Client: IGAD

INTERGOVERNMENTAL AUTHORITY ON DEVELOPMENT

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Feasibility Study for Groundwater Development and Management in the Merti Aquifer

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Merti Trans-Boundary Aquifer: Marsabit, Isiolo, Garissa and Wajir Counties in Kenya and Jubbada Hoose (Juba South) Region in Somalia

Feasibility Study Report

Volume I

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EXECUTIVE SUMMARY

Introduction

The objective of this project is to undertake a feasibility study on the Merti Aquifer between Kenya and Somalia on the aquifer characteristics and status. The results of the study will complement the existing knowledge, set up guidelines for groundwater exploration, management and protection and provide detailed plans to develop water-related infrastructure for socio-economic development. This project's outcomes have been divided into 5 reports for the three project phases:

Phase	Phase Task	Outcome/Reports
1	Desk Study and Inception Phase	• Inception Report • Desk Study Report
2	Fieldwork and Mapping Phase	• Interim Report
3	Feasibility studies for Groundwater Development and Improved Drought Resilience	• Feasibility Report • Report on General Guidelines

This report is the main output of the feasibility phase and includes the proposed technologies, engineering designs, cost estimates and risks and mitigation measures.

Approach and methodology

The methodology used in the Feasibility Study Phase included;

(i) The second stakeholders' workshop was held in Djibouti on the 5th and 6th March 2022. It was attended by key stakeholders; IGAD, The World Bank, and government representatives from Kenya and Somalia. The objectives discussed were the progress of the Interim Report, results and findings of the field study and challenges encountered during the study.

(ii) The preparation of a detailed implementation plan of the selected feasibility studies for approval by IGAD. It consists of detailed engineering designs, technical specifications, the implementation plan, the O&M plan, a Bill of Quantities and detailed cost estimates. The 5 most feasible sites for water buffering and supply are selected for each country for the preparation and execution of detailed implementation works.

(iii) Execution of the Feasibility Studies will be done per the approved plan for implementation. It elaborates on the designs for both water supply and buffering.

(iv) Groundwater Management and Monitoring Plan will be developed to ensure the sustainability of the developed infrastructure and the aquifer during and after development. The proposed plan takes into consideration of the regional context and capabilities to ensure sustainable development and management of groundwater resources and abstractions.

Proposed Technologies

Ten projects of different technologies have been proposed for development across the Merti Aquifer. Five project sites have been proposed in each country for both drinking water supply and water buffering. The technologies include boreholes, earth dams, sub-surface dams, water pans and shallow wells.. The water buffering technologies will also supply drinking water for livestock since boreholes are prioritized for human drinking water supply sources. These projects are both transboundary and in-country. The site locations and justifications for the projects are specified in Chapter 3.

Transboundary Technologies

Development projects for both drinking water supply and water buffering have been proposed across the Merti Aquifer. A total of five projects have been prioritized for implementation in each country (Kenya and Somalia), comprising both transboundary and in-country projects. Other suitable sites are set as the second priority. The proposed transboundary project locations are located in cross border towns, Dhobley and Liboi in Somalia and Kenya respectively.

Transboundary Projects - Pilot Phase

Sites	Main Infrastructure	Auxiliary Infrastructure
Dhobley 1 SO 3.3, 3.5	Three Boreholes i.e., 1 -monitoring, 2- production	Fences, solar pumps, rising main pipeline, storage distribution tank, water treatment system, reticulation systems, water kiosks, monitoring devices; telemetric and master meter, water troughs, piezometer
Dhobley 2	Earth Dams	Fences, inlet structures, offtake structure/infiltration gallery, draw off shallow well, solar pumping system, storage tank, water treatment system, pipe network, water troughs and communal water point.
Dhobley 3 SO 3.2, 3.3	Water Pans (Haffir Dam)	Fences, inlet structures, offtake structure/infiltration gallery, draw off shallow well, solar pumping system, storage tank, water treatment system, pipe network, water troughs and communal water point.
Liboi 1 KE 9	Three Boreholes i.e. 1 -monitoring, 2- production	Fences, solar pumps, rising main pipeline, storage distribution tank, water treatment system, reticulation systems, water kiosks, monitoring devices; telemetric and master meter.
Liboi 2 KE 8.1 KE 8.2	Two Earth Dams	Fences, inlet structures, offtake structure/infiltration gallery, draw off shallow well, solar pumping system, storage tank, water treatment system, pipe network, water troughs and communal water point.

In-Country Projects - Scaling Up Phase

Other in-country projects have been proposed for implementation away from the border of the two countries.

In-Country Projects – Scaling-Up Phase

Sites	Main Infrastructure	Auxiliary Infrastructure
Hoosingow 1 SO 4	Water Pan (Haffir Dam	Fences, inlet structures, offtake structure/infiltration gallery, draw off shallow well, solar pumping system, storage tank, water treatment system, pipe network, water troughs and communal water point.
Hoosingow 2	Boreholes 1- Monitoring 2- 2 production boreholes (Already existing boreholes to be rehabilitated)	Fences, solar pumps, rising main pipeline, storage distribution tank, water treatment system, reticulation systems, water kiosks, monitoring devices; telemetric and master meter.
KE 1.3 (Modogashe)	Four Cascading sub-surface dams	Sub surface dam weir, draw off pipe with filters, draw off well/sump, solar pumping system, storage tanks, pipe network, water kiosk, cattle trough, communal water point
KE 2 (Gurufa)	Three Boreholes i.e., 2- production boreholes 1- monitoring	Fences, solar pumps, rising main pipeline, storage distribution tank, water treatment system, reticulation systems, water kiosks, monitoring devices; telemetric and master meter.
KE 7 (Shantabaq)	Two boreholes i.e., 1- monitoring 1- production	Fences, solar pumps, rising main pipeline, storage distribution tank, water treatment system, reticulation systems, water kiosks, monitoring devices; telemetric and master meter.

Engineering Design

The designs of the proposed drinking water supply and water buffering structures were done based on geology, aquifer parameterization, hydrology, geophysical results, topography and water demand of the respective selected sites. The designed structures include; sub-surface dams, boreholes, earth dams and water pans. The design for storage and pipeline systems and engineering drawings for these structures are given in Sub-chapter 4.3.

Sub-Surface Dams

The four cascading sub-surface dams were designed across Togwein Lagha together with the storage and pipeline system to supply water to Modogashe town. The targeted population of 2309 people has

an estimated demand of 69.27 m^3/day. The excavation should be done to a depth of 4 m bgl where the stable layer is expected, based on the geophysical results. With the specific yield of the sandy material at 26%, the total estimated storage volume of the dams is approximately 212,963 m^3.

Boreholes

Most of the existing boreholes in the Merti aquifer operate for long hours, some upto 24 hours e.g., in Liboi. Others have penetrated the transition zone between the fresh and brackish/saline layers. To ease pressure on the aquifer, it is recommended that more boreholes be sunk at shallower depths and pump at lower yields but for longer hours to meet water demand of the beneficiaries.

i. Pilot Boreholes

Two exploratory boreholes of a recommended depth of 220m bgl are recommended; one in Dhobley and another in Liboi. The recommended spacing is 1.5km from the production boreholes such that the centre one will be used for monitoring. The exploratory boreholes will provide necessary details for the drilling of the production boreholes such as the required depth, diameter and other design parameters.

ii. Monitoring and Production Boreholes

In Hoosingow, rehabilitation of the existing production borehole is recommended. Monitoring boreholes are proposed for Dhobley, Hoosingow, Liboi, Gurufa and Shantabaq. Production boreholes are recommended at Dhobley, Liboi, Gurufa and Shantabaq. The projected depths of the boreholes in Dhobley and Liboi will be dependent of the results acquired from exploratory boreholes, while those of Gurufa and Shantabaq are 200m and 250 m bgl respectively. The storage and reticulation system for the Shantabaq borehole were designed to supply water to target populations of about 377 people and livestock in Shantabaq. From the available existing borehole data, the expected yield is about 83m^3/day for Gurufa and 240m^3/day for Shantabaq.

The proposed infrastructure in Dhobley has a target population of 22,000 with an estimated water demand of 660 m^3/day, while those for Liboi target a population of 1,203 people with a demand of 36.09 m^3/day. According to available data, the expected discharge for each borehole in Dhobley and Liboi is 120m^3/day.

Note: The boreholes proposed in Gurufa are meant to supplement the proposed sub-surface dams for water supply to Modogashe since the town currently has no reliable source of water. However, some water will be supplied to the residents of Gurufa to supplement the demand for livestock consumption. The Project has two Borehole water sources drilled 34 km away at Gurufa well fields. The proposed Borehole Water Source will augment sand dams cascaded along river 1 km away from Modogashe Town.

Earth Dams

Two Earth Dams with the dimensions 120 m x 70 m x 5m are recommended for both Dhobley and Liboi. The excavation depth is 5m bgl where the aquiclude is expected based on the geophysics results. The dam floor should be designed to have partial compaction to create room for both vertical and lateral infiltration for underground recharge. The estimated volume for each dam is 29,400 m^3.

Water Pan

It is recommended to rehabilitate two existing water pans in Dhobley and one pan in Hoosingow. Construction of a water pan of dimensions 150 m x 100m x 3.5 m is recommended at Goreale-Shantabaq (Site KE 6.2). The excavation depth is 3.5m bgl where the impervious layer is expected. The pan should be partially compacted to create room for vertical and lateral infiltration for groundwater recharge. The volume of the pan is estimated to be 31,500 m^3.

Implementation Plan

The main stakeholders and implementing institutions shall be identified while taking the following preparatory steps before project implementation. They include;

- High-level stakeholder meetings with the World Bank to clearly understand the project and its objectives in boosting economic development and promoting peace between Kenya and Somalia.
- Establishment of a joint management and monitoring committee that will work to ensure proper management and advise on best practices for groundwater development within the region.
- The signing of Memoranda of Understanding between the two countries and cross-state/county for projects development and aquifer and infrastructural management.

The implementation of the project will be done in phases;

Phase 1: Pilot Phase.

This is the first phase of the implementation plan and will act as a benchmark for the development of other infrastructure. It will focus on the development of the infrastructure in the cross-border towns, Dhobley in Somalia and Liboi in Kenya. This phase will be an entry point for the main stakeholders and implementers of the next phase of the project.

Phase 2: Scaling Up Phase.

This phase will involve the development of proposed in-country structures. This will be done by the Ministry of Energy and Water in Somalia, other relevant agencies from Somalia, the Ministry of Water, Sanitation and Irrigation in Kenya and any other relevant water resources development agencies on the Kenyan side.

The monitoring and evaluation period will follow the implementation of the project. Indicators of the project progress aligning with the main objectives of the study have been identified and set to be examined either annually, bi-annually or quarterly.

The design of the project aims to assure sustainability through;

Public-Private Partnerships: These are recommended for water supply and management efficiency in terms of access and coverage, billing efficiency, collection efficiency, operational cost expenditure and revenue water.

Institutional Sustainability: The project will support the main institutions that will be working to manage the project by enhancing their legal and institutional framework, to ensure they carry out their mandates efficiently in social, economic, technical environmental and M&E sectors.

Economic and Financial Sustainability: The project will boost this by creating job opportunities for some locals who will be kiosks operators and other technical personnel. This results in the improvement of the livelihoods of the community members. Improved livelihoods will lead to more water demand thus increasing finances for the operation and maintenance of the infrastructure.

