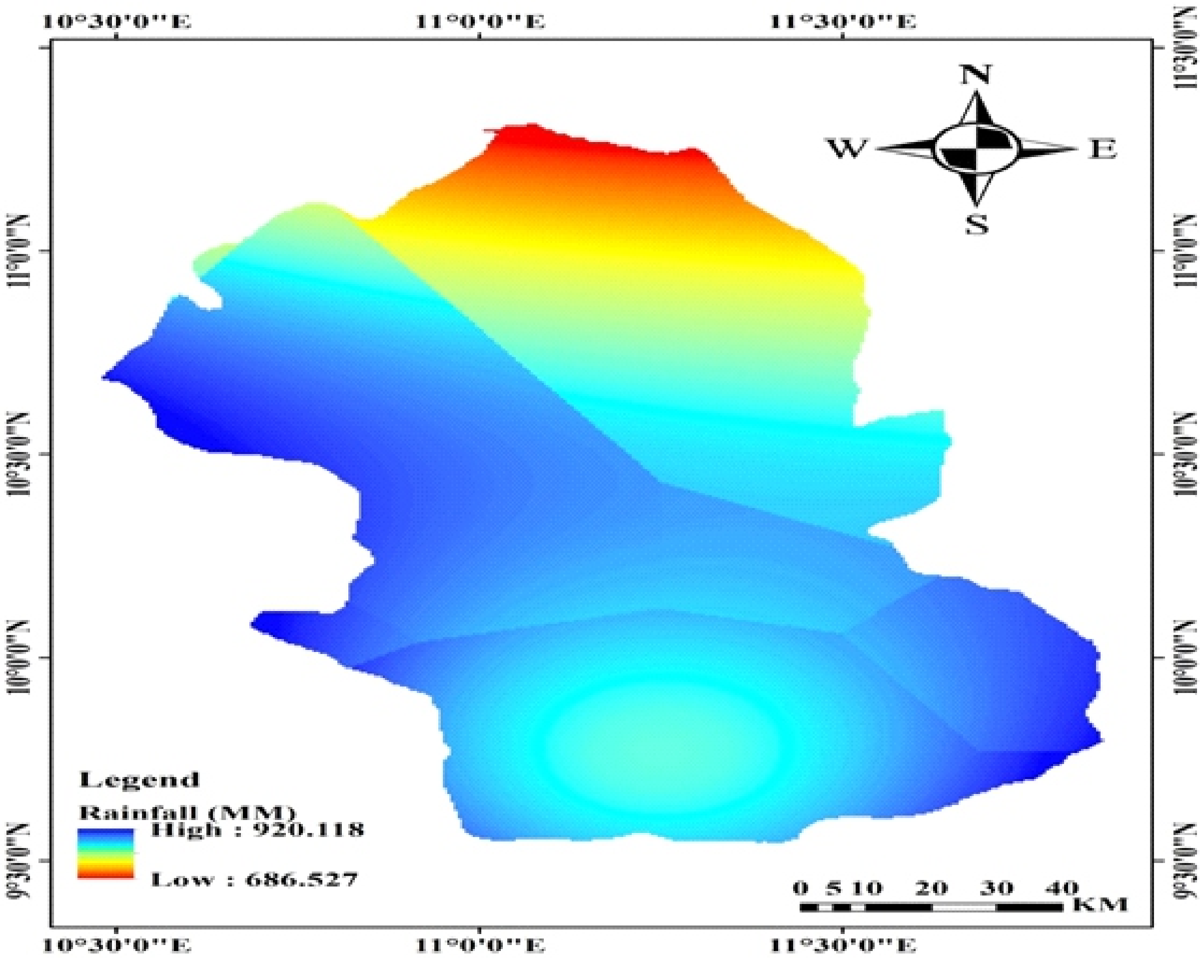


Figure 4: Rainfall trends in Gombe State

4.3.2 Evaporation data

There are no available evaporation data for the proposed site. Although the potential evaporation rates can be computed from climate data, it was deemed best to use actual observed evaporation rates. As seen in Figure 5, the monthly mean evaporation rate of Nigeria was used because evaporation rates are nearly constant over a wide area and may vary with seasonal temperature differences.

The evaporation data shows tendency of drying up of well water during the dry season: this was confirmed by respondents during the field survey, stating that water from wells and earth dams are the only two sources of water in the proposed site for canal construction. The wells dry up annually in early February after which the source would only be the earth dams for a month and some weeks before this source also disappears.

This situation remains unchecked in these areas, forcing 95% of the population who are subsistence farmers to rely on commercial water tankers, after selling their farm produce to buy water. For instance, it can cost up to N100 at Komi and Wawa villages of Funakaye Local Government to have 25 liters of water for domestic use and feeding of livestock. People living in villages like Kari and Gudu buy it at N150. A commercial water tanker of 45 drums costs N25,000 and while a tanker carrying 37-38 drums costs residents N20,000. Three commercial water tankers supply them water from Biri, a neighboring village. In Dukku, 25 liters gallons can be as high as N70-80. The whole tanker of 38 drums that supplies the water from Gombe Abba, costs N12,000. At Gadam and Kwami, all in Kwami LGA, a 25-liter gallon of water also costs N70-80. The commercial water tankers of 40 and 45 drums, supply water from the Gombe metropolis at the cost of N16,000 and N18,000 respectively at Gadam, while it is N15,000 in Kwami. The construction of the proposed canal will help to ease the water crisis in the three local governments.

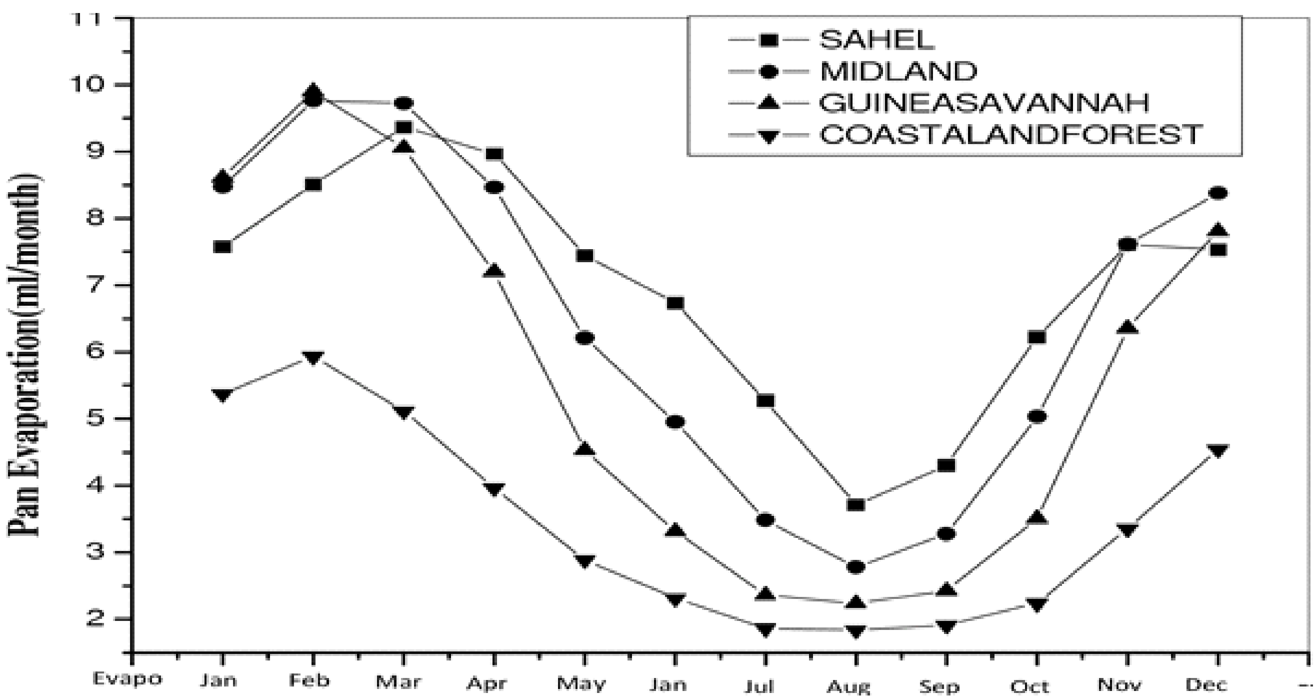


Figure 5: Monthly evaporation in Nigeria

4.4 Pedologic and Geologic Analysis

Soil is one of the most important natural resources that are available in almost every area. It is normally the major determinant of so many human activities. For instance, farmers consider its types, fertility, and texture among others for site suitability for their various crops production; civil engineers relate soil types to residential development, the availability of some mineral resources also largely depend on the soil types.

Soil Science Society of America (2017) stated that soil is a vital part of the natural environment, and it is just as important as plants, animals, rocks, landforms, lochs, and rivers. It influences the distribution of plant species and provides a habitat for a wide range of organisms. It controls the flow of water and chemical substances between the atmosphere and the earth and acts as both a source and store for gases (like oxygen and carbon dioxide) in the atmosphere.

Soils not only reflect natural processes but also record human activities both at present and in the past. They are therefore part of our cultural heritage. According to FAO (2002), a better understanding of the linkages between soil life and ecosystem function and the impact of human interventions will enable the reduction of negative impacts and more effective capture of the benefits of soil biological activity for sustainable and productive agriculture. Hence, spatial distribution of soil is very important to so many disciplines that rely on such spatial data for decision making.

The geology of a place is also an important tool to locate the earth energy sources, how to extract them from earth more efficiently and at a lower cost, and with the smallest impact on the environment. Water, an important natural resource, is scarce in many parts of the world. The study of geology can help to find underground water resources to reduce the impact of water scarcity on people and civilization. Moreover, the spatial distribution of the geology of an area also helps in the assessments, monitoring and prediction of possible environmental hazards in the area. Among these hazards are floods, soil erosion, droughts earthquake among others.

Consultant and LTMP representative examining the water level along the Gongola River

The knowledge of geology can help by estimating where earthquakes are most likely to occur (known as fault lines) and to recommend the type of technology to be used in the construction of buildings in these vulnerable areas. Finally, most countries of the world depend heavily on the available mineral resources in their domain for their growth and development. The endowments of these mineral resources largely depend on the geology and the soil types of the area.

The soil map of Nigeria was collected from FAO, UNESCO and ISRIC (1996) while Geologic data was collected from NGSA (2009). The soil and geology data collected were digitized as polygon, other visible features such as local government boundaries were also digitized and overlaid on the two generated soils and geology maps. The clip sub module of the ArcGIS was used to define each of the local government in both maps and the soil and geology. The area in square kilometers of the soils and geology units in the entire State and in each LGA was obtained using the area calculation module of the ArcGIS.

The result display in Figure 6 shows that dystrict nitosol are the predominant soil found in the proposed site for the canal construction. This soil type extends to the west of Dukku LGA to Gongola riverbank on the western plain. The dystrict nitosol also extends to the southern part of Nafada and the western parts of Funkaye and Kwami LGAs. The nitosols are regarded as the most well drained tropical soil that has diffuse horizon and boundaries. This type of soil has a sub-surface horizon that consist of 30% clay and a moderate strong and angular blocky structure which breaks into a polyhedral or flat edged. This type of soil has been classified by FAO to be the most fertile of tropical soils due to the presence of high nutrient content and deep permeable structure.

Figure 6 shows nitosol as the only soil type in the proposed canal construction site extending to the west of Dukku LGA and the western Gongola River with only roads as limiting factor. If pedogenic analysis is the only factor for consideration for the building of canals, there is no doubt that the Gongola River at the western part of Dukku LGA would have been a perfect site for water supply.

Lithosol is another type of soil that is found at some points of the southern-eastern region of Nafada LGA. The type of soil is also found in Funakaye and Kwami LGAs standing as a barrier between the water source of the eastern Gongola riverbank and the proposed canal construction site. Lithosols are usually referred to as a soil consisting of partially weathered rock fragments which are usually on a steep slope. The presence of this soil at the location as shown in Figure 6 is one of the challenges of canalizing water from the eastern plain of Gongola River.

The last type of soil that is found in Nafada, Funakaye and Kwami LGAs that bond the eastern Gongola River is the luvisol. This type of soil is widely used for agricultural activities due to their argic horizon. The formation of this type of soil in this location does not have any negative implication to the canalization of water in the proposed site within the eastern plain of Gongola River as water sources.

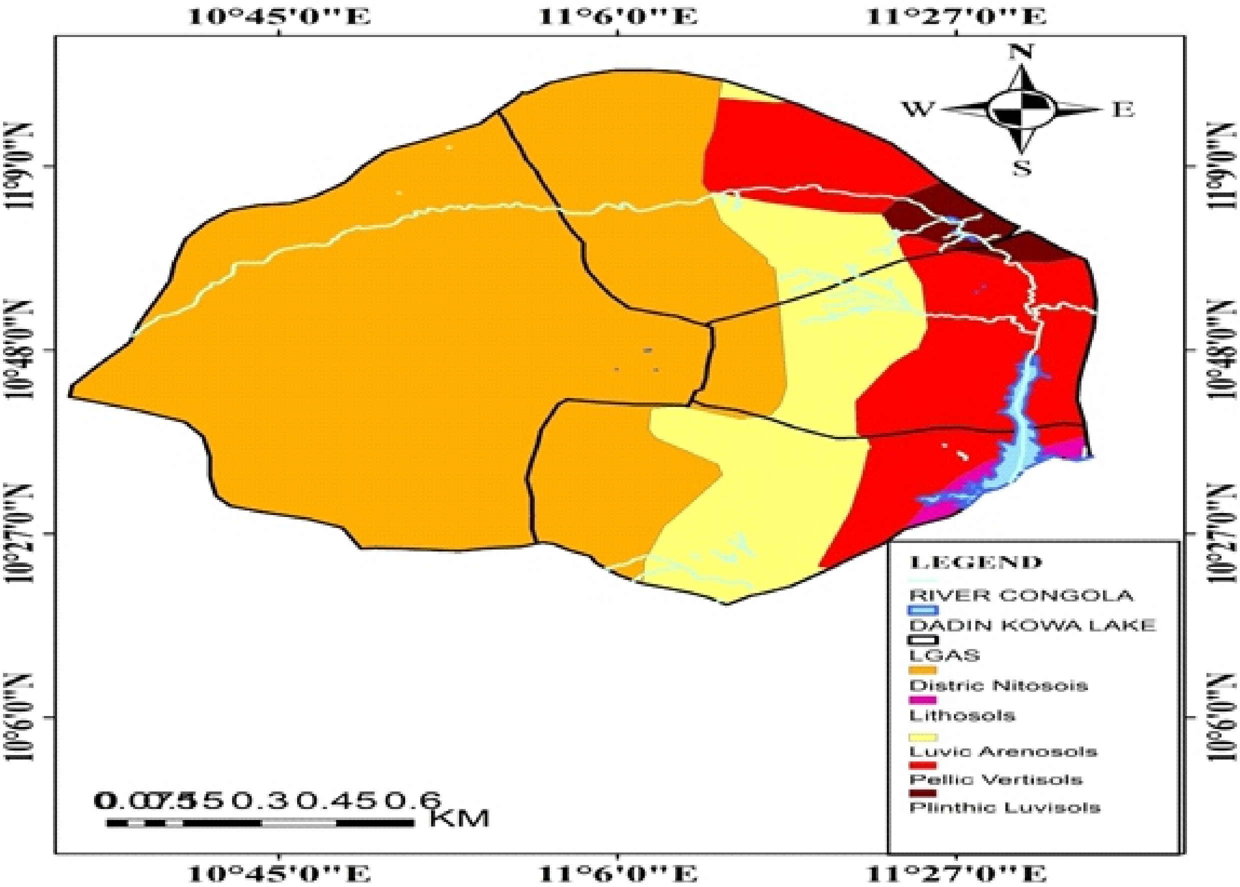


Figure 6: Soil types and properties of the proposed canal site

Figure 7 shows the geologic composition of Gombe state. The geologic units related to the proposed site of water canalization include sandstone, shale and clay which are the dominant geologic composition of the proposed canalization site extending to some part of Dukku, Nafada, Funakaye and Kwami local government. Figure 7 also shows that part of the lithosol is sandstone, siltstone, shale, coal, or ironstone. This composition is a problem for the canalization project from the eastern plain of Gongola River as water source. However, a point was discovered at Bodor community as a potential path for canalization into WZGR, as shown in Figure 10.

Wawa-Zange Grazing Reserve

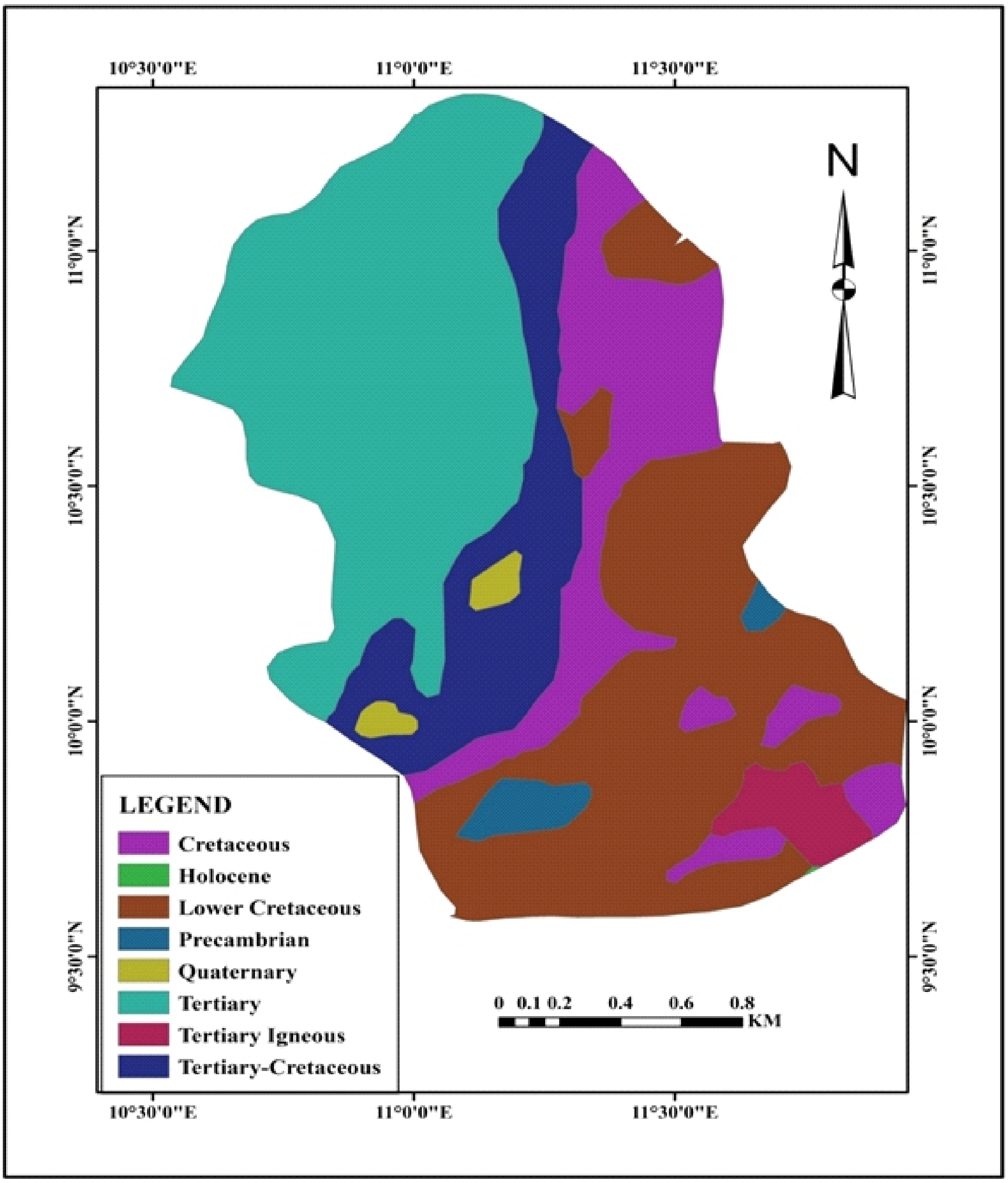


Figure 7: Pedologic properties of the proposed construction site

4.5 Elevation Analysis

Figures 8 and 9 show that the elevation of the canal construction is on the highland plain of altitude of between 409-498 meters within Dukku, Nafada, Funakaye and Kwami LGAs. The higher elevation around the western plain of Dukku local Government favors the western plain Gongola River as a potential water source for the canalization since water moves easily due to gravity from higher plain to lower plain thereby preventing the backflow of water and other environmental issues.

The area within the eastern plain of Gongola River falls within low plain of altitude 324-409 meters thereby making it difficult for the canalization of water into the proposed project site using the eastern plain of river Gongola as a water source. This problem will be easily solved with increase in depth to counteract the effect of the slope. The creation of a pump house as shown in Figure 10 will also eradicate this difficulty.

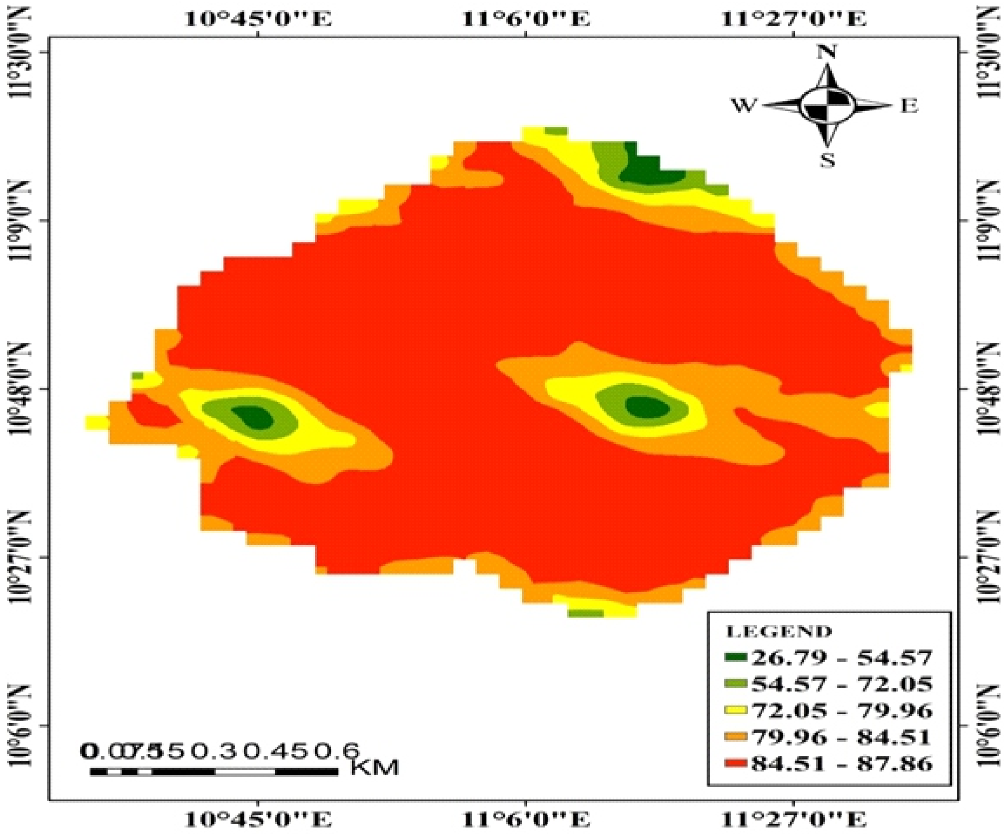


Figure 8: Elevation of the proposed area

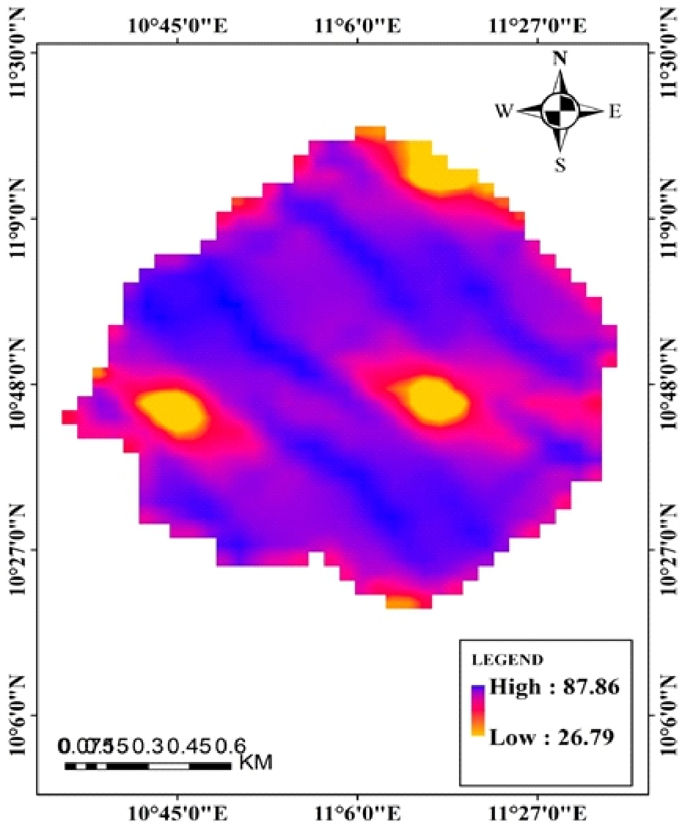


Figure 9: Elevation of the proposed area showing high and low points

4.6 Environmental Safeguarding Analysis

4.6.1 Project screening

The following selection criteria will be applied to the proposed canal in other to achieve a long-lasting function and viable investment opportunities through the canal. They are based on avoiding impacts which, taken individually or in combination, are likely to cause the canalization initiative to be classified "A" for environment under the ADB Safeguards Policy Statement (2009). These safeguards are articulated below:

- The proposed canalization will not:
    - be subject to water use conflict or water security issues
    - encroach upon or cause impacts on protected areas or critical habitats
    - be undertaken where significant soil contamination occurs
- The proposed canalization will avoid monuments of cultural or historical importance
- No groundwater will be used as primary water source for proposed canalization
- Additions to irrigation command areas should not be immediately upstream of ecologically sensitive areas

4.6.2 Regulatory framework for Environmental Impact Assessment

The canalization is judged to have minimal site-specific environmental impacts, mostly occurring during the construction phase, an Initial Environmental Examination, including an EMP will be required.