Environmental and Social Sustainability: This will be done through adherence to the World Bank and the two Countries' Social and environmental policies. Environmental and Social Assessments will be carried out before the project implementation.

Operation and Maintenance Plans

Operation and maintenance are critical in improving the performance, efficiency, and sustainability of water supply infrastructure. Water infrastructure must be professionally supervised, designed, developed, constructed, installed, and maintained to ensure its longevity. A participatory monitoring approach should include the local community, who are the main and direct beneficiaries, thereby strengthening the local community's sustainable management of the water resource in the area and giving them a sense of ownership of the project. Within the study area, there is a less formalized local organization in charge of water resource management, with limited skills required for the operation and maintenance of various water infrastructure technologies. It is therefore critical to improve the aspect of practical management tools for water committees and conduct recurring and periodic training to refresh their skills with existing and new technologies. The formation of partnerships between communities, external institutions and agencies will aid in the improvement and support of the communities' management and O&M capacities.

Women's participation in the design, construction, operation, and maintenance of water infrastructure needs to be considered. They have been less involved in decision-making processes

despite being the primary domestic water users, owing to the communities' way of life. Their underrepresentation in water committees may hamper effective implementation in management structures and facility designs, which has been the case in many parts of the region. Their participation in management, operations, and maintenance capacities should be encouraged, and their capacities improved through training, to boost self-esteem and social standing in the community. Existing gender policies should be strengthened to promote gender equality and women's empowerment in various sectors, including the water sector.

Different tariff structures such as flat rate per household, flat rate per unit volume, charge per unit of livestock and block tariffs exist for water supply projects in the study area. The pricing should be set in a fair, rational and manageable manner through direct discussions with water users to support the project's O&M costs. However, schools and vulnerable groups such as people with disabilities may be exempt from water payment. Tariffs may be revised due to inflation, the changing cost structure, demand patterns and the need for increased funds for further expansion of the water infrastructure. To optimize and reduce O&M costs, it is recommended to make use of renewable energy sources such as solar energy; increase spare parts availability at an affordable price; leverage economies of scale of large systems to reduce consumer costs; involve water users in preventive maintenance activities; installation of systematic leak control; establishing a solid maintenance culture within the community and professional staff; and, adopting well-functioning financial management mechanisms.

Groundwater Management and Monitoring Plan

Proper management practices for the Merti Aquifer and the entire catchment as a whole within the Integrated Water Resource Management (IWRM) framework are vital for its sustainability to ensure resilience and socio-economic growth of the region covered by the Merti in the riparian states. The localised deterioration of groundwater quality and quantity experienced at abstraction points is due to overexploitation in settlement areas i.e., uncontrolled drilling showcases, improper management strategies and improper planning for the Merti and its catchment. Strategies for management of water resources management are proposed for the Merti area to achieve:

- Improved monitoring networks- hydro-meteorological, surface water and groundwater.
- Ensure water balance by implementing artificial groundwater recharge (MAR) and catchment protection programmes.
- Characterise the use of the Merti according to water parameters incorporating conjunctive use of surface water.
- Stakeholder engagement in promoting integrated, sustainable land management which enhances sustainable socio-economic development.
- Implementation of joint water resources planning for the basin area for the Riparian states.

Management of the Merti is dependent on the cooperation of the riparian states in the successful drawing-up and implementation of policies, strategies and their relation to institutional aspects. Joint management of the Merti and its catchment could be achieved in two ways:

- Establishment of joint bodies/committees of experts with representatives from the Riparian States from different sectors who will jointly plan for equitable utilisation of the Merti.
- Cooperation in management and development is organized without established joint bodies. Water managers should meet on regular basis to agree on set objectives for planning and developing the shared resource by the individual countries. Shared objectives for protection and ensuring sustainability should be set with agreed implementation plans to be carried out by the individual states. Kenya and Somalia should hence agree on where to undertake the meetings and facilitate data sharing without involving joint set institutions. Since the implementation of activities for the shared resource is to be implemented under national water strategies, it is difficult to track specific numbers.

For the joint committees, the following institutions are proposed:

I. ***Merti Aquifer Management Committee (MAMCo)-*** this committee will plan for the management and development of the Merti and its entire basin, deciding on the planning vision, objectives and key issues, identifying options and considering alternative scenarios. These plans should conform to those of national and regional governments in Kenya and Somalia. Key experts in the committee will constitute Hydrogeologists, Engineers and Socio-economists from both countries. It may also include legal and international relations experts.

II. ***Merti Catchment Technical Secretariat-*** The main duty of the secretariat will be to coordinate MAMCo. The secretariat will constitute technical representatives from various ministerial institutions from the riparian states including surface and groundwater management institutions; hydrometeorological management institutions; environmental institutions; and planning and development institutions.

Joint data sharing and management form an essential part of ensuring informed management for the entire basin area. IGAD should therefore formulate data-sharing protocols for both countries and establish a centralised database for groundwater data for the entire Merti catchment area.

A common line of action should be agreed upon and signed by the Riparian States to form a foundation for negotiation in the protection and management of the Merti TBA to ensure its sustainability. A legal instrument, treaty or MoU, should recognise the importance of the Merti in alleviating poverty, acknowledge the rights and duties of the riparian states sharing the aquifer, appreciate achievements of the improvement of the scientific knowledge of the Merti, highlight the importance of cooperative management of the Merti in improving the management of the shared resource. Financial arrangements in the management of the Merti and its catchment as a whole should be part of the agreement.

Implementation Budget

For the implementation of the project, various items further grouped into components and sub-components have been considered and then given the various market values in both Kenya and Somalia. Before commencing the project works, tendering should be done to determine the most convenient contractors for the different project items, components, sub-components and the best prices in the bidding process. The cost of the pre-mandate activities and management is given in Appendix 1. The project is intended to have an initial phase where the priority projects have a total cost. These costs of both transboundary and in-country projects are presented in Appendix 2. This is to be followed by the scaling-up phase where alternative projects within the individual countries will be developed. The costs are presented in Appendix 3. The pre-mandate activities and project management costs are estimated at 5,269,200. The total cost for the initial phase of the transboundary projects is estimated at USD 2,296,981 while the in-country priority site costs are estimated at USD 5214905. The alternative phase is estimated at USD5.527,299. The cumulative cost for all project phases is approximated at USD 18,308,385.

Risks and Opportunities

The pilot TBA technologies may pose a few risks that may interfere with the expected output quality of the initiative. The risks are categorised into technical, health and community risks that account for versatile possibilities. However, the TBA technologies also offer vast opportunities for both Kenya and Somalia, more so economically and peace building. The sustainability of this initiative critically depends on the cooperation of local communities, traditional leaders and stakeholders from both countries to individually take responsibility at their respective levels. As soon as observations of the risks are made, the proposed mitigations should amend the situation with advisory from authorised technical specialists and support from involved stakeholders.

The major opportunities that both countries will fundamentally gain include meeting the water demand in the area, water security, peace, stability, economic growth and improved infrastructure.

The initiative is a gateway for constructive investments in health, education and economic growth for both Kenya and Somalia.

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LIST OF ABBREVIATIONS

AfDB - African Development Bank
AGM - Annual Genera
Amsl - Above Mean Sea Level
ASAL - Arid Semi-Arid Lands
Bgl - Below Ground Level
BoQ - Bill of Quantities
BPT - Break Pressure Tanks
CAAC - Catchment Area Advisory Committee
CHIRPS - Climate Hazard Group InfraRed Precipitation with Stations
EC - Electrical Conductivity
EIA - Environmental Impact Assessment
ENNCA - Ewaso Ngiro North Catchment Area
EQMS - Enterprise Quality Management Systems
ESIA - Environmental and Social Impact Assessment
FAO- Food and Agriculture Organization
FEWS NET - Famine Early Warning Systems Network
GALWA - Galkayo Water Agency
GCA - Ground Conservation Areas
GIS - Geographical Information System
GoK - Government of Kenya
GSM - Global System for Mobile
GTZ - Deutsche Gesellschaft für Technische Zusammenarbeit
GWI - Ground Water Initiative
HH - Household
HoA - Horn of Africa
IGAD - Intergovernmental Authority for Development
IWRM - Integrated Water Resources Management
KWSCRP -Kenya Water Security and Climate Resilience Project
MAMCo - Merti Aquifer Management Committee
NEMA - National Environmental Management Authority
SCMPs - Sub Catchment Management Plans
SWALIM- Somalia Water and Land Information Management
WRA - Water Resource Authority

1 INTRODUCTION

1.1 Background Information

The HoA-GWI is an initiative that focuses on the Intergovernmental Authority on Development (IGAD) region. The initiative's aftermath will support World Bank policies for large investments in the HoA region to propel economic development, agriculture, and human welfare while enhancing resilience to drought. Implementation of the program is by IGAD through the Water Unit at the IGAD Secretariat in Djibouti. The initiative is organized around four main components. The components are:

Component 1: Expand the knowledge base on groundwater resources.

Component 2: Strengthen capacities in groundwater development and management

Component 3: Maximize the benefits of groundwater through feasibility studies in selected aquifers.

Component 4: Project management, monitoring and evaluation

1.2 Study Area

1.2.1 Location

Merti aquifer is located east of Kenya and extends into Somalia, to the South West in the Jubbada Hoose region and covers approximately 73,713 km^2. The area of interest extends from Sericho, Modogashe, Habaswein, Meri, Fafi, Dadaab, and Liboi to Goobweyn and Afmadoow in Somalia (approximately along the length of Ewaso Ngiro/ Lagh Dera).

1.2.2 Physiography

The study area is generally a plain covered by mostly ephemeral drainage channels and scarce vegetation. The region gently slopes towards the East, towards the Indian Ocean. The western fringe of the area is established by the slopes of Mt. Kenya and Mt. Marsabit, which rise to elevations of over 1500 meters above mean sea level (m amsl) and the altitude descends to 400m amsl at 39^0 E, at gradients of up to 10m/km. Parallel to the Kenyan-Somalia border, the ground is gently sloping, at a gradual descent of 0.8m per km, and lesser values are observed throughout the area. (Lester, 1985).

There are four main distinguished morphological units in Lower Juba Region.

1. Flat terrains with a slightly undulated central plateau between the Juba River and the Xumbaweyne catchment (west)
2. Hill lands along the right Juba riverbank
3. Domed basement hill and (in the east)
4. Alluvium plain in lower Juba

1.2.3 Drainage

The drainage pattern depends on the flow of rivers in the region, which drain to South East. The three main rivers flowing in the region are perennial, i.e., Ewaso Ngiro in Kenya, Juba and Shebelle in the Far East on the Somalia side. The majority of the drainage channels comprise ephemeral such as Lagh Dera (forming the axis of the Merti aquifer), Lagh Boghal, Lagh Bor, Lagh Kotulo and Lagh Diima.

1.2.4 Climate

The region is predominantly of arid and semi-arid climate, especially the Eastern and South-Eastern parts. The parts receive rainfall of less than 300mm annually and experience high temperatures for most of the months. Moreover, the evaporation rates exceed the rainfall received. However, the catchment area to the West of the Merti aquifer zone experiences a humid tropical climate.