The objectives of the IEE are to include the following:

- Describe the natural and socioeconomic resources surrounding the proposed area
- Identify and assess significant impacts based on environmental conditions during canal pre-construction, construction, and post construction stages
- Identify and recommend mitigation measures to minimize any potential impacts caused by canalization activities
- Undertake public consultations to present environmental issues to project stakeholders and local people to collect community concerns
- Develop an EMP with cost estimates and monitoring plan for the construction and operation stages to guide subproject implementation

The screening and design issues for the proposed canalization focused on the following areas:

- No encroachment on protected areas and no impact on critical habitats
- Matching the total planned Wawa-Zange Grazing reserve for farming and grazing activities in both wet and dry season

4.6.3 Protected areas and critical habitats

The location of the proposed canal was checked against Myth of Empire (MOE) maps and data in the International Biodiversity Assessment Tool (IBAT). These checks showed that the proposed canalization area does not encroach upon any legally protected areas, international conservation agreement areas, or key biodiversity areas (KBAs).

4.6.4 Water availability

The question of water availability in WZGR relates to the amount of the water resource and the delivery of that water. The hydrological analysis undertaken for the feasibility study on the proposed canalization concluded that there is sufficient water available at the eastern plain of River Gongola all year round from a combination of inflow from tributaries in Yobe and Borno states. The findings also show the Dandi Kowa dam and Kiri dam as another reason why the eastern plain of River Gongola is best to be used as water sources. However, the delivery of water to WZGR is from lower elevation to higher elevation. This can be controlled using pump station to increase the water velocity and difference in depth to counteract the effect of the slope.

4.6.5 Construction impact

During construction of the proposed canal, the potential issues envisaged may include air and water pollution, soil erosion, and damage to adjoining lands, all of which can be managed by engaging competent contractors and maintaining strict control of construction contractors as well as effective implementation of EMP mitigation and monitoring measures.

The preparation and approval of work schedules and method statements for key construction activities is required as part of each EMP. The work plan and scheduling should be approved by the relevant councils, considering the need for access during harvesting and planting periods. Special measures to minimize impacts on residents, including agreed working hours and access, will be developed in consultation with residents.

The absence of villages within the flood prone command area means that there are few sensitive receptors that will be impacted by noise and dust from works along the main canal and secondary canals as such require adequate protection from construction impacts in this area.

Dredged spoil from the proposed canal will deepen and widen the canal. However, if the pile of dredged spoil is not cleared from the embankment, the unintended consequences could be erosion in the canal itself and unprecedented flooding in the surrounding area of the canal. The pile high on embankments can be eroded by floodwaters and cause siltation in the proposed canal as well as overtopping and overland flow, causing unintended flood afflux in other areas.

The embankments should be retained as low as possible and surplus excavated materials should be removed and reused only in locations defined in the EMP. The construction easement, including stockpile sites and access ways, should be clearly delineated in the plan, and marked on the ground to ensure that equipment operators stay within these boundaries. Any temporary damage that is not covered in the marked and agreed construction easement should be compensated promptly by the Contractor in line with the project entitlement matrix.

4.6.6 Post-construction impact and operations

- Agricultural chemicals: The main concerns for the proposed canal are local increases in the levels of agricultural fertilizer and pesticide residues and their effects on water quality and people. Significant fertilizer and agricultural pesticide residues are not indicated by the baseline sampling. To safeguard against increases in these factors due to increases in cropping, post-construction mitigation will focus on capacity building and training and responsible use of fertilizers and pesticides. This will involve the promotion of Integrated Pest Management (IPM) practices and the application of fertilizers based on soil nutrition needs and environmental circumstances, rather than as routine operations.

- Pump station: It is proposed to install three pumps and operate two at the same time to achieve a discharge capacity of 1.2 m3/s at the propose pumping station. When the specifications of the pumps are confirmed, noise modeling should be undertaken to determine the level of noise impact on nearby residences. Previous work on other pump stations indicates that noise attenuation from a properly insulated pump house is in the order of 35% noise reduction at 20m. Noise levels within similar pump houses are commonly in the range of 80-85 dB, depending on the size of pumps, which at 20m would reduce to 50-55 dB. These levels of noise mitigation should be targeted by the pump house design. Operational guidelines will also include limitations on the maximum pump running hours per day during daytime.
- Greenhouse gas: GHG emissions from the proposed canal site will result from the pump powerhouse due to diesel utilization (powered by internal combustion) for water movement. The use of the solar-power pump will increase water delivery to the grazing reserve through gravity and will reduce the use of small diesel-powered pumps, which account for more than 60% of the total GHG generation. This will further reduce GHG generation from this source.

4.6.7 Environmental management plan

The IEE will include an EMP, where the identified environmental impacts and mitigation measures will be transformed into an action plan for their implementation. The plan will include methods of mitigation, responsibilities, indicators of progress, and frequency and nature of monitoring activities with cost estimates. The EMP will be a critical document for the subproject. The provisions of the EMP will be incorporated in the tender documents and construction contracts and monitored by the project implementation team for compliance.

4.6.8 Key takeaways from the environmental safeguarding analysis

Most of the identified environmental impacts are assessed as not significant. The main risks that have been identified in the assessment can be addressed by mitigation and management measures and reinforced by project assurances. It is concluded that:

- The infrastructure subproject planned for the proposed canalization has significant potential benefits for the rural populations of these areas
- The design features, operational regimes and construction management safeguards will address the range of potential environmental impacts identified and will be actioned through the Project EMP and continuously checked in the EMP

Some settlers on Wawa-Zange Grazing Reserve

4.7 Socio-Economic Analysis

This section provides an overview of the socioeconomic conditions of the four local governments where the proposed canal is located. The findings were taken from secondary information mostly available in the secondary database (National Population Commission of Nigeria, National Bureau of Statistics), and the socioeconomic survey (SES) conducted in the four local governments. The four local governments in the proposed project site have a total population of approximately 1,305,200 according to World Bank projection 2022.

LGA	Population	Area (km2)	Population Density (km2)	Annual Change (%)
Dukku	347,700	3,743 km2	92.89/km2	3.3%
Funakaye	398,000	1,275 km2	312.2/ km2	3.3%
Kwami	324,800	1,850 km2	175.5/ km2	3.3%
Nafada	234,700	1,220 km2	192.4/ km2	3.3%

Table 1: Human population and population density within canal site

Males account for about 51.8%, 55.6%, 51.4% and 56.4% of the total population in Dukku, Funakaye, Kwami and Nafada respectively while the rest of the percentages are female. In the local governments, people of working age (15-60 years) account for 50.3%, 48.9% 49.2% and 49.2% of the population in Nafada, Kwami, Funakaye and Dukku LGA respectively. One-third of the population is comprised of young people under 15 years old, and girls account for 50.4% of the youth. The proportion of youth to working-age adult results in a child dependency ratio of 0.52, that is, approximately every two working adults must support one child.

In the proposed canalization site, it is estimated that 95% of the households are engaged in agriculture, specifically crop farming, fishing, and raising livestock. Though women like men are engaged in these occupational activities, they are less likely to be involved in the physical and production aspect of crop farming in certain LGAs such as Dukku. Besides this, there is no significant difference between men and women within most of the occupational groups, where there are significant numbers of employed people. Agriculture remains the dominant source for household income, and so far over 10,000 animals belonging to 110 livestock households have already settled in WZGR.

The survey results also showed that the local communities have favorable perceptions of the proposed canalization of the WZGR. The respondents indicated that the proposed project would stabilize water availability for livestock and farming. All key informants noted the canalization will reduce the effect of water scarcity experienced during dry season. Other anticipated positive impacts include: (i) reduced flooding and drought; (ii) increased agricultural productivity; (iii) improvement of public infrastructure in the proposed project site; and (iv) job creation for local farmers.

4.7.1 Takeaways and Limitations from Socio-economic Analysis

Poverty and social assessment: Alongside and complementary to future assessments such as MC's Objective II assessment which focuses on the development of 3-4 investible business cases, a detailed poverty and social inclusion assessment (PSA) should be conducted in the proposed canalization areas. This is especially as MC seeks to target 50% women and youth. Our field study witnessed minimal presence of women on the farmlands visited around the Gongola River. Further enquiries indicate that culture plays a role in this.

The objectives of the PSA will be to: (i) assess the current socioeconomic conditions and poverty in the communities within the proposed site of canalization; (ii) identify expected benefits as well as potential negative impacts, such as conflict and other risks posed by the proposed project to the local people, particularly to women, youths and other socially disadvantaged groups; and (iii) propose mitigation measures to address the potential negative impacts and enhance the distribution of proposed project benefits in the area. The impacts and associated mitigation/enhancement measures will be provided in a Social-Inclusion Action Plan (SAP).

In addition, the lack of data and statistics was a limitation of the study which limited the scope of our analysis. Likewise, access to secondary data pertaining to the communities around WZGR was another challenge. The study base was restructured based on the findings. Though a smaller sample was chosen, this may not be a material representative of the populations as people sometimes appropriate information. The survey was to be conducted within a week which also posed limiting factor.

Low water level on the western plain of the Gongola River

5 Canal Planning & Design

5.0 Canal Planning & Design

The reason for the planning and design of the canal is to enable an effective and viable economic utilization of water for irrigation and grazing purposes. The preliminary design of the canal facilities is made based on the suitability of the canal for irrigation and grazing purposes. The following topics have been briefly discussed to explain the planning and design of the canal.


Low water level on the western plain of the Gongola River

5.1 Canal Functions and Requirements

Since the canal is for irrigation and grazing purposes, the current study suggests the division of the canal into main canal, lateral and sub-lateral canal, and tertiary units. The main canal is responsible for the conveying of water from River Gongola into the grazing reserve in the most economical way. The main canal is planned to be originated from the eastern plain of the River Gongola where water resources is all year round. The lateral and sub-lateral canals are responsible for the delivery of water from the main canal to the tertiary units where the water is utilized for irrigation and grazing purposes within the grazing reserve.

5.2 Canal Layout Planning

The two types of layout planning that was performed for the feasibility study of the Wawa-Zange Grazing Reserve include map and field survey layout. The map layout planning was to achieve the following:

- Ensure the canal adjustment should be straight and short as much as possible
- The alignment is planned not to pass via village yards and compounds so as to avoid damage of public facilities
- Ensure the proposed canal water should be kept as high as possible to serve the intended purposes
- The cost of the canal construction can be minimized

Based on the field survey and map layout, canalizing water from the western plain into WZGR was not considered feasible, the most feasible option is to canalize from the eastern plain and for the following reasons:

  - The western plain has a seasonal recharge and cannot be considered as a water source for the canal construction
  - The eastern plain is the most feasible source of water for the canal construction and can adhere to the initial planning of the map layout
  - The alignment of the proposed canal can be in a straight line and short distance, but a pump house is needed because the topographic data of the eastern plain is lower than the topography of the WZGR
  - The geologic data also shows that there is a basalt rock that will hinder the construction of the proposed canal from the eastern plain of river Gongola as a water source, but a point was discovered at Bodor community were the problem can be solved
  - Determine the topographic survey of the route and cross-sectional survey along the lateral canal and tertiary units show high feasibility.

5.3 Canal Alignment and Discharge Design

The alignment of the proposed canal is represented in figure 10; the alignment type was selected to achieve a discharge rate that will be enough to supply the canal with the required amount of water. The figure also shows that a pump house is required to solve the problem of topographical difference. The pump will also be used to eradicate the difficulty associated with the geologic landform of the proposed canal construction path. The type of the canal design will be concrete lined canal and the canal will consider the following properties: pump house, canal velocity, freeboard, waste bank, width, depth and slope, distribution and control structures, crossing structures, water measurement structures, and erosion control structures.

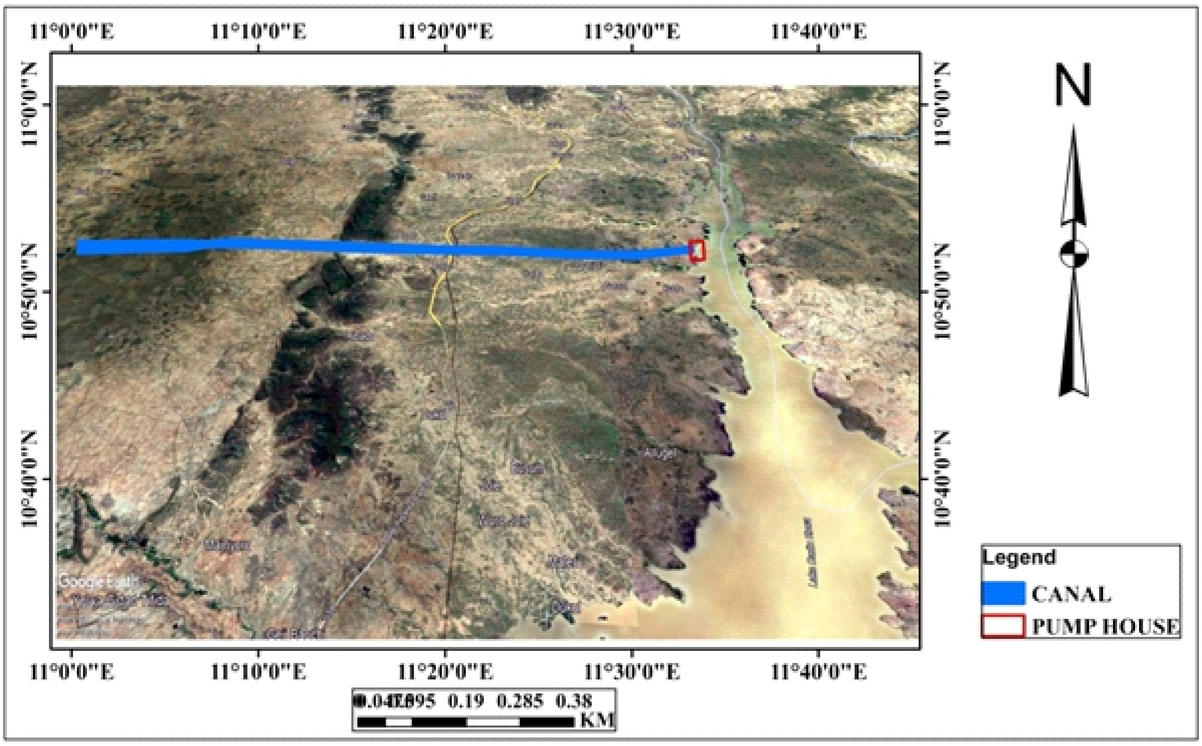


Figure 10: Map of Wawa-Zange showing proposed canal

5.4 Canal Pumping Station

Canals are usually fed by diverting water from streams and rivers into the upper parts of the canal, but if no suitable source is available, a pumping station can be used to maintain the water level. An excellent example of a canal pumping station is the Claverton Pumping Station on the Kennet and Avon Canal in southern England, United Kingdom. This pumps water from the nearby River Avon to the canal using pumps driven by a waterwheel which is powered by the river. Where no external water supply is available, back pumping systems may be employed. Water is extracted from the canal below the lowest lock of a flight and is pumped back to the top of the flight, ready for the next boat to pass through. Such installations are usually small. In the case of the proposed Wawa-Zange canal, a pump station is needed to counteract the effect of elevation because the eastern plain of river Gongola is higher than the proposed site of the canal construction.

Figure 11: Grand Union Canal Pumping Station (An example of Pumping Station)

There are different types of pumps, but it is recommended that centrifugal pump be used, shown in Figure 12. The centrifugal pump is one with an element, called an impeller, rotates, driven by a motor. Water enters the case at the center, through the suction pipe. The water is immediately caught by the rapidly rotating impeller and expelled through the discharge pipe.

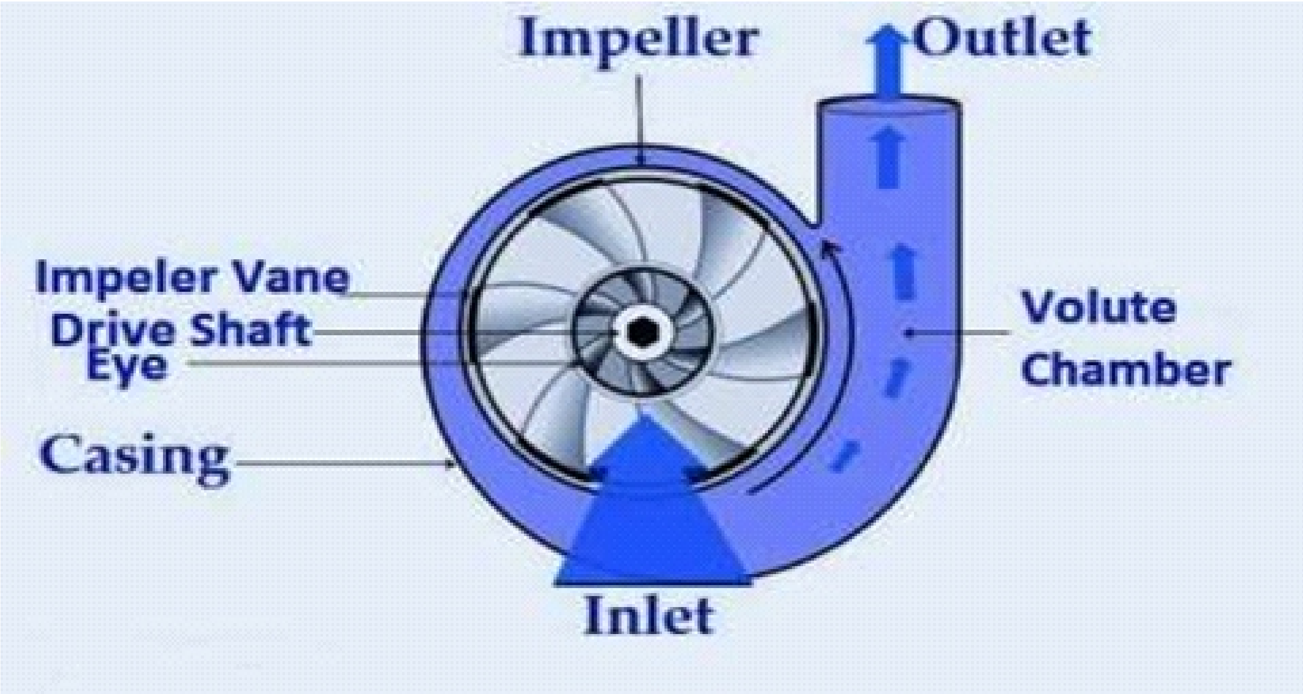


Figure 12: Diagram of a centrifugal pump

The working principle of a centrifugal pump is based on forced vortex flow. The forced vortex flow means that when a certain mass of fluid rotates by an external force (leading to an external torque), there is an increase in the pressure head of the liquid. This increase in the pressure head causes the water to be transferred from one point to another. It is a centrifugal force applying to the fluid that makes it flow inside the casing.

The centrifugal pump operates on the forced vortex flow concept. When a specific quantity of fluid or liquid is permitted to rotate by an external torque, a rise in the rotating liquid's pressure head occurs. Water is delivered from one site to another via this increase in pressure head. The fluid flows within the casing due to the centrifugal force exerted on it. A centrifugal pump is an important product for industrial applications. Centrifugal pumps can generally operate with large quantities of fluids and very high flow rates. Besides, they can adjust the flow rates over a wide range. In general, centrifugal pumps are designed to be well suited for fluids with relatively low viscosity, such as water.

5.5 Canal Velocity, Freeboard, Waste Bank, Width, Depth and Slope

Velocity: The maximum velocity (1.2ms) and minimum velocity (0.8ms) will be used to prevent erosion and deterioration of the proposed canal. This will also prevent sedimentation and growth of aquatic plants.

Freeboard and waste bank: The freeboard in the proposed canal will be determined after considering the canal size, location, velocity, water inflow and water fluctuation, which is caused by wind action, soil characteristic etc. The freeboard is determined using:

$$Fb = 0.05 \times d + hv + (0.05\text{-}0.15)$$

Where Fb is minimum freeboard (m), D is water depth for maximum discharge (m), Hv is velocity head (ms)

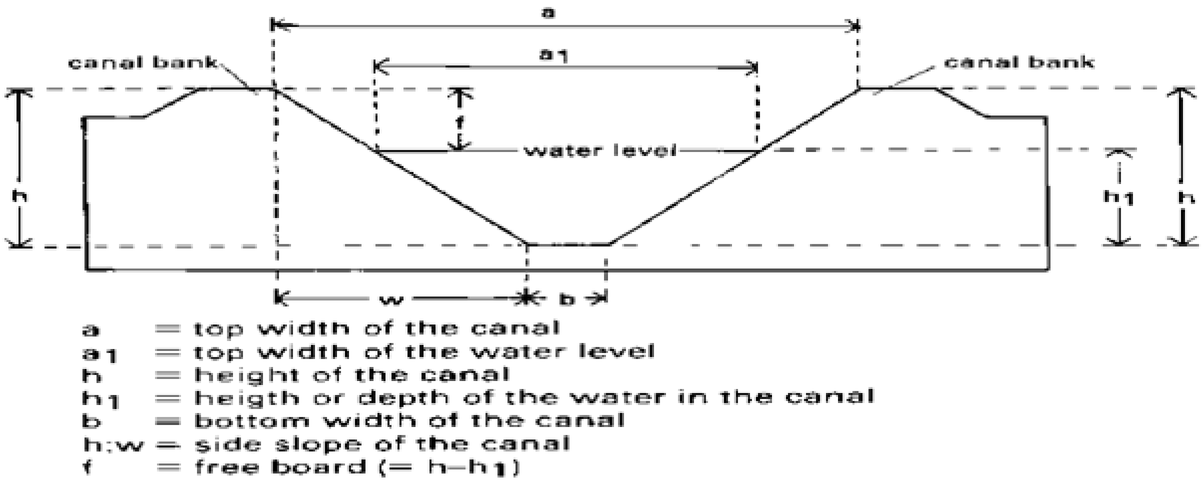


Figure 13: Freeboard of the proposed canal

The height of the waste bank will be 0.3m and the width will be 2.0m because a concrete-line canal is proposed.

Canal based width/ water depth (b/h) depth: The rate of the canal base width and water depth was determined to be 1.5m.

Slide slope: The side slope of the proposed Wawa-Zange canal is expressed as ratio, namely the vertical distance or height to the horizontal distance or width. The side slope of the proposed canal has a ratio of 1:2 (one to two), this means that the horizontal distance (w) is two times the vertical distance (h) as shown in the figure below:

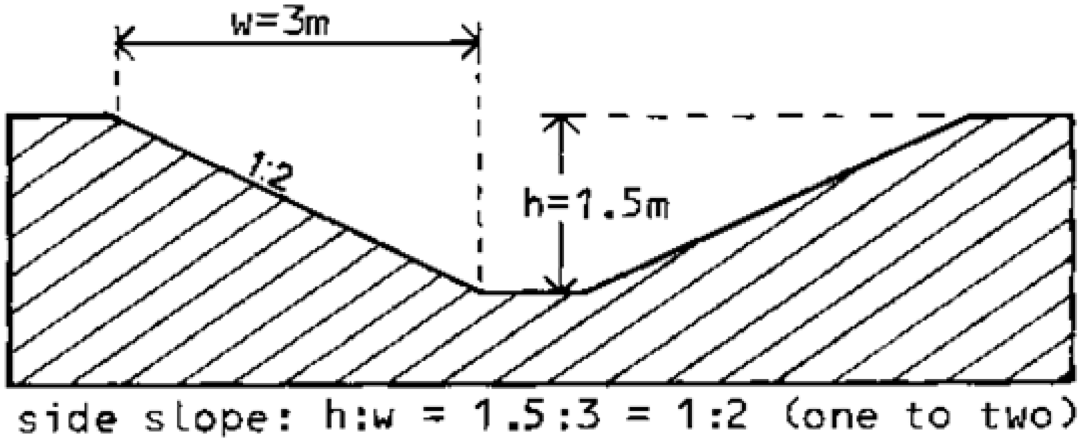


Figure 14: Showing the slide slope of the proposed canal

Lining of the canal: The proposed canal should be lined with 6cm thick plain concrete to prevent seepage from the canal banks and bottom and to protect the canal section against erosion.

5.6 Design of Related Structures

5.6.1 Distribution control structures

Distribution control structures are required for easy and accurate water distribution within the irrigation system and on the reserve.