The following are key historical climate trends in Somalia (since 1960);

a) A warming trend has been observed in the study area.

b) All average temperatures in the past decades have been higher than normal, and the period between 1991 and 2016 was one of the warmest periods on record.

c) An increase of between 0.5°C and 1.5°C has been observed in the absolute maximum monthly temperatures in the past three decades. The average increase in minimum temperature is 1.5°C and the increase is most significant in April and May.

d) Rainfall is increasingly erratic, with marked seasonal deficits when compared to long term past averages. The changing dynamics are associated with decreases in crop and livestock production and increasing food deficits.

e) A significant increase in rainfall has been registered for April – May and October – November and the period between 1991 and 2016 was recorded with high rainfall rates.

f) Heavy rainfall events appear to be increasingly frequent, with changes in rainfall patterns, including decreased reliability and less predictability

g) The number of extreme events is likely to increase and droughts appear to be increasingly frequent

1.2.5 Land Use/Land Cover

The study area is scantily covered by vegetation, whereby the majority of plant life is grasslands and bushes on the plains, while tall trees grow alongside riverine vegetation and on the slopes of the catchment area.

Since the area experiences harsh climatic conditions, most of the inhabitants practise pastoralism. In the catchment area, the land is used for farming since the climate is more favourable to crop cultivation and the availability of water for irrigation.

1.2.6 Human Migration and Population

The communities living within this region take part in seasonal trans-human migration in search of water and pasture for their livestock. The migration follows two categories of routes which depend on the livestock i.e., dry grazing routes and the stock routes. The dry grazing routes are followed in search of water and pasture while the stock routes are followed during the trading season. The largest markets for livestock and livestock products are in major towns and cities of both Kenya and Somalia; such as Kismayo, Mogadishu, Garissa, Marsabit, Isiolo and Nairobi. Due to the climate and pastoralism culture of the residents, the population in rural areas is largely controlled by weather conditions which force the movement of people and their livestock for greener pastures. However, the area also has refugee camps such as Dadaab which are more densely populated than rural areas.

Somalia

Merti aquifer extends to Somalia in the lower Juba (Jubbada Hoose) region. The population in the region is estimated to be about 103,400 people and the area of the region is approximately 61,000km^2.

Kenya

Local Community

The total population of local communities within the general area of study is 818,390 people.

Table 1: Population Projection

2019	2026	2030	2035	2040	2045
818,390	1,006,620	1,132,447	1,313,639	1,523,821	1,767,633

Source: [1]KNBS (2019)

The field report shows that the total human population within priority areas in this study is 102,797 people; 54,765 males and 48,032 females distributed amid 17,194 households. Regarding age, 90.37% of the population is below the age of 50 years. The people in the age gap 18-49 who are in their productive age belong to 40.41% of the population, whilst the elderly substitute to 9.63% of the total population.

Refugee population

The area hosts refugees from neighbouring countries distributed into five sub-camps within Dadaab Refugee Camp. The camp hosted about 218,873 refugees as of August 2020(UNHCR Camp Population Statistics, July 2020).

[1] [1]KNBS (2019)

1.2.7 Infrastructure

The transport infrastructure in the region is underdeveloped. In Somalia, the roads are mostly loose surfaces which are effective during the dry weather season. The main road within the study is the Dhobley-Tabda-Afmadoow road. In Kenya, the main tarmac road within the study area is Garissa-Modogashe Road, while other roads such as Modogashe- Wajir and Wajir-Mandera are dry weather roads in the process of tarmacking. Most roads connecting the region are dry weather roads.

Most of the towns are already connected to the national grid electric power, while others use solar-generated power through individual connections.

1.3 Key Findings and Recommendations from Phase II of the Study

1.3.1 Hydrogeology and Groundwater Potential of the Aquifer

The Merti basin is a sub-catchment of the Juba-Shebelle catchment, which has few perennial rivers and numerous laghas that all flow towards the South East of the basin. Merti Aquifer is a confined aquifer within semi-consolidated sedimentary formations. It is about 64m thick and encountered at depths of 110m to 180m bgl depending on the area as shown from different boreholes' data. Aquifer's extent is unspecified due to inadequate borehole data, especially in Somalia. The aquifer's central axis produces the best water quality and quantity which follows the approximate drainage channel of Ewaso Ngiro/ Lagh Dera, the aquifer's main recharge. Merti aquifer extends from Habaswein to Dadaab to Liboi and crosses over to Somalia. Through groundwater modelling, the aquifer's drawdown has been quantified as a result of significant groundwater abstraction.

1.3.2 Socio-Economics

The Merti aquifer is in an arid zone and available water resources are over-exploited and undermanaged. The communities within this region are mainly pastoralists that require water to maintain their livelihoods. The socioeconomic benefits the project will provide outstandingly justify the cost of this project. Some of the benefits include peaceful coexistence along the Kenyan-Somali border, improved sanitation and hygiene, provision of clean water and improved education opportunities for children (particularly girls) in the region. The project will enhance living standards for the people, especially economically as a result of improved pastoralism, and irrigation amongst others.

1.3.3 Water Security Status and Potential for Improvement

Providing water security within the study area will greatly contribute to economic development for the residents. The proposed area is an ASAL region whereby at its core, water security is a challenge and therefore a political issue. Water security within this region is defined by groundwater from the Merti aquifer, but with proper infrastructure and management is highly sustainable.

1.3.3.1 Water Usage

The priority use for water is domestic purposes, where part of the population travels for up to 5km to purchase it. Livestock follows closely, as pastoralism is the popular source of income among inhabitants. Agricultural and industrial activities also take place within the region, hence consuming a small percentage.

1.3.3.2 Water Accessibility and Demand

The issues surrounding water accessibility in the Merti region seem to control the general livelihoods of community members. During the rainy season, surface water collects in the river beds and water pans for a while before the drought. Rain water serves communities for domestic purposes and livestock for about three months before it finally dries up or infiltrates the ground. The water access infrastructure are water pans, earth dams, shallow wells and boreholes which are developed to utilise surface water and groundwater from Merti. The local community and their livestock use shallow wells and boreholes developed in sites located on publicly accessed lands by either the local government or NGOs.

The water demand is relatively high as most of the people or livestock travel for long distances to access water, especially during drought. **Error! Reference source not found.** contains

socioeconomic data analysing the water demand in some towns located within Merti TBA. The table refers to the data population of the study area from the 2019 National Population data which disaggregates the rural and urban up to sub-location levels was used.

Data from the household (HH) survey was filtered to determine the proportion of the population that could not access 20 litres per capita/day of safe water (from boreholes). Considering that there are ancillary uses for the water, the study classified the water demand threshold at 30 litres per capita/day. From the table, the total water demand for the human population that demands 30 litres and below per capita/day is 42,584.55m^3 in Kenya. Moreover, the water demand from livestock in Kenya is 201,015.46m^3.

1.4 Layout of the Reports

This project comprises four phases:-

(i) Desk study and inception phase,
(ii) Fieldwork and mapping phase,
(iii) Feasibility studies for groundwater development and improved drought resilience Phase and
(iv) Final reporting.

This Feasibility Study Report is the 4th deliverable for this study. It contains two volumes: Volume I is a synthesized report of the priority and alternative proposed projects while Volume II is an annex report comprising engineering designs and drawings.

2 APPROACH AND METHODOLOGY

This chapter briefly describes the approach and methodology used in this phase. Detailed approach and methodology have been provided in the Interim Report.

2.1 Feasibility Studies for Groundwater Development and Improved Drought Resilience

2.1.1 2nd Stakeholder Workshop

A second stakeholder consultation workshop was held in Djibouti (5th to 6th March 2022) attended by representatives of IGAD, the World Bank Group, EQMS Limited and the Lead Consultant, Earth Water Ltd. Representatives of the Somali and Kenyan Federal Governments from the ministries of water including WRA were also present. The progress of the Interim Report and the results and findings from fieldwork and mapping including challenges encountered during the study were discussed. This meeting was organised mainly to share findings of the Interim Report and decide on the location, number, type, size and work plan for feasibility studies for economic development, drinking water supply and improved water security interventions.

2.1.2 Preparation of Detailed Implementation Plans of the Selected Feasibility Studies

Implementation plans have been prepared for approval by IGAD. They include detailed engineering designs with drawings, technical specifications, Bill of Quantities (BoQ) and detailed cost estimates. The plans also include implementation and O&M measures including an organizational and financial set-up to secure O&M for at least 5 years. From the second stakeholder workshop, sites for groundwater development plans for drinking water supply and economic development and water buffering to improve drought resilience were identified. From these, the 5 most potential feasibility studies have been selected in each country for the preparation and execution of detailed implementation plans.

2.1.3 Implementation of the Feasibility Studies

The selected feasibility studies shall be done following the approved implementation plan. This task will elaborate on the designs for groundwater development and buffering implementation plans. This activity will include on-site visits by various specialists such as water supply engineers and surveyors. Institutions involved in the management of natural resources; including water will be identified and analysed using modified SWOT.

2.1.4 Groundwater Management and Monitoring Plan

Management and monitoring plans (technical, institutional, and legal) shall be developed to assure sustainable development of the groundwater resources during the development and exploitation phase. This shall include: Designing a monitoring network (locations, frequency, type of measurements); Development of guidelines for implementation of the monitoring plan; Development of guidelines for the preservation of data in a dedicated database for monthly and annual comparisons to establish the behaviour of the aquifer over a certain period; Guidelines for monitoring reports during development and exploitation phase; Development of management strategies for sustainable use of groundwater resources, based on monitoring; and, institutional and legal issues. The proposed groundwater management and monitoring plan shall consider the regional context and capabilities to assure sustainable development of groundwater resources development and abstraction.

2.2 Final Report

2.2.1 Final Feasibility Study Reports

Submission of final reports including the management and monitoring plan shall be done upon comments and critique by the client and other stakeholders. We will compile and recapitulate all data and outcomes from the previous phases and reports, combined with the write-ups of the detailed plans of the 10 selected feasibility studies to come up with the Feasibility Report.

2.2.2 Report on General Guidelines

Based on the findings of the study we have prepared a report with general guidelines for groundwater assessment, exploration, management and monitoring in a practical, accessible and

adequate way while considering the regional context and capabilities for sustainable groundwater resources development and management.

3 PROPOSED TECHNOLOGIES

3.1 Introduction

Various technologies have been proposed across the Merti aquifer for drinking water supply and water buffering. These technologies include; boreholes, shallow wells, infiltration/ injection wells, infiltration trenches/ditches, water pans/infiltration pools and dams. Out of all the possible proposals, five projects in each country have been selected as a priority. The priority projects comprise developments that will be executed as transboundary and in-country projects. The remaining projects are listed as alternative projects and are given 2nd priority. It is worth noting that the infrastructure recommended for water buffering will also be used to supply drinking water. The transboundary projects will make up the pilot phase while the in-country will make up the scaling-up phase. These sites have been discussed in depth in the interim report.

Boreholes

Most of the existing boreholes in the Merti aquifer operate for long hours, some upto 24 hours e.g., in Liboi. In this scenario, others have penetrated the transition zone between the fresh and brackish/saline layers and are being pumped at high yields. For instance, in Dhobley and Hoosingow boreholes have average depths and yields of 220 m bgl and 17 m^3/hr, this has deteriorated the groundwater quality where EC values are elevated above 3,000 µS/cm. Over pumping at high yields for long hour results to the upconing of the saline layer and sea water intrusion which is a long-term effect in the aquifer. More boreholes should be sunk at shallower depths which will pump at lower yields but for longer hours to meet the demand. This abstraction regime will ease pressure on the aquifer. This will put the fresh water piezometric head and the saline levels at equilibrium, hence preventing mixing. Optimization of the well designs should be maximized. This approach is a long-term plan for all proposed boreholes to prevent further systematic salinization of Merti aquifer..