- **Division boxes:** Division boxes are used to divide or direct the flow of water between two or more canals or ditches. Water enters the box through an opening on one side and flows out through openings on the other sides. These openings are equipped with gates.
- **Turnouts:** Turnouts are constructed in the bank of a canal. They divert part of the water from the canal to a smaller one.
- **Checks:** To divert water from the field ditch to the field, it is often necessary to raise the water level in the ditch. Checks are structures placed across the ditch to block it temporarily and to raise the upstream water level. Checks can be permanent structures or portable.

Figure 15: Example of a turnout

Figure 16: Example of checks

Figure 17: Sample check structure proposed for canal

5.6.2 Crossing structures

It is often necessary to carry water canal across roads, hillsides, and natural depressions. Crossing structures, such as flumes, culverts, and inverted siphons, are then required.

- **Flumes:** Flumes are used to carry irrigation water across gullies, ravines or other natural depressions. They are open canals made of wood (bamboo), metal or concrete which often need to be supported by pillars.
- **Culverts:** Culverts are used to carry the water across roads. The structure consists of masonry or concrete headwalls at the inlet and outlet connected by a buried pipeline.
- **Inverted siphons:** When water has to be carried across a road which is at the same level as or below the canal bottom, an inverted siphon is used instead of a culvert. The structure consists of an inlet and outlet connected by a pipeline. Inverted siphons are also used to carry water across wide depressions.

Figure 18: A sample of proposed culvert for crossing drain and road

5.6.3 Water measurement structures

The principal objective of measuring irrigation water is to permit efficient distribution and application. By measuring the flow of water, a farmer/herder knows how much water is applied during irrigation. In irrigation schemes where water costs are charged to the farmer/herder, water measurement provides a basis for estimating water charges. The most commonly used water measuring structures are weirs and flumes. In these structures, the water depth is read on a scale which is part of the structure. Using this reading, the flow rate is then computed from standard formulas or obtained from standard tables prepared specially for the structure.

- **Weirs:** Effective use of water for irrigation requires that flow rates and volumes be measured and expressed quantitatively. Measurement of flow rates in open channels is difficult because of non-uniform channel dimensions and variations in velocities across the channel. A weir is a calibrated instrument used to measure the flow in an open channel, or the discharge of a well or a canal outlet at the source. In its simplest form, a weir consists of a wall of timber, metal, or concrete with an opening with fixed dimensions cut in its edge. The opening, called a notch, may be rectangular, trapezoidal, or triangular.
- **Flumes:** Flumes are specially shaped, engineered structures used to measure the flow of water in open channels. Flumes are

static in nature - having no moving parts - and develop a relationship between the water level in the flume and the flow rate by restricting the flow of water in various ways. Advantages of flumes over weirs, include the ability to measure higher flow rates than a comparably sized weir, less head loss (~1/4th that of a weir), more readily passes debris, wide range of styles and sizes, off-the-shelf availability, smaller installation footprint and less rigorous maintenance requirements.

5.6.4 Erosion control structures

- **Canal erosion:** Canal bottom slope and water velocity are closely related, as the following example will show. A cardboard sheet is lifted on one side 2 cm from the ground. A small ball is placed at the edge of the lifted side of the sheet. It starts rolling downward, following the slope direction. The sheet edge is now lifted 5 cm from the ground, creating a steeper slope. The same ball placed on the top edge of the sheet rolls downward, but this time much faster. The steeper the slope, the higher the velocity of the ball. Water poured on the top edge of the sheet reacts exactly the same as the ball. It flows downward and the steeper the slope, the higher the velocity of the flow. Water flowing in steep canals can reach very high velocities. Soil particles along the bottom and banks of an earthen canal are then lifted, carried away by the water flow, and deposited downstream where they may block the canal and silt up structures. The canal is said to be under erosion; and the banks might eventually collapse.

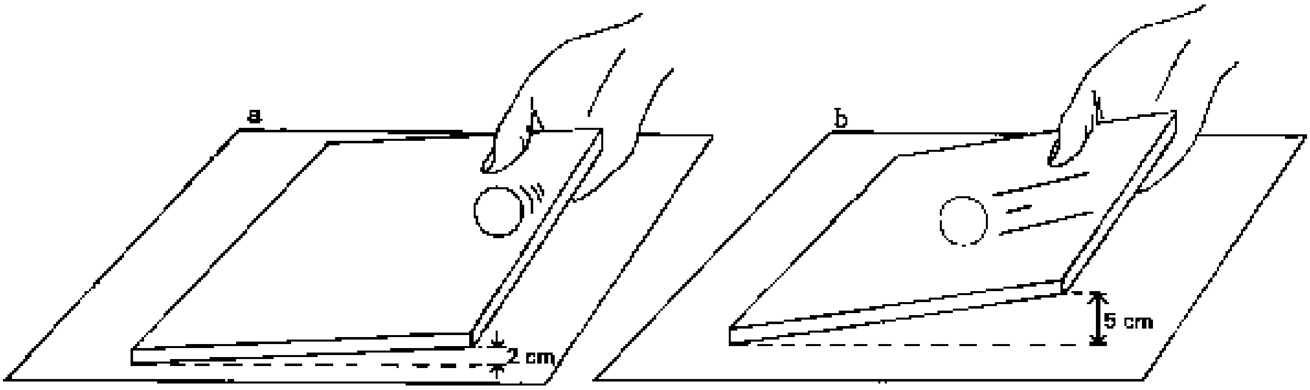


Figure 19: The relationship between slope and velocity

- **Drop structures and chutes:** Drop structures or chutes are required to reduce the bottom slope of canals lying on steeply sloping land in order to avoid high velocity of the flow and risk of erosion. These structures permit the canal to be constructed as a series of relatively flat sections, each at a different elevation. Drop structures take the water abruptly from a higher section of the canal to a lower one. In a chute, the water does not drop freely but is carried through a steep, lined canal section. Chutes are used where there are big differences in the elevation of the canal.

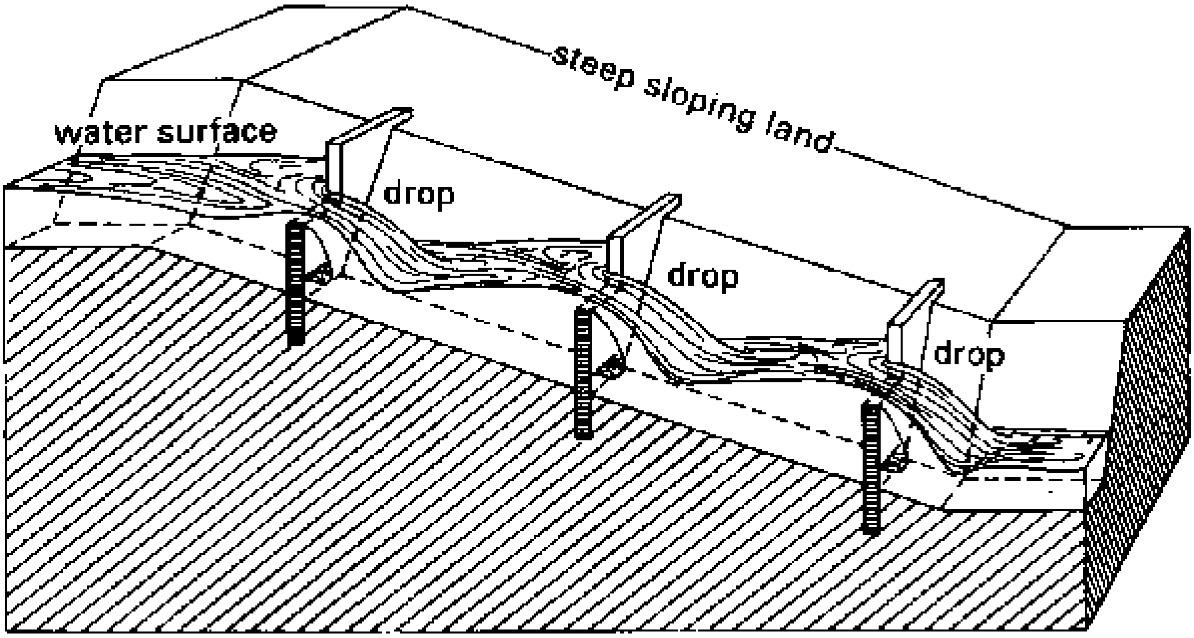


Figure 20: Longitudinal section of a series of drop structures

Debriefing session chaired by Special Adviser Budget, Planning and Development Partner Coordination Office.

6 Conclusions and Recommendations

6.1 Conclusion

Based on the findings from stakeholder engagement, water source options, the alignment of the proposed canal, geological analysis and topographic survey, the report concludes that canalizing water from the western plain of the Gongola River into Wawa-Zange Grazing Reserve may not be the most viable option. The most feasible option based on the above criteria is to canalize from the eastern plain of the Gongola River into the grazing reserve.

Potential sources of the water supply between the western and eastern plain of river Gongola were assessed based on water availability and volume. The volume of the water was determined by the evaluation of the net inflow from both catchment areas. The result obtained shows the water from the eastern plain to be the best source of water supply to the proposed canal construction. This is because the western plains of river Gongola depends on recharge from runoff during rainy season and as such have low water level and flow rate during the dry season. The mean flow rate in dry season is around 5.7 cubic meters per second (201 cu ft/s). The study shows that the eastern plain received water from neighboring tributaries such as Hawul and Gungeru streams. In addition, the presence of the Dadin Kowa and Kiri dam along its path increases the flow rate along this plain to about 21 cubic meters per second (741.6 cu ft/s).

Secondly, though the elevation of the canal into WZGR is on a higher plain, the alignment of the proposed canal supported by the pump house will help achieve a discharge rate that will be enough to supply the canal with the required amount of water. This solves the problem of topographical difference between the water source and the grazing reserve. The pump will also be used to eradicate the difficulty associated with the geologic landform of the proposed canal construction path. It is anticipated that the type of the canal design will be concrete lined canal with the following properties; pump house, canal velocity, freeboard, waste bank, width, depth and slope, distribution and control structures, crossing structures, water measurement structures, erosion control structures.

Lastly, all stakeholders engaged showed no signs of unrealistic expectations of the proposed canal project. All stakeholders engaged expressed optimism on the potential outcome of the canal. Locals seemed in tune with the realities of the current water challenges faced and were not just willing to avail their experiences with these challenges, but also willing to support in any way possible. Generally, all stakeholders expressed high expectations that the canal would reduce incidence of herders/farmers conflict, provide more economic opportunities through job creation and access to markets to sell produce as well as better access to social, health and agricultural extension services. Besides these, there were no indications of unrealistically high expectations about the canal.

Based on the above, the consulting team's robust environmental analysis suggests that the eastern plain of River Gongola is best suited for the canalization of water into WZGR. Based on these conclusions, the following key recommendations have been identified as articulated in the next section of this report.

6.2 Technical and Environment-Focused Recommendations

- To reduce the risk of flooding in Dukku, Funakaye, Nafada and Kwami LGAs, a control point should be built at the main canal which should be closed during rainy season.
- Support contractors to adopt and put in place monitoring mechanisms for compliance to the ADB Safeguards Policy Statement (2009).
- Conduct an IEE, develop an EMP, and engage competent contractors who can follow mitigation and monitoring guidelines in the EMP. Furthermore, the work plan and schedules for the canalization initiative should be approved by the relevant traditional and State councils and developed in consultation with residents considering the need for access during harvesting and planting periods.
- A project implementation team who will monitor the activities of competent contractors for compliance to the EMP, comprising of relevant stakeholders from the government, traditional authorities, residents, and MC should be inaugurated.
- To mitigate the effect of using the eastern plain of River Gongola where the delivery of water to WZGR is from lower elevation to higher elevation, a pump station to increase the water velocity and to counteract the effect of the slope and difference in depth should be installed
- To minimize noise from the pump station noise, the pump house should be designed in such a way that the noise levels are controlled such as through sound proofing the walls and locating the pump house to face a direction with minimal effect on residents. Also, operational guidelines which will include limitations on the maximum pump running hours per day during daytime should be put in place.
- To minimize the generation of GHG from pump station activities, solar-powered pumps should be used as this will reduce the use of small diesel-powered pumps, which account for more than 60% of the total GHG generation.
- Canal embankments should be retained as low as possible and surplus excavated materials, such as dredged spoil, should be removed and reused only in locations defined in the EMP.

6.3 Socioeconomic-Focused Recommendations

- To improve future access and broader participation and engagements at the community level, villages along the canal corridor should be organized, clustered, and coordinated through10 clusters.
- Due to the high soil fertility and nutrient content of land (luvisol and nitisol soil types) along the canal corridor, investible business cases that leverage land as a key natural resource should be developed. Some of these business cases could include planting of hybrid Napier grasses for rotational grazing, silage, and fodder business models, and developing the business case for milk collection centers.
- To safeguard against increases fertilizer and pesticide use due to increases in cropping, post-construction mitigation should focus on capacity building in the responsible use of fertilizers and pesticides by promoting Integrated Pest Management (IPM) practices and the application of fertilizers based on soil nutrition needs and environmental circumstances, rather than as routine operations.

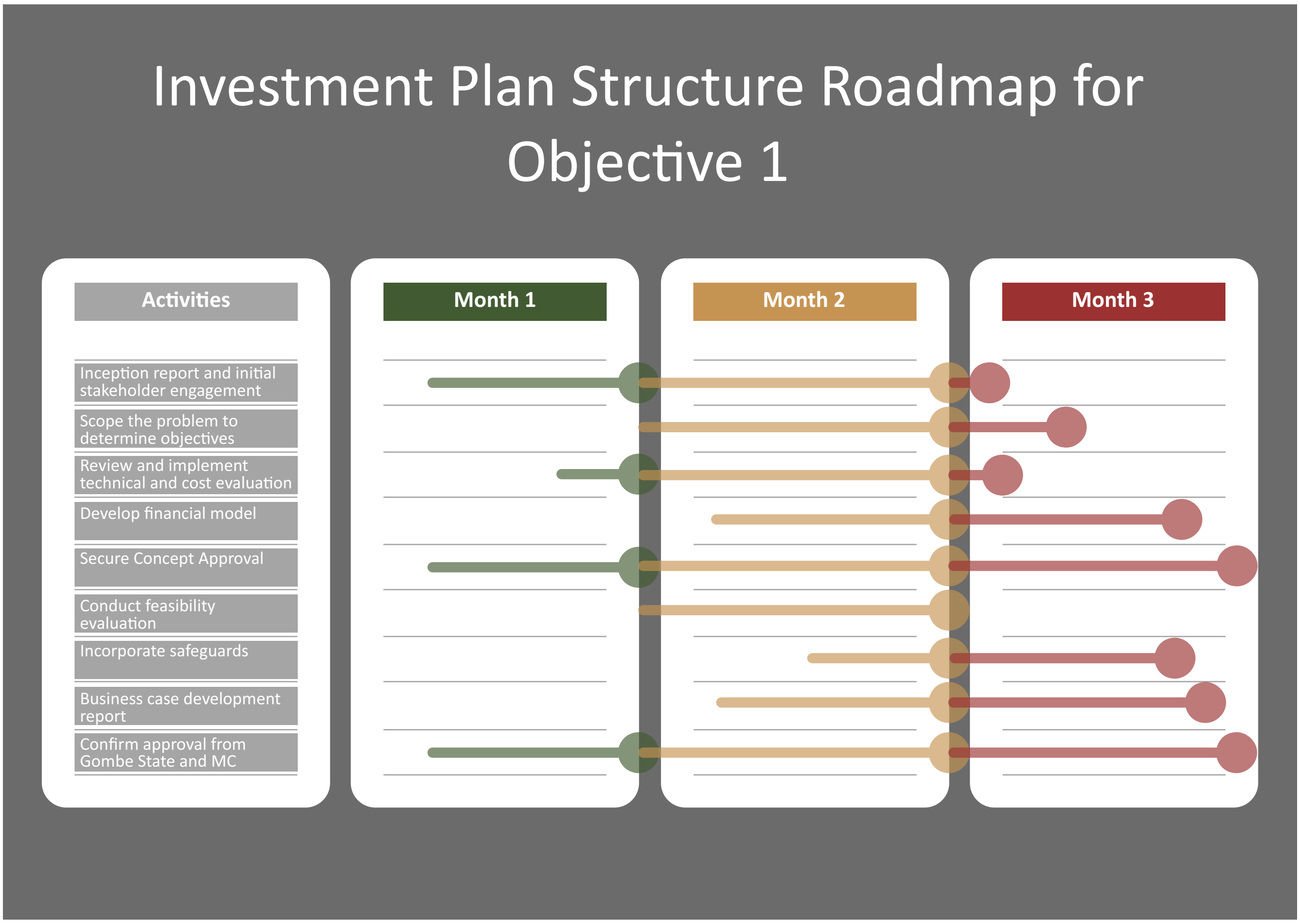
The Honourable Commissioner of Science and Technology flanked by reps of the Ministry, LTMP team, SIO and Consultants

Engagement with the Honourable Commissioner of Trade and Tourism at the Ministry

7

Appendices

1 - Investment Plan Structure Roadmap



2 - List of Stakeholders Engaged

Stakeholders	Date
Senior Special Assistant/Team Leader, Gombe State Livestock Transformation Management Project	4th October, 2022
Commissioner of Water Resources	5th October, 2022
Commissioner of Finance and Economic Development	5th October, 2022
Commissioner of Trade and Tourism	5th October, 2022
Commissioner of Science and Technology	5th October, 2022
Special Adviser Budget, Planning and Development Partner Coordination Office	6th October, 2022
Key Informants (Dukku, Nafada, Funakaye, Kwami)	6th October, 2022

3 - Economic and Financial Analysis

a. Background and Sector Overview.

Improved productivity of irrigated agriculture and water resources is vital to Nigeria's economic development, likewise Gombe's state. Agriculture (i) accounts for 28% of Nigeria's gross domestic product (GDP), (ii) employs more than 70% of the labor force.

Despite the contribution to the economy, Nigeria's agricultural sector faces many challenges which impact on its productivity. These include poor land tenure system, poor irrigation farming, climate change and land deterioration. These challenges have stifled agricultural productivity and the Government has implemented several initiatives and programs to address the situation.

Nigeria has 70.8 million hectares of agriculture land area with maize, cassava, guinea corn, yam beans, millet and rice being major crops. Animal production has remained underexploited. Livestock mostly reared by farm families in Nigeria are the small ruminants like goats, sheep, and cattle accounting for 76million, 43 million and 18 million respectively.

b. Project Overview

Item	Description
Main Canal System	35.95km
Canal type	Concrete lined canal
Total flow rate	741.6 cu ft/s
Gross Command Area	146,000 ha
Cultivable Command Area	116,800 ha
Canal Elevation	324-409 meters
Source	Gongola river

Table 1: Physical and environmental summary of project area

Table 1 above shows that the proposed canal covers a length to 35.95km from its start point into Wawa-Zange Grazing Reserve in Gombe State with a gross command area of 146,000 hectares (ha) and has an estimated cultivable command area (CCA) of 116,800 ha. The estimated cost of the canal infrastructure into WZGR is N1.5 billion. The type of canal is characterized as a Concrete Line Canal. The estimated cost of the canal includes irrigation canals, night store reservoir, drains, spillways, and distributary turnouts.

The elevation of the canal into WZGR poses some failure risks, and may make overall irrigation service delivery unreliable, particularly at the tail ends of canals. So far population growth and farm fragmentation has resulted in significantly increased cropping intensities. This is also driving demand for irrigation water, an opportunity which the proposed canal will help address especially for cropping intensity along the length of the canal path and more importantly cattle herders at the tail of the canal in WZGR. To meet their needs, the canal includes a distributary canal for increased reliability and water supply; as no effective groundwater management is in place, and much of Gombe has rapidly declining water tables. The WZGR water canal project will result in economic growth and improved sustainability of water and land resources.

The Gongola River diverts water to the WZGR canal and the distributary irrigation canal system to supply irrigation to more than 116,800 ha. In addition to the solar-powered pump station, the irrigation system requires minimal operating and maintenance and will enhance management capacity for water distribution. The present CCA area along the canal path is about 116,800 ha (making allowance for existing encroachment and infertile pasture areas); previously nonexistent, farmers and cattle herders can install tube wells to supplement canal water with the conjunctive use of rain-fed water.

This makes meeting the increasing irrigation demand possible to meet a cropping intensity of up to 280% along the canal path and increase in beef and dairy production by at least 46% and 160% respectively. The surface water table in Gombe State has been declining and sips into the aquifer and adding surface water to the mix with a well concrete lined canal is required in WZGR corridor to ensure sustainable availability of water.

The main canal and associated structures of WZGR canalization project has five components related to the WZGR canal: (i) Main canal; (ii) Service Road (iii) Sector turnouts, (iv) Pumping station, and (v) Storage reservoir. The WZGR canalization project also includes development of the irrigated agriculture project preparation facility, which will prepare subsequent projects under the objective 2 of the canalization project.

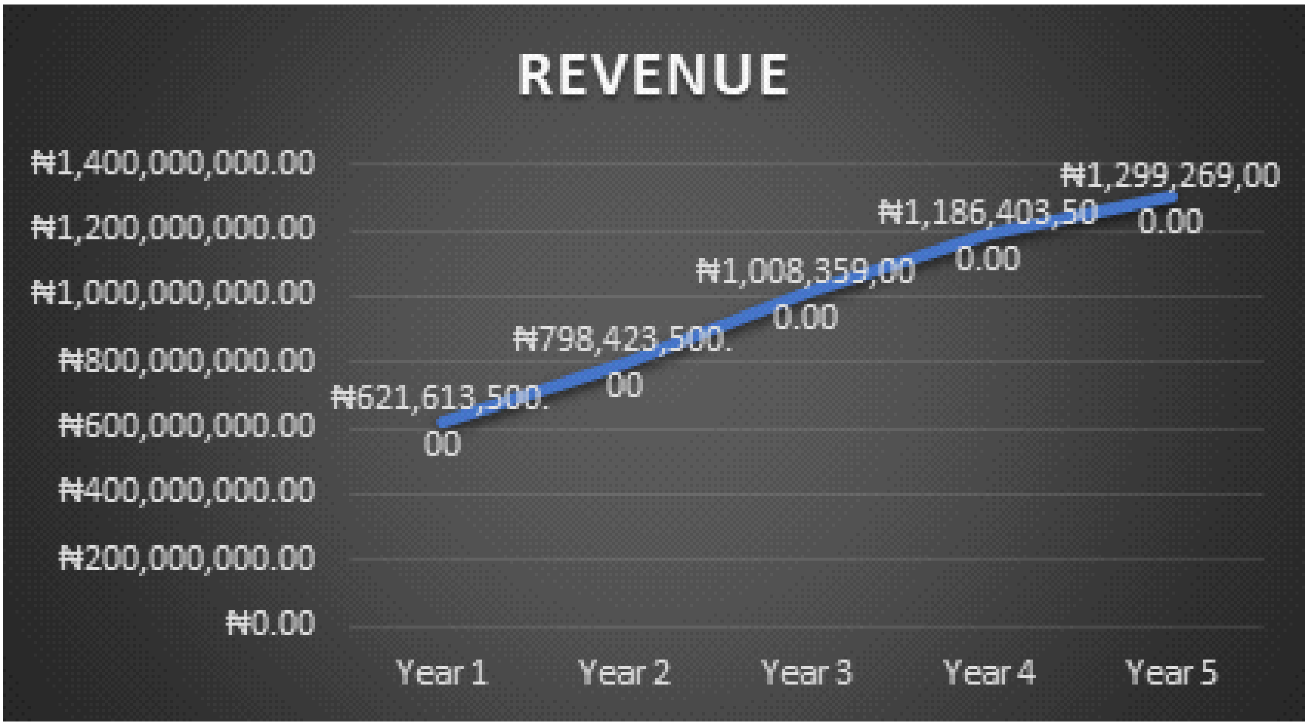
c. Economic and Financial Analyses Overview (Financial model spreadsheet)

Land area of the state covers a total land area of about 20,265sqkm, exceeding 40 degrees celsius" during the hottest months (March – May). It is mainly mountainous, undulating, and hilly to the South-East and flat open plains in the Central, North, North-East, West, and North-West. The state lies in the center of North-East Geopolitical Zone of Nigeria. It shares common boundaries with Adamawa and Taraba State to the South, Bauchi State to the West, Borno State to the East and Yobe State to the North.

Vegetation in Gombe is generally a guinea savannah grassland with concentration of wood lands in the Southeast and Southwest. Annual rainfall has average of 850mm. The people of Gombe State are primarily farmers producing food and cash crops, which include cereals (maize, sorghum, rice and wheats), legumes (cowpeas, groundnuts, soya beans and bambara nuts), fruits (orange, lemon, mango, guava, paw-paw and grapes), vegetables (tomatoes, pepper, onions, okra, pumpkin and melon), tree crops (gum Arabic, kenaf, sugar cane, sunflower and ginger).

WZGR water canal project is a N1.5 billion investment program proposed for financing through a proposed multi-tranche financing facility of development partners, government, and private sector. It will provide (i) construction, operation and maintenance of canal and irrigation infrastructure, (ii) potential institutional reform for water management, (iii) improved and sustainable irrigation service delivery, and (iv) capacity development and revamp the livestock sector in Gombe State. The investment amount is based on sector needs, funds devoted to the sector, the identified project, the absorptive capacity of Mercy Corps, Government of Gombe, Private Sector Partners and anticipated inflation during the program period.