3.2 Priority Projects

The map below shows locations for priority transboundary and in-country projects.

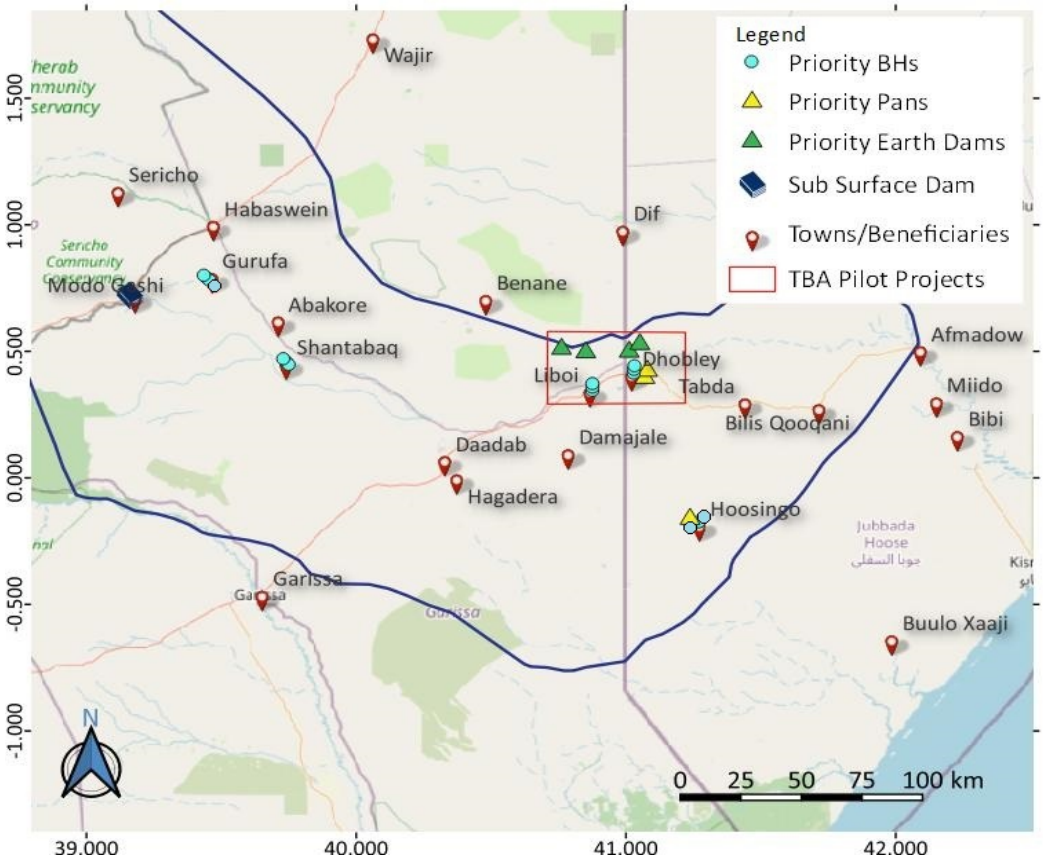

Figure 1:Priority Transboundary and In-Country Projects

3.2.1 Transboundary Project-Pilot Phase

This phase is categorized as one project.

Table 2: TBA Pilot Projects

Sites	Main Infrastructure	Coordinates			Descriptions	Auxiliary Infrastructure
		Specifics	Lat	Long		
Dhobley 1 SO 3.3, 3.5	Borehole	P BH 1	0.404691°	41.025079°	• 3-boreholes; 2-production and 1-monitoring • Recommended depth for Exploratory bh -220m bgl • Borehole spacing is 1.5km • Depth of production and monitoring boreholes to be determined from results obtained during exploratory drilling • The targeted population is about 22,000 people with an estimated water demand of 660m^3/day.	• Fences, water troughs, water kiosks, storage tanks, pipeline systems, solar pumps monitoring devices; telemetric and reticulation systems i.e., master meter, piezometer, storage tanks, pipelines, solar pumps, etc.
		M. BH	0.409766°	41.02506°		
		P BH 2	0.413913°	41.027617°		
Dhobley 2	Earth Dam		0.498089^0 0.528022^0	41.011334^0 41.050898^0	• Two earth dams are recommended to serve both pastoralists and the nearby communities. • The earth dams are recommended across the tributaries to Lagh Dera.	• Fences, inlet structures, water troughs and water kiosks.
Dhobley 3 SO 3.2, 3.3	Water Pans (Haffir Dam)		0.409766	41.025061	• Two water pans are recommended to serve	• Fences, inlet structures, water

			0.413913	41.025061	both pastoralists and the nearby communities.	troughs and water kiosks.
Liboi 1 KE 9	Boreholes	P BH 1	0.345224^0	40.874434^0	• 3 boreholes; 2 for production and 1 monitoring. • Exploratory borehole Recommended depth-220m bgl • Depth of production and monitoring boreholes to be determined from results obtained during exploratory drilling • Borehole spacing is 1.5km • The target population for this area is 1203 people with an estimated demand of 36m^3/day • The settlement is at a distance of about 782m north of KE 9. (Water should be piped to the settlement area).	• Fences, water troughs, water kiosks, monitoring devices such as telemetric gadgets and reticulation systems i.e., master meter, piezometer, storage tanks, pipelines, solar pumps, etc.
		M.BH	0.358777^0	40.874910^0		
		P BH 2	0.372349^0	40.874910^0		
Liboi 2 **KE 8.1** **KE 8.2**	Earth Dam		0.509104^0 0.495587^0	40.760393^0 40.85029^0	• Two earth dams are recommended to serve the livestock • Water demand for livestock is estimated to be 117m^3/day • KE 8.1: Water will be supplied through a pipeline for a distance of about 4.12 kilometres. • KE 8.2: Water will be piped for a distance of about 5.73 kilometres. (Water should be piped to the settlement area). • The sites for the earth dams have been located on one of the tributaries of Lagh Dera.	• Inlet structures, outlet structures, infiltration galleries and shallow wells, intake structures, water kiosks, cattle troughs, fences, • Inlet structures, fences, water kiosks and water troughs

Key

M Bh – Monitoring Borehole

P Bh – Production Borehole

NB:

The exploratory boreholes will then be used for either production or monitoring, therefore the only three boreholes will be drilled per site in Dhobley and Liboi.

3.2.1.1 Project Justifications

Due to the transboundary nature of this aquifer, both countries need to find a common approach to the utilization and management of the resource. Hence transboundary development proposals are made for the pilot phase. Liboi and Dhobley were the most suitable locations to propose transboundary projects since they are the major border towns between the two countries and, therefore, have the highest potential for economic growth. One of the aims of this project is to develop infrastructure for socio-economic development and Liboi and Dhobley areas have the highest potential, regionally (i.e., between Kenya and Somalia along the Merti aquifer).

Drinking-Water Supply

The existing boreholes in Liboi are designed to produce at high yields for extensive periods per day with pumping regimes of up to 24hrs in some instances. This increases the likelihood of up coning and subsequent salinization. To reduce this risk, it is prudent to develop more boreholes and also consider borehole spacing to meet the demand. Consequently, the pumping regimes will involve lower yields for longer pumping hours which will in turn reduce the rate of upconing.

Water Buffering

Liboi area has a shallow saline interface. Water buffering is therefore critical for this area since it will lower up coning and subsequent salinization by supplementing water supply which in turn reduces the amount of water abstracted and also replenishes water in the entire aquifer with time.

The proposed water buffering technologies will also provide water for livestock since the sites are located near stock and dry grazing routes.

3.2.2 In-Country Projects- Scaling Up Phase

This is the other category of the project and will be implemented based on the success of the pilot phase

Table 3: In-Country Projects

Sites	Main Infrastructure	Lat	Long	Descriptions	Auxiliary Infrastructure
Hoosingow 1 SO 4	Water Pan (Haffir Dam)	0.165132˚ S	41.260576˚E	Water Pan Rehabilitation Rehabilitation of the existing pan should be executed using the following dimensions; length- top 180 m, bottom 168m; width- top 100 m, bottom 88m; depth- 3.5m The site is near an existing borehole and a pan which was dry during fieldwork The existing pan measures 150m*170m and it is publicly owned.	Addition of infiltration gallery off-take, fence, water treatment facility, water troughs and reticulation system i.e., solar pump, elevated storage tank etc.
Hoosingow 2	2 Boreholes- Rehabilitation of 2 production boreholes	0.169723 ˚ S	41.268246 ˚E	Borehole Rehabilitation Assessing the condition of the boreholes to establish the remedy, whether rehabilitation or replacement Approximately 4,500 people are targeted in the area therefore the demand is 135m^3/day	Fencing, constructing water tanks, animal troughs, solar panels and water distribution points
		0.171075 ˚ S	41.270458 ˚E		
	1 Monitoring Borehole	0.170413˚S	41.269581˚E	Drilling of a Monitoring Borehole Drilling of one borehole for monitoring Recommended depth: 100m bgl	
Modogashe KE 1.3	4 cascading sub-surface dams	0.718893°N	39.16087°E	Sub-Surface Dam Dimensions The sub-surface dams should be cascaded from the first one at 0m to 557m followed by a second one from557m upstream at a distance of 1518, this should be followed by a third one at a distance of 2060m upstream from the previous another dam is to be set at a further 550m from the third one. The fourth one is to be set 330m upstream from the third one. Lagga width 50m Approximately 2309 people are targeted in the area therefore the demand is 69m^3/day The water demand for livestock is approximately is 371m^3/day Infiltration Gallery Drilling to 10m	Infiltration gallery, water kiosk, reticulation system i.e., pipelines, elevated storage tanks, solar pump etc.

				Galleries 1,3 and 4 to be set on the Isiolo side of the lagga while gallery 2 should be set on the Lagh Dera(Garissa County) side Solar power source for each infiltration gallery Proposed tanks are the existing storage tanks in both communities' settlement areas. Community to decide whether the system joins the existing supply system Separate collection tanks are recommended for both communities (One on each side)	
Gurufa KE 2	3 boreholes; 2 P BH 1 M BH Spacing- 1.5km	Production Borehole 1		Recommended depth: 200m bgl Yield: Sufficient ~10m^3 /BH Water Quality: Good Gurufa's Elevation (m amsl): 189 Modogashe's Elevation (m amsl): 260 Elevation difference: +71m Distance between Gurufa and Modogashe (km): 33 (Water should be piped to the settlement area) Water supply from Gurufa should be split upon reaching Modogashe to serve the two communities in different storage tanks Since the water is intended for residents of Modogashe, the target population is 2309 whose water demand is 69m^3/day	Fences, water kiosks, monitoring devices such as telemetric master meter, diver piezometer and reticulation systems i.e. storage tanks, pipelines, solar pumps, etc.
		0.797292°N	39.419779°E		
		Monitoring Borehole			
		0.794396°N	39.433794°E		
		Production Borehole 2			
		0.798381°N	39.447603°E		
Shantabaq KE 7	Boreholes 2 boreholes: 1 P BH 1 M BH	Production Borehole		Recommended borehole depth: 250m The site is between town centre /settlements According to the socioeconomic analysis of the study, the target population of Shantabaq is 377 with an estimated water demand of 11m^3/day. This demand fluctuates since the location is near a dry grazing route.	
		0.473917°N	39.726257°E		
		Monitoring Borehole			
		0.467290°N	39.733323		

Key

M BH – Monitoring Borehole

P BH – Production Borehole

3.2.2.1 Project Justifications

Water Buffering

Water buffering sites were selected around the upstream areas to the location of the central Merti since natural recharge was already possible along with the downstream areas which are generally flood plains. Modogashe and Shantabaq areas are proposed for water buffering. These areas have good geology of sands which allow seepage. Modogashe also has poor groundwater potential therefore water buffering enhances both the quality and quantity of water in the shallow aquifer. Technologies recommended for water buffering will also serve as water supply sources for livestock.