The main canal base costs are approximately N1.3 billion for the five components directly related to the canalization and will be financed from a consortium comprising development partners, government, and private sector. The irrigated agriculture project has a base cost of N58.29 million. Together with contingencies and taxes, which is estimated at N143 million.

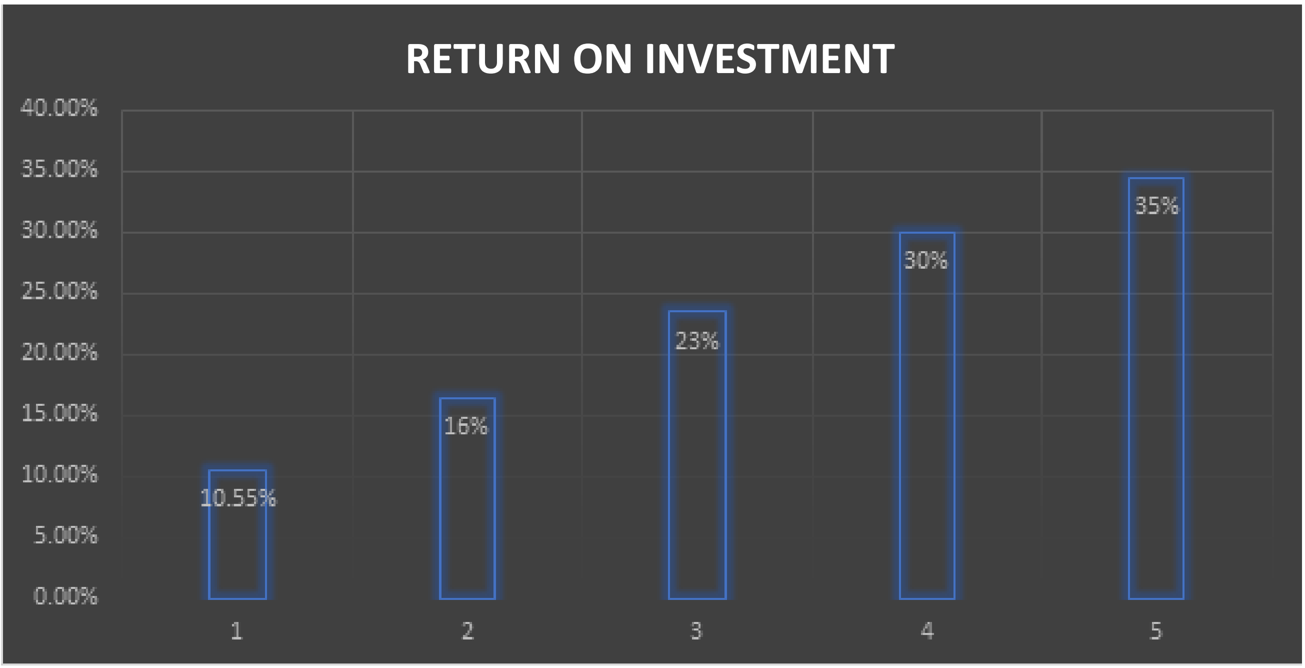


<u>Revenue:</u> The project is expected to generate yearly revenue of **₦621miilion** and this shall increase to **₦1.299 billion** in year 5.

<u>Gross Profit:</u> In its first year of operations, the project will start out with a gross profit of **₦242,243,880.00** and steadily progress to **₦597,272,451.87** in year 5. The gross profit is basically your Sales revenue less your cost of production or more simply, your selling price minus your cost price.

<u>The gross profit margin</u> i.e. the percentage of your revenue (sales value) that is profit, after cost of production is deducted, will have a median average of **76%** for the first five years of the project's operations. This means that for every one Naira generated as revenue **76%** of it (or 76 kobo of it) is profit (after deducting all direct production costs). The gross profit margin only shows your profitability before all overheads are taken into consideration.

<u>The net profit margin</u> for this project will start at 31% in Y1 and the grow to **37%**, **42%**, **46%**, **48%** in Y2, Y3, Y4 and Y5 respectively. Net profit margin shows how profitable you are after all know production costs and overhead costs have been deducted from your sales revenue.



Return on Investment (ROI): The ROI ratio shows you how much revenue you are generating from your investment. For this project, the ROI will start out at 10.55% in Y1, and will continue to progress positively to 16% in Y2, 23% in Y3, 30% in Y4 and 35% in Y5.

FINANCIAL RATIOS							
YEARS		1	2	3	4	5	Average
PROFITABILITY							
Gross Margin%	Gross profit / Net sales	76%	76%	77%	77%	77%	76%
Net Operating Margin%	Operating income / Net sales	31%	37%	42%	46%	48%	41%
Return on Capital Employed	Profit Before Interest and Tax / Total Capital Employed	15%	17%	19%	20%	19%	18%
Return on Equity	Profit after Tax / Shareholder's equity	11.5%	15%	18%	19%	19%	17%
Return on Assets	Net income / Total assets	9.48%	14%	19%	23%	26%	18%
Return on Investments	Net Income/Total Investments	10.55%	16%	23%	30%	35%	23%
TURNOVER RATIO							
Asset Turnover	Net sales / Average total assets	31%	39%	46%	51%	54%	44%
Capital Turnover	Net Sales (Cost of Goods Sold) / Capital Employed	37%	40%	43%	42%	40%	41%
YEARS							
Debt to Equity	Total liabilities / Shareholder's equity	29%	19%	11%	5%	1%	13%
Debt Ratio	Total liabilities / Total assets	24%	18%	11%	6%	1%	12%
Interest Coverage Ratio	Operating income / Interest expenses	4.77	8.54	16.87	41.19	-	14.27

Payback Period; The payback period is the length of time it takes to recoup your investment from the future net cashflow the investment will generate. For this investment, the payback period is approximately 5 years and 1 month. This is to say that, based on the assumption that cashflows will be accrued evenly throughout the months in the life of this project, it will take approximately 6 years and 7 months to recoup the investment.

INVESTMENT APPRAISAL - NET PRESENT VALUE											
YEAR	0	I	2	3	4	5	6	7	8	9	10
CASH FLOWS	1,557	129	177	298	422	513	513	513	513	513	513
DCF @ WACC	I	I	I	I	I	I	0	0	0	0	0
PRESENT VALUE	1,557	114	137	203	253	270	238	209	184	162	143
NET PRESENT VALUE	357										
INTENAL RATE OF RETURN	18%										

in millions of naira

Sources of Funds: It is expected that 30% of the funds required for the canalization will be sourced through debt financing from Gombe State bond. The yield of this bond is 16%. The balance 70% of funds will be equity contribution by the Gombe State government, sourced from taxation income and other internal revenue generating activities

4 - Demand Analysis

This section provides an analysis and information required to answer the broad question: How many animals can be grazed on the land without doing damage and at the same time underutilizing the grazing reserve? To determining the stocking rate to figure out how many animals can be on the land, it is crucial to first determine the forage supply.

a. Forage supply

Forage supply = forage pounds per acre land produces

The pounds of forage per acre land produced are highly dependent on soil type, precipitation, plant species and previous management. The feasibility study shows that luvisol is mostly found around the WZGR, precipitation and plant species also favor the quality of forage in the area. Given this, we estimate 400 pounds per acre. A good rule of thumb is to only use 35% of forage. The rest should be split between future health of the plant (50%) and wildlife use (15%).

b. Forage demand

Forage demand is expressed in Animal Unit Month (AUM).

- 1AUM = 1000-pound cow and calf (Assuming a fully grown cow and calf weigh 800 & 200 pounds respectively)
- Total CCA = 116,800 hectares or 288,618 acres pasture
- Total CCA * 400 pounds/acre = 115,447,200 pounds forage production

Assuming

- 35% forage
- 50% future health of plant
- 15% wildlife use
- 35% (115,447,200 forage production) = 40,389,440 pounds available forage production for grazing
- If a 1,000-pound cow can eat 800 pounds forage/month,
- Forage demand = 800 pounds forage per month
- Total Serviceable cows = 40,389,440

pounds forage production / 800 pounds forage per month which serves 50,498 cows/month

c. With- and Without-Project Scenario

The approach to the economic and financial analyses is based on projected outcomes with and without the project. The without-project scenario is characterized by the non-existence and continued degradation of any irrigation system in WZGR. This limits canal water distribution, especially at the tail end, and reduces limit groundwater recharge, as pumping of groundwater increases to make up for the lack of canal water. This will result in further decline of the water table with subsequent higher pumping costs, replacement of centrifugal tube well pumps with more powerful turbine pumps, and possible loss of access to groundwater by poorer farmers and cattle herders.

Mixing of canal water is critical to enhancing and revamping the livestock stock at the tail end of the canal in WZGR, this is also similar for cropping intensity on the path along the canal before WZGR. While overall productivity will decline and all farmers will suffer in the without-project scenario, tailenders, who are potentially cattle herders and already worse off, will suffer the most as livestock wellbeing and productivity continue to deteriorate. In the with-project scenario, these negative outcomes will be avoided. Not only will important productivity gains for the entire WZGR occur, but also significant positive equity implications for the tail ends will result.

Under the without-project scenario, the existing limited water infrastructure around the grazing reserve and its associated works will continue to deteriorate and continued use without rehabilitation or upgrade will increase the probability of damage or failure during a severe flood or may even trigger flood itself. Potential beneficiaries are more likely to continue to face dire water shortage. This may result in excessive pumping and further depletion of groundwater to try and meet irrigation needs. Furthermore, moderate to severe floods currently caused by breaching of the right bank levy will cause more flood damage to crop and other livestock in adjacent areas and inundates important roadways.

CCA Assumptions. The economic and financial analyses of the WZGR canalization project were carried out based on changes in gross margins from the incremental agriculture productivity. To account for the heterogeneity of WZGR corridor 116,800 ha CCA, it was divided into three broad categories based on 35% of forage, 50% for future health of the plant and 15% for wildlife use.

Prices. Gombe state has intensive and progressive farming compared to many states in Nigeria this is evidenced in the high yields recorded in 2022 with crops sold in numerous markets throughout the area. Most inputs like seed, fertilizers, and pesticides are provided through a well-developed network of private dealers located in local markets. Farm-gate prices in the analysis were established after market assessments. Financial prices were converted to economic prices through standard methods. The shadow exchange rate was estimated by weighting the effective export and import exchange rates by the proportion of total trade. The standard conversion factor for traded goods, the reciprocal of the shadow exchange rate, is estimated at 90%.

Import and export border parity prices for the main agricultural commodities and factors of production were calculated to establish the price relationship between the local market value of traded commodities produced on the farm and their internationally traded values. Financial prices were adjusted to economic values by eliminating transfer payments (subsidies and taxes) and adjusting the costs of traded inputs involved in the production chain (e.g., storage, haulage, and processing). Specific economic conversion factors were calculated for internationally traded agricultural commodities including both farm produce and inputs used (e.g., chemical fertilizers).

d. Project Benefits and Assumptions

Nearly all the project benefits (87%) accrue from increased agricultural productivity within the WZGR CCA including (i) increased cropping/livestock intensity, (ii) increased yields, and (iii) crop and livestock diversification. Benefits are anticipated to increase to their full potential over 10 years with forage area and yield figures being interpolated in a linear fashion between years 1 and 5. Benefits start to be realized in year 5 of the Project.

The canalization is assumed to enable the canal to safely pass its maximum flow allocation of 201 cumecs when completed; an increase from the current maximum of about 0 cumecs. Distribution of water supply will be improved through canal. The Project is assumed to have a 30-year life, although rehabilitation and upgrade of some infrastructure should yield benefits far longer than this.

5 - Economic Viability of the Proposed Canal

According to the World Bank (2011), most research studies carried out on performance of irrigation schemes have monitored the performance over time. To evaluate the impact of the proposed canal in the host community the focus was on the analysis of inputs and outputs of irrigation projects which include water, land, labor, value of production, cost of operation, and maintenance.

The concept of this viability study is to test if the proposed canalization will generate sufficient income to satisfy the household income expectations of the irrigators and to cover basic operational and maintenance costs of the irrigation infrastructure while not minding the natural resources (soil and water). Further considerations include the ability of the scheme to maintain cash flows and consistency of income generation over time and management of risks and shocks associated with small-scale farming.

Construction of the proposed canal will significantly contribute toward improving the rural economy and livelihoods of the host communities. The framework developed for these studies is based on studies of the efficient utilization and management of proposed canal.

Theoretical Framework

The study was based on production theory. In this theory, farmers were considered to want to maximize their revenues by trying to attain the highest profits from the proposed canal construction. This framework is represented as follow:

$$Max\,\pi = P_a q_a - P_x x - wl \qquad (1)$$

- **π is the profit**
- **qa is the quantity of product (vegetable that the farmer gets from the farm)**
- **pa is product price in this case the price of vegetables**
- **px is the price of variable factors**
- **wl is the amount of labor multiplied by the wage rate**

The inputs px are a vector of a number of inputs like seeds, maintenance costs, costs of transporting crops, and binding costs in a contract.

The cost of labor (l) will be obtained by multiplying the wage rate (w) by the quantity of labor. The farmers' revenue is income derived from the sale of crops at the given market price.

The maximization equation is set up as follows:

$$Max\,\pi = (P_a q_a - P_x x - wl)$$

Subject to: $g(q_a, x, l; z^q) = 0$,

Supply function:

$$q_a = q_a\,(P_a, P_x, W, Z^q) \qquad (2)$$

Factor demands:

$$X = X\;(P_a, P_x, w, Z^q) \qquad (3)$$

$$l = l\;(P_a, P_x, w, Z^q) \qquad (4)$$

z^q (fixed capital, farm size) = fixed factors and farm characteristics Thus the farmers will be maximizing profits from sale of the farm products subject to the constraints being faced which may be management, institutional, and financial constraints. This can be represented as

$$Max.profit\;\pi = (P_a, x, y, z) \qquad (5)$$

- pa – price of crops and its products
- x – institutional constraints which include information availability, customer search costs, length of supply chain, cost of contracts, groups, opportunity cost of time, and standards of measurement
- y – financial constraints which include debt, debt asset ratio, asset base, and financial records
- z – managerial constraints which include farm size, farmer characteristics, production system, and crop type

The profit equation is maximized through as follows:

$$\pi = \beta_i X_i + \beta_j X_j + \beta_k X_k + \pounds \qquad (6)$$

- π – profitability
- xi – institutional constraints for the farmer
- xj – financial constraints for the farmer
- xk – managerial constraints for the farmer

During the research design and sampling, a cross-sectional survey research design was performed. The design was useful in describing the economic viability of the proposed canal construction to be used by farmers along the proposed canal production path for crop production.

a. Crop Irrigation by Households

All (100.0%) of the households interviewed within Funakaye, Kwami, Dukku and Nafada local government show interest of wanting to or already practicing irrigation farming. Water is a scarce resource in the proposed canal construction path during dry season, and most household couldn't practice irrigation farming. Majority of the households (100%) indicated interest to irrigate their crop in the months of November to January with only (33%) able to irrigate their crops in Nafada, Funakaye and Nafada especially those located along the bank of river Gongola from the eastern plain.

About 33.5% irrigated between the months of August and October before the water scarcity begins in Dukku local Government. A few (14%) irrigated their fields between the months of February and April (14.0%) and May and July (3.7%). The construction of the proposed canal will enhance the practice of irrigation farming in the period between August and January which is mainly associated with the fact that it coincides with the dry season, while the period between February and July is mainly a wet season.

Respondents were requested to indicate the main challenges faced in the practice of irrigation and the majority of the respondents cited the high cost of irrigation equipment (15.7%) as the main challenge in irrigation. Other respondents indicated unavailability of water (45.0%), unavailability of irrigation equipment (21.4%), difficulty in using irrigation equipment (10.7%), and high maintenance cost (7.2%) as the major challenges in their implementation of irrigation farming. Majority of the respondents (100%) suggested that the construction of the proposed canal is the best solution for the challenges facing the adoption of irrigation farming in the study area.

b. Present and Future Crop Production and Patterns Along the Canal

Currently in Funakaye, Nafada and Kwami Local government specifically in areas that are close to the eastern plain of river Gongola, the cropping pattern has a cropping intensity of 200% per year with two rice crops a year grown in the dry season and wet seasons supported by unreliable surface irrigation and rainfall. In Dukku local government and some parts of Funakaye, Nafada and Kwami local government which are far from the eastern river Gongola plain, irrigation is not possible, agriculture is restricted to one crop grown during the dry season without irrigation, and the land remains fallow for the rainy seasons, overall only a 100% cropping intensity. With the construction of the proposed canal, the future cropping pattern is projected to increase to 280% with a change from rice production to include other valuables soya beans, maize, groundnut, wheat, and vegetables production during the rainy and dry season.

c. **Benefit-Cost Ratio (BCR) Analysis**

The objective in this study sought to determine the economic viability of the construction of the proposed wawa-zange canal. The benefit-cost ratio (BCR) analysis was used for judging the economic soundness of the projects. From an economic point of view, an irrigation project with BCR greater than 1.5 is generally accepted.

BCR is obtained by dividing the annual total benefits by the annual total cost. The net annual benefit is computed as a difference between the value of produce and total running costs incurred in production. Running cost included expenditure on seeds, manure/fertilizers, pesticides, hired labor/equipment, and government taxes/ levies, among others. The interest on capital cost of the project at the prevailing rate is included in the denominator. BC ratio is thus a division of the total discounted benefits by the total discounted costs. In calculating the simple benefit-cost ratio, the following formula was used:

$$\Sigma\ (B_i / (1+d_i) / \Sigma\ (C_i / (1+d)_1 \qquad (7)$$

- **B_i = the benefits of the project in year i, i = 0 to n**
- **C_i = the costs of the project in year I**
- **n = the total number of years for the project duration**
- **d = the discount rate**

The economic viability of the proposed canal construction was analyzed. Hereafter, the decision-making criteria was used to determine the economic viability/desirability of the canal in the study area. The benefit-cost analysis in this study made use of market prices. This is because there is no evidence of distortions of market prices of factors and products. Furthermore, while it is possible to calculate values for intangible impacts, such will be discussed in qualitative terms. Although sophisticated equipment is not used in manual irrigation system, such an arrangement was not considered as costless. This study determined the running cost, duration to maturity, and yield and market information in the production of rice, maize, wheat, cowpea, groundnut, soya beans, and vegetables in the proposed canal construction area (table 2).

These costs included expenditure on seeds, manure, fertilizers, pesticides, hired labor, and others. To verify the feasibility of the construction of the proposed canal, the benefit cost ratio was calculated. The interest on capital cost of the canal construction was calculated at the prevailing rate. BCR is thus a division of the total discounted benefits by the total discounted costs. The main reason for discounting is because a dollar available some years in the future is not as good as a dollar available now. This is because a dollar available now can be invested and earn interest and would be worth more than a dollar in future. With an interest rate of r, a dollar invested for t years will increase to (1 + r)t . Therefore the amount of money that would have to be deposited now so that it would grow to be one dollar t years in the future is (1 + r)t . This is called the discounted value or present value of a dollar available t years in the future.

The benefits and costs are in constant value dollars, and therefore the discount rate used must be the real interest rate. In this study, the present value of the streams of benefits and costs is discounted at a 11% back to time zero since the interest rate on long-term treasury is 18% and the rate of inflation is 17%. In calculating the simple benefit-cost ratio, the following table (Table 2) was to compare BCR of the four irrigation systems in the production of rice, maize, wheat, cowpea, groundnut, soya beans, and vegetables. The BCR of 2.165, 2.690, 1.982, 1.356, 2.491, 1.838 and 1.813 when producing rice, maize, wheat, cowpea, groundnut, soya beans, and vegetables respectively when farmers use the proposed canal if constructed confirms the economic viability in the construction of the proposed canal.

A lower than 1 BCR implies that the costs incurred during production are greater than the benefits. These is because the BCR with the use of the proposed canal for production of the crops are all greater than unity (1) implying that they lead to greater benefits as compared to costs.

Parameters	Crops	Maize	Rice	Wheat	Soya beans	Vegetable	Groundnut
Running costs (naira)	Seeds	40,000	70000	65000	50000	50000	60000
	Manure	50,000	50,000	50,000	50,000	50,000	50,000
	Fertilizer	157,000	157,000	157,000	60,000	157,000	50000
	Pesticide	65,000	87000	115000	40,000	45000	36,000
	Labor	240,000	360,000	210,000	32,000	40,000	35,000
	Transport	30,000	50,000	50,000	50,000	50,000	50,000
	Other cost	50,000	120,000	130,000	80,000	150,000	70,000
Duration to maturity and yield	Vegetative cycle (month)	2-4	3-4	3-4	3-5	2-3	4-5
	Yield (t/ha)	10	3	10	2.5	18	2.7
Marketing / commercialization	Producers (naira/kg)	80	400	200	150	150	300
	Market (naira/ kg)	300	1000	650	500	300	900
Return	Gross (naira/ha)	3000000	3000000	6500000	1250000	5400000	2430000
	Net (naira/ha)	2,368,000	2,106,000	5,723,000	8,080,000	4,858,000	2,079,000

Table 2: Running cost, duration to maturity, yield and market information for selected crops

The impact rate can be calculated based on the crop under consideration e.g. for maize
Total land on canal part = 200 x 35.950 = 7190 ha

So total wealth generated for maize farming on the canal part
= 7190 x 2,368,000 = 17, 025, 920 000 naira
Since the average monthly salary in Nigeria is 42500 naira

Average salary in 4 month is 170000 naira

So total impact on the canal part = 17, 025, 920 000/ 170000 = 100, 152.47
This means 100, 152 lives will benefit from the canal construction along the path

d. Agricultural Productivity Benefits and Assumptions

To assess livestock and crop production and projections, secondary data sources such as the National Bureau of Statistics and Nigerian Geological Survey were used. Based on the analysis, intensity is projected to continually increase from about the current 2% to 46% with the project for cattle. Without the Project, cropping intensity is assumed to decrease gradually by 1%, although this may be much greater if groundwater tables continue to fall. Crop yields like maize are anticipated to increase by 34,000 tonnes per annum along the canal path. Agriculture currently with the greatest deficiencies in water requirements, which may be up to 30% for livestock and 40% for wheat and maize around the WZGR corridor, will experience the greatest gains. Accordingly, wheat is anticipated to increase by 14,000 tonnes and livestock production by 460%.

Based on social and land tenure data gathered during the feasibility study, the canalization project will have an important impact on rural incomes and rural poverty. Over 27,000 farm families live in the four local governments around the WZGR area with an average family size of 4.5, though these numbers are of lower bounds, the Project will impact at least 121,000 people.

Land ownership is skewed, with about 12% of farm families holding nearly 45% of the farm area in the medium- to large-farm category (farm size is above 5 ha). Their average landholding is 9.6 ha. However, the vast majority are smaller farms below 5 ha, which is about 55% of the population in Gombe, 88% of all farms are owned by about 23,000 farm families (103,000 people). The average landholding within this group is 1.5 ha. Based on this, a representative small-farm model was created to simulate the project impact on a 1.5 ha average farm.

Based on this model, the gross margin of the average small farm will see an annual increase in income from about N42,500 to between N210,600 to N808,000 or an annual increase of income of 1,900% at full development depending on the crop. Within the four LGAs around WZGR, about 30% of the command area is occupied by farms that are less than 2 ha. The average landholding for this group of farmers is 1 ha; many of these farmers are operating at a subsistence level. Project sustainability was simulated on all categories of cattle herder, small cattle herder (1 – 20 cattle) and large-scale cattle herders (200 and above) in the tail-end of the canal inside WZGR. Under the Project, these cattle herders will see an annual increase in gross margins increase 4 times at full development. Project benefits will thus have the greatest impact on farmers who are currently the worst off in the WZGR area. These estimates are of low bounds.

In addition to the quantified benefits in the analysis, the canalization has other benefits that are not quantified, but will help ensure a robust economic and financial sustainability. The institutional changes will enhance irrigation service delivery, especially improving water distribution with important equity and productivity gains; however, project benefits are not directly contingent upon the institutional reforms. Emphasis on the management water will ensure that this resource is conserved and used in a sustainable manner, which will reduce pumping activity and costs to farmers and ensure widespread grazing and cropping intensity is maintained.

e. Risk Analysis.

Most benefits come from incremental agricultural production. The canal is more sensitive to a decrease in benefits than to an increase in costs; thus, loss or delay of benefits poses the largest risk. The project's comprehensive and integrated approach of the Project helps to mitigate this risk. The Project addresses water management at all levels including the canal system, on-farm water management, and ensure that supplemental irrigation water and improved conveyance efficiency result in water reaching cattle in the grazing reserve. In addition to improved water supply and management, the Project includes support for agricultural support services that will help farmers make the best use of the improved irrigation water to achieve productive benefits.

6 - Potential Development Partners for Water Projects

Over 23 global and pan-African institutions are already working together on water projects in Africa and these partners have officially joined the water investment program and are working together in trying to find ways on how to narrow the water investment gap.

Pictures

Engagement meeting with the LTMP Team

The Honourable Commissioner of Finance flanked by members of the LTMP team, SIO and Consultants.

The Honourable Commissioner of Water Resources flanked by reps of the Ministry, LTMP team, SIO and Consultants

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