Drinking-Water Supply

Proposed projects for drinking water supply for Modogashe town and Shantabaq have been prioritized due to the scarcity of water in the two areas, especially Modogashe town. Drinking water for Modogashe will be piped from boreholes in Gurufa. This is due to the low groundwater potential and lack of permanent rivers in Modogashe. Shantabaq on the other hand is suitably located within the central Merti therefore construction of a borehole would be suitable.

3.3 Alternative Projects

Further studies are required to determine the feasibility of the projects listed below:

Table 4: Alternative Projects

Sites	Main Infrastructure	Descriptions
Tabda 1 SO 5	Earth Dam	Dimensions: 120m x 70m x5m
Tabda 2 SO 6	Borehole	Borehole Depth: 220m
Bills Qooqani 1 SO 7	Borehole	Borehole Depth: 220m
Bilis Qooqani 2 SO 8	Earth Dam	Dimensions: 120m x 70m x5m
Arbajahan KE 3	Borehole	Recommended borehole depth: 320m bgl
	Infiltration/ Injection Wells	This technology is very expensive and limited in its purpose compared to other water buffering options. Further studies are required to determine whether the water level at this point has been reducing with time
Gurufa 2 KE 2	Water pans	Approximate dimensions: 150m length by 100m width by 3.5m deep
Habaswein KE 4.1, 4.2 & 4.3		
Abakore KE 6.1		
Goreale KE 6.2		
Ademasajida KE 5.1	Groundwater Development	There may be potential for groundwater development, but additional investigations are required.
Habaswein KE 5.2		
Abakore KE 6.3		
Eldera KE 1.1	Sub-surface dams	
Barkuke KE 1.2		

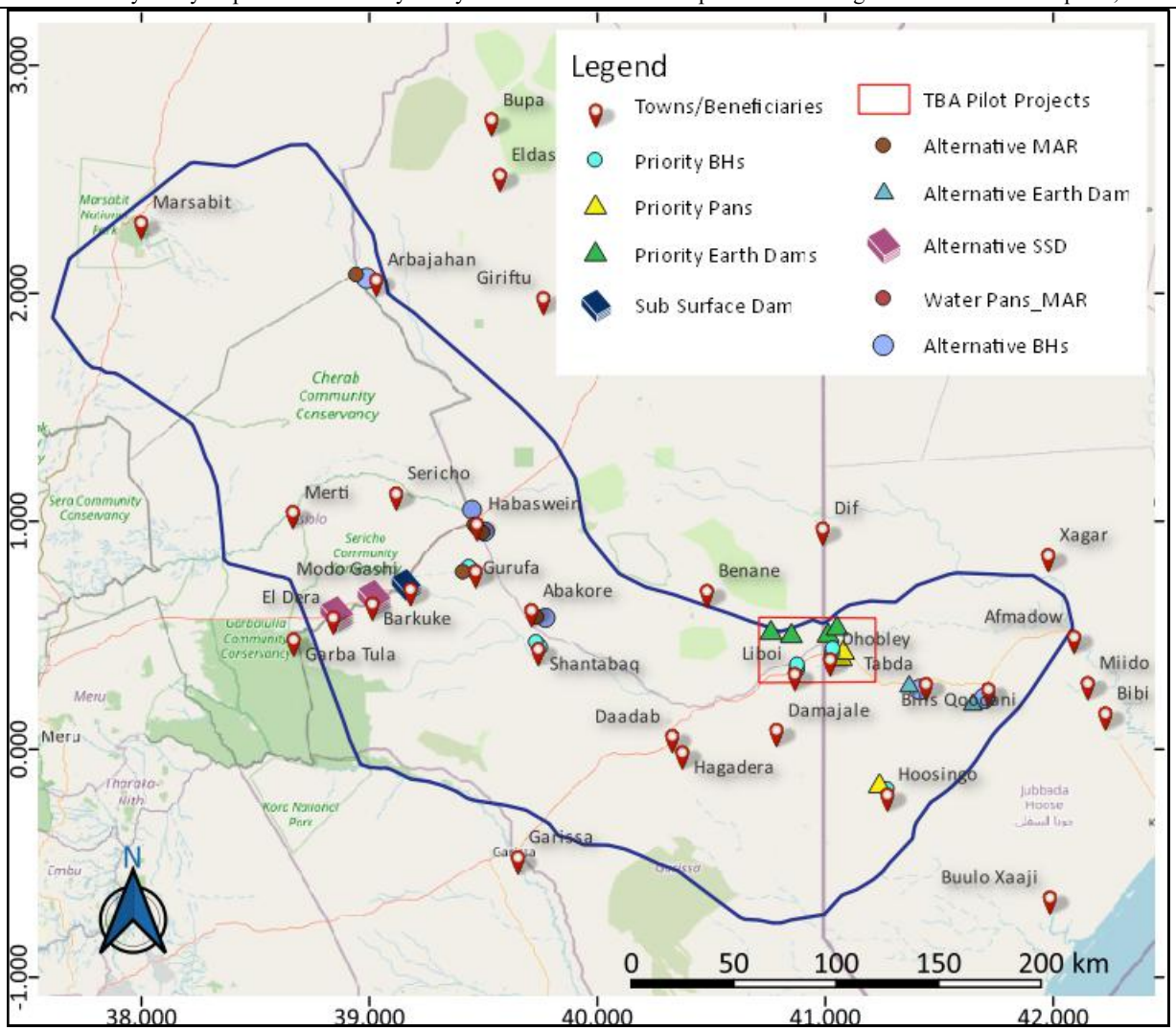

Figure 2:All Recommended Projects for the Study

4 ENGINEERING DESIGNS

4.1 Design Parameters

Before the design of the proposed drinking water supply and buffering structures, the following parameters were considered.

4.1.1 Geology

Based on the available geological logs and previous studies the aquifer formation is a sedimentary formation consisting of friable to semi consolidated gravel, grit, sand, silt and clay, generally intercalated in lenticular beds. This was considered during the actual engineering design to determine the type of rock formation per site and its potentiality to be used as the foundation for some technologies such as Sub-surface dams, water pans and Earth Dams.

4.1.2 Hydrology

Hydrology per site was analysed to help in designing earth dams and water pans. This emphasized determining the source of recharge, site catchment area and the amount of surface runoff expected during the normal and excessive rainfall which are critical in computing the dams and pans dimension and the amount of volume which is congruent to the surface runoff. The study revealed that the recharge of the Merti Aquifer is basically from River Ewaso Ng'iro whose sands provide an excellent storage capacity, especially considering their depth. For more details refer to Interim Report.

4.1.3 Hydrogeology/Aquifer Parameterization

Based on the available borehole data, Merti Aquifer is defined to be a confined aquifer found in the permeable zone of the Merti beds with moderate specific capacity and transmissivity whose groundwater is found at a rather uniform depth between 105 and 150 meters bgl. Hydrogeology was analysed to understand the interface between fresh and saline water in high and low-lying areas. In the low-lying areas, water is struck at a depth of 340m bgl. Saline interface in the Aquifer is expected at a depth greater than 350m bgl in high area zones and a depth of greater than 150m bgl in a low-lying area. This aided in recommending the terminal depths and designs of boreholes in different sites.

4.1.4 Geophysical Results

For the construction of appropriate competent engineering structures, the foundation grounds upon which they rest must be determined to be capable of supporting them. The excavation depth for the construction of the Sub-surface Dams, Earth Dams and Water Pans was derived from the geophysical results of the respective sites. This is discussed in detail in sub-chapter 3.6 and 3.7 in the Interim Report. The best sites for borehole location and recommended depths were deduced from the analysed existing borehole data within the vicinity and geophysical results.

4.1.5 Topography

Slope orientation was considered during the engineering design of the pipeline system and storage tanks. Some of the proposed technology sites are undulating-relatively flat where water is expected to flow by gravity from the source to the targeted points, unlike others where water will be piped to higher elevated points where booster stations are designed as shown by the engineering drawings.

4.1.6 Water Quality

Water quality is relatively good in the recommended sites for development. The following parameters concerning the basic requirements for drinking water supply were considered while selecting the best sites for sources of good quality water for consumption;

- ***Salinity status***- salinity is within the acceptable limit
- ***Taste and odour-*** contains no compounds that impart offensive taste or smell
- ***Colour***- low turbidity
- ***EC status***- they are within the permitted limits

- ***Chemical Integrity***- the drinking water conform to the maximum limit for chemicals for health significance. It is free from harmful inorganic compounds
- ***Absence of aggressive substances***- no presence of aggressive elements that can cause adverse effects on human and livestock health.
- **Fluorides**-areas with elevated fluorides concentrations were avoided during the drinking water supply site selection.

4.1.7 Water Demand and Estimated Discharge/Capacity

Water demand, estimated yield, discharge and Capacity of the recommended technologies played a vital role in the engineering design of the appropriate size of the storage tanks and reticulation systems of the technologies. The targeted population to be served by the proposed technology, their water demand and the estimated expected yield and capacity for the technologies are summarized in the table below per site;

Table 5: Site-Specific Human Consumption Water Demand

Site	Location	Proposed technology	Targeted Human Population	Human Water Demand	Livestock Water Demand	Total Demand	Estimated Discharge /Capacity
S01, 3.1&3.5	Dhobley 1 (Somalia)	• 3-boreholes, 2-production and 1-monitoring • Recommended depth - 220m bgl for exploratory drilling • Borehole spacing 1.5 km	~22,000 People	240,900 m^3/yr.			87,600 m^3/yr
	Dhobley 2 (Somalia)	• 2- Earth Dams are recommended • Dimensions 120m by 70m by 5m					58,800m^3
SO 3.2 &3.3	Dhobley 3 (Somalia)	• Rehabilitation of existing pans • Dimensions 120m by 100m by 3.5m					160,000m^3 + 85,200m^3 =245,200 m^3
SO 4	Hoosingow (Somalia)	• Rehabilitation of one existing borehole • Construction of a new monitoring borehole	~4,500 People	49,275 m^3/yr.			73,000 m^3/yr
		• Rehabilitation of existing water pan					136,000 m^3
KE 9	Liboi 1 (Kenya) Liboi 2 (Kenya)	• 3- boreholes, 2-production and 1-monitoring • Recommended depth -220m bgl • Borehole spacing 1.5km	~1,203 people	13,173 m^3/yr	42,544 m^3/yr	55,717 m^3/yr	87,600 m^3/yr
KE 8.1 & 8.2		• Two dams are recommended; 1 on each site • Dimensions 120x 70x 5m					58,800m^3
KE 1.3	Modogashe (Kenya)	• 4-cascading Sub-surface Dams	~2,309 people	25,284 m^3/yr	135,465 m^3/yr	160,749 m^3/yr	212,963 m^3
KE 2	Gurufa	• 2-boreholes					30,295 m^3/yr
KE 7	Shantabaq (Kenya)	• 1-borehole • Recommended depth – 250m bgl	~377 people	4,128 m^3/yr	23,006 m^3/yr	27,134 m^3/yr	87,600 m^3/yr

NB:

1. Based on borehole data, the average yield in;
    a. Hoosingow is taken as $10m^3/hr$
    b. Liboi is taken as $12m^3/hr$
    c. Dhobley is 12 m^3/hr- the borehole data gives an average discharge of $17m^3/hr$. A lower abstraction rate is recommended to reduce the rate of upconing therefore $12m^3/hr$ has been used in the calculations above.
    d. Shantabaq is 24 m^3/hr
    e. Gurufa is 8.3 m^3/hr
2. The discharge for boreholes is calculated using 10 pumping hours per day.
3. The capacity provided for water pans and dams is for three dry months considering one refilling per wet season. It is assumed there are two wet seasons per year in Somalia and one wet season in Kenya.
4. The target population of Hoosingow remains 4,500 since the proposed development involves rehabilitation of the existing boreholes which supply water to these residents.

Water Demand Projection

The water demand projection has been calculated for 3 horizons i.e., 2021-2025, 2025-2030 and 2030-2035. The population projections are expressed by the equation:- $Pt=Po\ (1+r/100)^{t}$.

- Po = the population at the beginning at time t
- R = the population growth rate in percentage

The national population growth rates of 2.92% and 3.22% for Somalia and Kenya respectively are adopted for all horizons in rural areas.

Table 6: Human Water Demand Projections

Town	2021		2025		2030		2035	
	Baseline Targeted Population (Po)	Annual Demand (m^3/yr)	Projected Targeted Population (Pt)	Annual Demand (m^3/yr)	Projected Targeted Population (Pt)	Annual Demand (m^3/yr)	Projected Targeted Population (Pt)	Annual Demand (m^3/yr)
Dhobley	22,000	**240,900**	23,984	**262,625**	27,696	**303,274**	31,983	**350,214**
Hoosingow	4,500	**49,275**	4,906	**53,719**	5,665	**62,033**	6,542	**71,635**
Liboi	1,203	**13,172.85**	1,323	**14,486.762**	1,550	**16,974.25**	1,816	**19,888.86**
Madogashe	2,309	**25,283.55**	5,335	**58,416.081**	21,541	**235,879.2**	86,983	**952,460.5**
Shantabaq	377	**4,128**	415	**4,540**	486	**5,319**	569	**6,233**

Table 7: Livestock Water Demand in Priority Sites

Site	Location	Cattle Population	Water Demand	Shoats	Water Demand	Donkey	Water Demand	Camel	Water Demand	Poultry	Water Demand	Total Water Demand
SO1, 3.1,3.5,3.2 &3.3	Dhobley (Somalia)	417	2920 m^3/yr	400,000	511,000 m^3/yr	-	-	2,188	27,010 m^3/yr	-	-	540,930 m^3/yr
SO 4	Hoosingow (Somalia)	1,500	10220 m^3/yr	36,000	43,800 m^3/yr	-	-	7,875	96,360 m^3/yr	-	-	150,380 m^3/yr
KE 8.1 8.2 & 9	Liboi (Kenya)	1,642	11,088m^3/yr	8,505	10,865m^3/yr	167	1,524 m^3/yr	1,559	19,062 m^3/yr	178	5 m^3/yr	42,544 m^3/yr
KE 1.3	Modogashe (Kenya)	7,238	48,875 m^3/yr	24,255	30,985 m^3/yr	590	5,384 m^3/yr	4,107	50,218 m^3/yr	103	3 m^3/yr	135,465 m^3/yr
KE 2	Gurufa (Kenya)	3763	25,410 m^3/yr	8345	10,660 m^3/yr	327	2,984 m^3/yr	-	-	-	-	39,054 m^3/yr
KE 7	Shantabaq (Kenya)	1,658	11,196 m^3/yr	3,653	4,667 m^3/yr	185	1,688 m^3/yr	446	5,453 m^3/yr	76	2 m^3/yr	23,006 m^3/yr

NB:

1. Water abstracted from the boreholes proposed in Gurufa will also be used to supplement the existing supply in the area in order to meet demand for livestock consumption.
2. The rainfall for the area is below 400mm annual and therefore livestock carrying capacity of 0.4 Livestock units per Ha is adopted.
3. The average livestock walking distance adopted for the project site is 2.5km.
4. Given that a livestock unit consumes 50 litres per day, the following equivalences of livestock units were used in calculation of the water demand;
    - 1 Local Cattle: 0.37
    - 1 Sheep / Goat (Shoat): 0.07
    - 1 Camel: 0.67
    - 1 Donkeys: 0.5
    - 1 Chicken: 0.0015

Livestock Water Demand Projection

Livestock Population Growth Rate for all animals have been average to estimate the projected demand.

Table 8:Livestock Growth Rates

Livestock	Growth Rate
Cattle	0.01
Shoats	0.0165
Donkey	0.01
Camel	0.07
Poultry	0.0165
Average	**0.0246**

Table 9: Livestock Water Demand Projections

	2021		2025		2030		2035	
Town	Baseline Targeted Population (Po)	Annual Demand (m^3/yr)	Projected Targeted Population (Pt)	Annual Demand (m^3/yr)	Projected Targeted Population (Pt)	Annual Demand (m^3/yr)	Projected Targeted Population (Pt)	Annual Demand (m^3/yr)
Dhobley	402,605	**540,570**	433,054	**553,227**	489,006	**624,705**	552,186	**705,419**
Hoosingow	45,375	**152,410**	48,807	**287,080**	55,113	**324,171**	62,233	**366,055**
Liboi	12,051	**42,544**	12,962	**76,245**	14,637	**86,096**	16,528	**97,219**
Madogashe	36,293	**135,465**	39,038	**229,620**	44,082	**259,287**	49,777	**292,788**
Gurufa	12,435	**39,055**	13,376	**76,486**	15,104	**86,368**	17,056	**97,527**
Shantabaq	6,018	**23,006**	6,473	**38,075**	7,309	**42,994**	8,254	**48,549**

4.1.8 Design References

The design for drinking water supply and water for buffering has been carried out based on the following codes and standards:

- Ministry of Water and Irrigation -Practice Manual for Water Supply System in Kenya
- Ministry of Energy and Water – Practice Manual for Water Supply System in Somalia
- KS 06-217-Specification for uPVC pipes for water supply.
- BS 8110 and 8009 for the design of reinforced concrete structures
- Practice Manual for Small Dams, Pans and other Water Conservations Structures in Kenya, 2nd Edition.

4.1.9 Design Horizon

The Ministry of Energy and Water's practical manual for water supply in Somalia and the Ministry of Water and Irrigation Practice Manual 2005 in Kenya provide guidelines for the selection and determination of the project design horizon. The guidelines were adopted to determine the design horizon for the drinking water supply and water for buffering.

The design period for water supply is 20 years as per provisions of the practice manuals in both countries.

Table 10: Project Design Horizon

Design Period	Duration from Commencement	Narrative
Initial year	5	This is the year when the water supply is expected to be commissioned into operation, which may be assumed to be five years from the date of commencement.

Future year	10	It is assumed to be 10 years ahead of the initial year.
Ultimate year	5	It is assumed to be 5 years ahead of the future year. This is based on the life expectancy of electrochemical components

These timelines are however espoused at this stage to plan the works with the possibility of future changes.

4.2 Elements of Drinking Water Supply

4.2.1 Pipelines Design

The transfer pipeline has been designed to convey water from the proposed water sources to communal water points. The pipeline has been properly designed to control frictional energy losses to move the desired flows through the system, by conserving energy at some points and burning it off at other points. Careful selection of the pipe sizes and strategic location of the storage tanks, reservoirs and tap stands have been done. The gravity flow in pipes will be encouraged at the points of drinking water supply if appropriate. A booster station is recommended along the transfer pipeline where water is pumped to an elevated point. Spreadsheet-based hydraulic designs are recommended along the pipeline route to limit the risk of low pressure arising from intermediate terrain changes as shown by the engineering drawings.

Thrust blocks shall be provided at the bends and appropriate protection surrounds provided at road crossings. Washouts and air valves shall be placed at all low points and peaks on the primary and the secondary distribution pipelines respectively. Line valves shall be placed at the selected points on the primary and secondary mains. As portrayed by the Design Manual (2005), no peak factor shall be applied to the water demand unless directly referred to. Pipeline routes will be along the river valleys, access roads existing public roads to avoid the issue of displacement/compensation when pipeline wayleave is acquired through private lands.

4.2.2 Treatment Works

The quality of water for human consumption is good and therefore the project will not adopt the conventional treatment plant. However, chlorination dosing system has been proposed at the storage/distribution tank. This will ensure a 100% guarantee of safe water to the targeted beneficiaries.

4.3 Technical Specifications, Standard Designs and Engineering Drawings of the Priority Technologies

4.3.1 Boreholes

4.3.1.1 Pilot/Exploratory Borehole Drilling

Two exploratory boreholes of a recommended depth of 220m bgl is recommended one in Dhobley and another in Liboi. The recommended spacing is 1.5km from the production boreholes such that the centre one will be used for monitoring. The exploratory boreholes will provide necessary details for the drilling of the production boreholes such as the required depth, diameter and other design parameters. The monitoring borehole shall be installed with telemetric devices such as Master Meter and Airline Piezometer to monitor abstraction rates and water levels respectively.

a) Drilling Method

The Contractor may use any of the hydraulic rotary drilling techniques (Mud Circulation, Air drilling, Reverse Circulation) that he feels applicable to achieve the terminal depths and diameters required within the time for completion specified in the contract. This should be done using a drilling bit of 10” diameter and 6” steel plain and screened casing will be installed.

b) Sampling of Cuttings

Sediment cuttings will be collected every 2m or at each lithological change along the penetrated section and kept to define the borehole lithology. Grain size analysis shall be conducted for the whole aquifer sequence. Gamma-ray and resistivity logs will be conducted to accurately identify the changes between lithological units and their properties. A dielectric coupling connection shall be installed to prevent galvanic corrosion in the borehole.

c) Aquifer Protection

The contractor shall bear full responsibility and take all necessary precautions to avoid pollution and contamination of the aquifers intersected during drilling. This includes all necessary precautions, based on the state of the art, to avoid infiltration of saline water into fresh aquifers.

d) Gravel Pack Installation

A quartz gravel pack with grain size 0.8-1.5 mm shall be installed in the borehole to fill the annular space.

e) Borehole Development

Once screens, gravel pack, seals and backfill have been installed, the borehole should be developed. This shall be done uniformly through all water-bearing zones using polyphosphate solution to sort the gravel pack, open up the pore spaces blocked during exploratory drilling, clean the drilling residual and clean up the overall borehole.

f) Test Pumping

Constant discharge/Step drawdown and recovery tests shall be carried out within a duration set out in the code of practice and as directed by the supervising hydrogeologist. Water level observation and measurement shall be taken for the computation of borehole efficiency. All this will be done to determine the aquifer parameters

g) Water Sampling

A water sample will be collected in the final hours of the test pumping for chemical and bacteriological analysis by a competent laboratory. The samples shall be collected in clear containers supplied by the laboratory in the manner conventionally used by the laboratory.

h) Borehole Disinfection

The borehole shall be disinfected with chlorine and chlorine compound such as chlorinated lime, calcium hypochlorite, sodium hypochlorite or any other suitable chemical compound. This will be sprayed in the borehole to ensure that all the exposed borehole wall surfaces are coated.

i) Borehole Capping

A Sanitary seal shall be constructed at the wellhead to protect the borehole from contamination. The top of the borehole shall be sealed with a cap that shall comprise a round plate of mild steel. This will be continuously welded in a single pass to the mild steel borehole casing or should be lockable.

4.3.1.2 Monitoring and Production Boreholes

This shall be designed on completion of the exploratory boreholes based on prevailing hydrogeological conditions in Dhobley and Liboi. Both Liboi and Dhobley should have three boreholes in total. 2 of these will be designated to production and 1 for monitoring in each country. Rehabilitation of the two existing production boreholes and development of one monitoring borehole in Hoosingow is recommended. Development of new production boreholes in Gurufa and Shantabaq has been proposed. The recommended depths for the boreholes in Hoosingow, Gurufa and Shantabaq are 100m, 200m and 250 m bgl respectively.

a) Drilling Method

The Contractor may use any of the hydraulic rotary drilling techniques (Mud Circulation, Air drilling, Reverse Circulation) that feel applicable to achieve the depths and diameters required within the time for completion specified in the contract. This should be done using a drilling bit of 10” diameter and installing permanent casings and screens of 6” diameter.

b) Sampling of Cuttings

Continuous samples (minimum, 250 grams) of the strata penetrated shall be collected for each 2-m interval drilled and for every change of lithology by whatever method is standard for the drilling technique in use. The samples shall be put into suitable sample bags, labelled with waterproof labels with the depth interval. The contractor shall take every possible precaution to guard against sample contamination. Geological logging shall be the responsibility of the Supervising Hydrogeologist and is to be carried out by the contractor’s qualified Hydrogeologist.

c) Temporary Casings

Installation of any temporary casing if required for the construction of the borehole shall be done.

d) Aquifer Protection

The contractor shall bear full responsibility and take all necessary precautions to avoid pollution and contamination of the aquifers intersected during drilling. This includes all necessary precautions, based on the state of the art, to avoid infiltration of saline water into fresh aquifers.

e) Casings and Screens

The borehole shall be cased using 6" plain and slotted casings following the borehole design for enough annular space for the gravel pack. The screen open area shall not be less than 4% and shall have a uniform slot size of 1 mm. Aquifer zones shall be completely or partly lined with uPVC screen casing as decided and approved by the supervising hydrogeologist. The bottom end shall be sealed with a UPVC bottom cap as shown in the standard design drawing.

f) Gravel Pack Installation

The gravel pack shall consist of well-rounded particles of uniform grading with 90% siliceous material and conform to the 0.8-1.5 mm diameter. The gravel shall be washed clean before installation. A sufficient amount of gravel pack shall be installed to completely cover the annular space.

g) Borehole Development

Once screen, pack, seals and backfill have been installed, the borehole shall be developed. Borehole development shall be done by airlifting. This will be done uniformly through all water-bearing zones to sort the gravel pack, open up the pore spaces blocked during drilling, wash out the chippings that were left during drilling and clean up the overall borehole. Airlifting of the water will be done until the water is completely clear.

h) Test Pumping

A constant/step discharge test shall be done for 24 hours. This shall be preceded by a minimum of 8 hour-recovery test. Water level observation and measurement shall be taken. This will be followed by the removal of the test pumping equipment.

i) Water Sampling

In the closing hours of the test, a water sample shall be collected for chemical and bacteriological analysis by a competent laboratory. Water samples shall be collected in containers supplied by the laboratory in the manner conventionally used by the laboratory.

j) Borehole Disinfection

After removal of test equipment, the borehole shall be disinfected with chlorine/water solution at a concentration of about 50 milligrams per litre or greater of free chlorine. This will be sprayed in the borehole to ensure that all the exposed borehole wall surfaces are coated.

k) Well Capping and Scaling

A Sanitary seal shall be constructed at the wellhead to protect the borehole from contamination.

Temporary cap – the top of the borehole shall be sealed with a cap that shall comprise a round plate of mild steel, of thickness, not less than 3.0mm. This will be continuously welded in a single pass to the mild steel borehole casing or should be lockable.

l) Installation of Pump

The agreed pump shall be installed. The selection of the type and intake of the pump should be done based on the design and performance of the borehole.

m) Records

After completion of all works at the borehole, the contractor shall submit to the project manager within the agreed time a borehole completion report with the following conditions;

- Drilling penetration log
- Geological log

- Borehole Completion Record (Three complete sets of completion reports shall be submitted

4.3.1.3 Borehole Rehabilitation Procedure

a) Step One: Inspection

Before the actual rehabilitation of any borehole, a diagnosis/inspection should be carried out to determine the faults of the infrastructure.

By using advanced camera technology and logging probes, detailed diagnoses of boreholes, including video and physicochemical data, such as temperature and conductivity can be provided. The remotely controlled equipment is carefully lowered into the boreholes allowing for water sampling at different depths. The samples are analysed enabling the detection of any potential contamination or chemical components exceeding the recommended limits. The camera enables visualization of the conditions of the casings and water level.

b) Step Two: Results Analysis

Common signs presented are:

- deposits of e.g. carbonates, iron and/or manganese oxides
- bacterial growth
- partial clogging
- damages to the casing
- sand intrusion
- pollution
- Pump failure

These phenomena often lead to a reduction in the yield and/or a deterioration of the water quality. Once a borehole has been diagnosed, the decision to rehabilitate it or not can be made. The methods of rehabilitation are then selected at this point. The cost of rehabilitation versus the construction of a new borehole is an important factor to consider at this stage and choose the cheaper or most efficient option.

c) Step Three: Rehabilitation

Rehabilitation of boreholes can be done through chemical treatment and/or mechanical means. The process can involve simple compressed air cleaning and mechanical scrubbing or can extend to more delicate operations, such as unclogging slotted casings through chemical treatment or partial relining. Reinstallation of the pump can also be done.

4.3.1.4 Boreholes Design, Storage and pipeline System Design and Engineering Drawings

Table 11: Infrastructure Description and Target Demand

Structure	Location	Latitude	Longitude	Depth(m) bgl	Targeted population	Water Demand
BH 1	Dhobley 1 (Somalia)	0.404691^0	41.025079^0	220	22,000	660 m^3/day
M.BH		0.409766^0	41.02506^0			
BH 2		0.413913^0	41.027617^0			
RBH 1	Hoosingow 1 (Somalia)	Ceel Macan		220	2,920	87.6 m^3/day
M.BH				220		
BH 1	Liboi (Kenya)	0.345224^0	40.874434^0	220	1,203	36.09 m^3/day
M. BH		0.358777^0	40.874910^0			
BH 2		0.372349^0	40.874910^0			
BH 1	Gurufa (Kenya)	0.797293^0	39.419780^0	200	551	16.53m^3/day
M. BH		0.794396^0	39.433794^0			
BH 2		0.798381^0	39.44604^0			

BH 1	Shantabaq (Kenya)	0.473917^0	39.726257^0	250	377	11.31 m^3/day
M. BH		0.467290^0	39.733324^0			

NB: BH- Production Borehole
M.BH- Monitoring Borehole
R.BH- Rehabilitation Borehole

4.3.2 Sub-Surface Dam

The four cascading Sub-Surface Dams for drinking water supply are recommended at Modogashe (Site KE 1.3) across Togwein Lagha at a spacing of 42050m,1120m, 440m 280m from one another. The dams should be equipped with an infiltration gallery/Sump, Solar pumping system, water kiosk, reticulation system. Water will be pumped to elevated tank and further distributed to consumers through a pipeline network, elevated storage tanks, solar pump etc. The sub-surface dams are intended to serve the communities from Isiolo and Garissa counties which are strategically located here. The separate collection/storage tanks are recommended to solve water-sharing conflicts (one on each side).

Table 12: Sub-Surface Dam Descriptions and Target Demand

Structure	Location	Dimension	Latitude	Longitude	Targeted population	Water Demand
Dam 1	Modogashe (Kenya)	420m x 50m x 4m	0.718893°	39.160869°	2309 people	69.27 m^3/day
Dam 2		1120m x 50m x 4m	0.714754°	39.157826°		
Dam 3		440m x 50m x 4m	0.708453°	39.146576°		
Dam 4		280m x 50m x 4m	0.706099°	39.142294°		

a) Excavation

Excavation (a trench) for construction shall be done at the proposed site (KE 1.3) across Togwein Lagha to a depth of 4m bgl where the stable layer is expected to be found based on the geophysical results.

b) Concreting

The body of the dam shall be constructed using re-inforced concrete material. The concrete shall be mixed thoroughly in approved power-driven mixers of the type and capacity suitable for the work. The mixer shall be equipped with an accurate water measuring device. All materials shall be thoroughly mixed dry before adding water and the mixing of each batch shall continue for not less than two minutes after the water has been added and until there is a uniform distribution of the materials and the mass uniform colour.

c) Offtakes

The shallow well with an external diameter of 1.55m; internal diameter of 1.25m, will be made of culverts or concrete blocks. Manual excavation will be done at the inside of the ring thus lowering it as a caisson to the required depth. Permeable concrete building blocks or culverts will be used up to the elevation of the maximum water level in the sub-surface reservoir. Above this elevation, regular building concrete blocks, or precast culvert rings will be used.

d) Construction of Sub-Surface Sand Dams

Sand-storage dams will be constructed in stages This is to limit he height of each stage in order to keep a sufficiently high water velocity, so that fine particles are washed out while the coarse particles settle. Each stage is typically 0.30 to 0.50 m in height. Each stage should be filled with course sediments before the next layer is added. This is the main reason why the sand dams must be constructed in stages. It is possible to achieve the construction of multiple layers in one rainy season with careful monitoring of the sediment levels.

4.3.2.1 Sub-Surface Dam Pipeline Systems, Storage Systems Design and Engineering Drawings

4.3.3 Water Pans

4.3.3.1 Rehabilitation of the Existing Pans

Rehabilitation is recommended for an existing pan in Dhobley(SO3.2&3.3) and Hoosingow (SO4). Rehabilitation in Hoosingow should be executed using the following dimensions; length- top 180 m, bottom 168m; width- top 100 m, bottom 88m; depth- 3.5m.

During dam rehabilitation, the following procedure will be applied:

- Inspection of the water pan's status by an engineer, who will survey the site and carry out for the infrastructure for rehabilitation.
- Excavation of the pan to the required dimensions. There shall be hauling and compaction of the material excavated, and clay lining did on the dam's floor.
- Desilting the pan shall be done and the inlet, spillway and embarkment marked.
- Building of the wall's embarkment and spillway.
- Silt trap excavation/ rehabilitation will be done to filter excess sediment that may enter the pan. This will help to increase the pan's lifespan. The expected silt volume annually is about 1400m^3 hence a standard silt trap of (20*30*2)m will be adopted in the works.
- Construction of cattle troughs and elevated tanks. Cattle troughs shall be constructed to minimise water pollution by livestock.
- A solar-powered pumping infrastructure shall be installed to pump the water from the pan to the elevated tanks.
- Sanitation facilities should be constructed to minimise pollution by human waste around the pan.
- Fencing of the pan will be done to minimise contamination and other forms of destruction by livestock and wildlife. Drought resistant cover trees/vegetation will be planted to control soil erosion around the pan.
- Training facilitation for both the community and the pan caretaker is critical. The caretakers should be trained on the pan's operations and the community training on conservation of the catchment to ensure the sustainability of the water pan.

4.3.3.2 Construction of New Water Pans

A water pan of dimensions 150m by 100m by 3m is recommended at Goreale-Shantabaq (Site K.E 6.2). However, there is an existing privately owned water pan that supplies water to the community at a fee. The construction of the recommended water pan does not interfere with the existing water pan. This site is near a dry grazing route therefore providing water for livestock is critical. The pan should be equipped with an infiltration gallery off-take, fence, water troughs and reticulation system i.e., solar pump, elevated storage tank etc.

a) Site Clearing

To ensure that the immediate area of the pan is convenient to work, bush clearing shall be done using locally available tools.

***b)* Excavation**

Water holes shall be excavated in the ground for harvesting rainwater and surface run-off. The excavation shall be done to a depth of 3m where an aquiclude is expected to be found. Haul material from Pan through the buffer zone that is specified and construct an embankment around the excavated pan, Height 2.5m, crest width 5m and side slopes 1:2.4. The pan floor should be compacted partially to create a room for both vertical and lateral infiltration for ground recharge.

c) Inlet Structures

To convey water into the pan, at least one collection trench shall be constructed. The gradient of the trench should not exceed 1%. The length of the trenches has to be determined as a function of the

topography of the site. In the pan sites, the length of the inlet channels should be about 25m long. Weighted Gabion mattress of dimensions 6m x1m x 0.3m as a riprap at the inlet to the pan as shown in the engineering drawing.

d) Silt Trap

Silt trap shall be created as per the engineering drawings and cart away to embankment as shown in the drawings and as directed by the engineer. The concrete shall be mixed in the ratio of 1:2:4. Riprap protection shall be provided for the silt trap inlet walls and pan inlet walls and outflow channel as shown in the engineering drawings. Depending on the expected silt load, the dimensions of the silt trap will be 20m by 25m. The length of the silt will be 2m and the inlet width should not exceed 6m. Trap efficiency of the silt trap will be expected to decrease gradually as the silt trap fills up. Hence, de-siltation of the trap is highly desirable at a regular interval.

e) Spillway Structures

Overflow structures shall be provided for the water pan because it is situated on an undulating topography which are intercepting water courses. A flush earth channel type should be situated in a normal circumstance away from the embankment to avoid the necessity of constructing protection structures. The spillway design should provide adequate capacity to pass the design flows and provide a net safe freeboard under all conditions.

f) Off-take Structures

Two main systems are foreseen for the off-take structures; a hand-dug shallow well and an artificial infiltration channel of about 25m long.

g) Intake structures

Intake structures shall be laid to help in safely withdrawing water from the pans and discharge it to the withdrawal conduit, through which it will be conveyed to water kiosks or cattle troughs.

h) Fencing

Fencing shall be done for the pan area to protect it from being contaminated by people and animals. The total fenced-in area is 180m long and 90-m wide.

4.3.3.3 Water Pans Design and Engineering Drawings

Water pans design and engineering drawings are given in the Book of Drawings.

Table 13: Water Pans Description

Structure	Location	Dimensions	Latitude	Longitude
Water Pan	Dhobley	150m x 148m x 3.5m	0.409766	41.025061°
		200m x 170m x 3.5m	0.413913	41.027617°
Water Pan	Hoosingow (Somalia)	180m x 100x 3.5m	-0.165132°-	41.260576°
Water Pan	Goreale (Kenya)	150m x 100x 3m	0.474317	39.649518

4.3.4 Earth Dams

Two Earth Dams whose dimensions are 120 m x 70 m x 5m are recommended at Dhobley and Liboi. The dams are recommended to serve the pastoralists and the nearby communities. The dams should be designed with Inlet structures, outlet structures, infiltration galleries, cattle troughs and fences.

a) Site Clearing

Bush clearing should be done on the proposed sites for the earth dams to ease construction works.

b) Excavations

Excavation for construction shall be done at the proposed sites. A reservoir excavation shall be dug to a depth of 5m bgl where the impervious foundation/a stable layer is expected to be found based on the geophysics results.

c) Construction of the Embankment Wall

An embankment wall of 2-metres height shall be laid. The excavated material shall be used in part of making the wall. Filling and pressing tests with the material shall be carried out to establish quality control standards for filling. The Dam floor should be compacted partially to create room for infiltration.

d) Grouting

Grouting shall be done to strengthen the formation and reduce water flow through openings and faults if any exist.

e) Inlet structures

At least two collection trenches shall be done at each dam to convey water.

f) Spillways

These structures will be laid to withdraw excess water from the dam. The spillway design should consist of the crest of a width of about 5metres, an inflow section and an outflow section as shown by the engineering drawing.

g) Intake Structures

Intake structures shall be laid to convey water to the water storage unit. They should be made from a perforated pipe, weld mesh or a similar wire netting to prevent leaves or other materials from blocking the perforations in the pipe to be fixed in a concrete block to ensure stability. A gate or sluice valve just downstream the embankment, preferably with a washout possibility to be fixed in a valve chamber (lockable if possible).

h) Fencing

Fencing shall be done to protect the earth dam from contamination by humans, animals and intruders.

4.3.4.1 Earth Dam Designs and Engineering Drawings

Earth dams design and engineering drawings are given in the Book of Drawings.

Table 14: Earth Dams Description

Structure	Location	Dimension	Latitude	Longitude
Earth Dam	Dhobley	120m x70m x 5m	0.528022^0	41.050898^0
Earth Dam	Dhobley	120m x70m x 5m	0.498089^0	41.011334^0
Earth Dam	Liboi Site KE 8.1 (Kenya)	120m x70m x5m	0.509104	40.760393
Earth Dam	Liboi Site KE 8.2 (Kenya)	120m x70m x 5m	0.495587	40.850296

4.4 Auxiliary Technologies

4.4.1 Shallow Wells

Off-take shallow wells are recommended at sites K.E 1.3, K.E 6.2, K.E 8.1 and K.E 8.2. The recommended depth for a shallow well at site K.E 1.3 is 12 m bgl while for sites K.E 6.2, K.E 8.1 and K.E 8.2 are 10 m bgl each.

a) Drilling Method

The Contractor may use any of the hydraulic rotary drilling techniques (Mud Circulation, Air drilling, Reverse Circulation) or any other method that he feels is applicable to achieve the depth and diameters required within the time for completion specified in the contract such as hand-dug well.

b) Casing

The shallow well shall be cased using a pre-cast concrete casing following the shallow well design.

c) Gravel Installation

The gravel pack shall consist of well-rounded particles of uniform grading with 90% siliceous material and conform to the 0.8-1.5mm diameter. The gravel shall be washed clean before installation. A sufficient amount of gravel pack shall be installed to completely cover the entire annular space.

d) Well Development

Once the casings have been installed, the well should be developed. The well development shall be done by airlifting. This should be done uniformly through all water-bearing zones to open up the pore spaces blocked during drilling or hand-digging, wash out the chippings that were left during drilling and clean up the overall shallow well.

e) Test Pumping

Step discharge test shall be done until the water is clean. This shall be preceded by a minimum of a 2-hours recovery test. Water level observations and measurements shall be taken to determine the aquifer parameters.

f) Water Sampling

In the closing hours of the test, a water sample shall be collected for chemical and bacteriological analysis by a competent laboratory.

g) Well Disinfection

The well shall be disinfected with chlorine and chlorine compounds such as chlorinated lime, calcium hypochlorite and sodium hypochlorite or any other suitable disinfection chemical. This will be sprayed in the well to ensure that all the exposed well wall surfaces are coated.

h) Well Capping

A Sanitary seal shall be constructed at the wellhead to protect the borehole from contamination.

i) Pump Installation

The selection of the type and intake of the pump should be done based on the design and performance of the shallow well.

4.4.2 Infiltration Galleries

Infiltration galleries are recommended at the water pans, earth and sub-surface dams as off-take structures.

a) Excavation

A trench shall be excavated 1-meter below the water table. The trench has to be supported by employing props and formwork during the process of excavation to prevent collapsing of the trench.

b) Base Preparation

A layer of graded gravel shall be laid on the base of the trench and levelled.

c) Pipe or Drain Block Installation

A pipe or drain block shall be installed over the prepared base layer of well-graded gravel. Therefore, the top of the pipe and the sides are filled with more gravel.

d) Preparing Clay Layer

The whole gravel layer shall be capped using an impermeable layer of puddled clay to prevent the surface water to enter the gallery.

5 IMPLEMENTATION PLAN

5.1 Introduction

The Implementation Plan focuses on the arrangements to be made and steps to be taken in the development of the proposed water technologies both in-country and near the border/cross-border. It also lists the stakeholders to be involved in the process and the results indicators in the different phases of the implementation.

5.2 Stakeholder Engagement

Before the implementation of the project, a wide range of high-level, national, and local level stakeholders will be involved. High-level stakeholders such as the IGAD and the World Bank need to be involved before the implementation since they are the initiators and financiers. National stakeholders from both countries, such as the Ministry of Water & Irrigation and WRA from Kenya and the Government of Somalia and the Ministry of Energy and Water in Somalia should be involved in making decisions concerning the developments to be done since they are the highest-ranking authorities of the land in both countries. For the in-country implementation plan, the Water Works development agencies, counties, and states in Kenya and Somalia respectively, and the local leaders should be involved. The stakeholders, most of which are aware of the ongoing project, should then be informed of their roles in implementing the project.

5.3 Implementing Institutions

Project implementation at the near border towns, Liboi and Dhobley, will be mandated to the respective governments through the different institutions as set out by the respective governments. These institutions include:

- County Governments (Ministry of Water)-Kenyan side
- Jubaland State Government - Somalia side

Through the relevant ministries, the government will be financed to carry out the development works of the proposed technologies and the supply systems. However, after these works, the management and monitoring of the aquifer will be done jointly by the responsible teams from both countries.

After the near-border project implementation, the development of the other technologies proposed in areas further from the border will then kick-off. The Institutions tasked with this will be the respective Water works development agencies, and the county/ state governments in Kenya and Somalia respectively. It is advised that hydrogeologists, socio-economists, engineers, and all the relevant personnel be involved prior to the actualization of the project.

5.4 Preliminary and Preparatory Steps

5.4.1 High-Level Actions

High-level meetings between stakeholders from the two countries, IGAD and the World Bank will be organized. The meeting will ensure a clear understanding of the project and its objective of boosting economic development and promoting cooperation between the two countries. This will also serve as a key to the budget support from the financiers, who in this case are the World Bank.

5.4.2 Establishment of Project Management and Monitoring Committees

The project is on a shared water resource; the Merti Aquifer. For effective management and monitoring of the aquifer, the relevant institutions from both countries need to be involved. For this purpose, the establishment of a Trans-Boundary Aquifer Committee has been recommended. The Committee will compose of Stakeholders from the Ministry of Water and Irrigation, WRA from Kenya and the Ministry of Energy and Water, and the Jubaland State Department of Water on the Somalia side. The main mandate of the Committee will be to jointly manage and monitor the aquifer for the benefit of the two countries sharing it.

5.4.3 Signing of Memoranda of Understanding

Before the actualization of the project kick-off, there need to be clear objectives and the involved parties to clearly state what they expect from each other. To facilitate this, the following steps need to be taken;

- Signing of joint Trans-boundary Aquifer management Memoranda of Understanding
- Signing of Cross-County/State Memoranda of Understanding for water development

5.5 Implementation Strategy

Full implementation of this project will be carried out in two phases; Pilot Phase and Scaling Up Phase. The first phase will be based on the sites proposed in the cross-border towns, Dhobley and Liboi, while the second phase involves the development of all the other sites proposed further from the border or the in-country sites.

5.5.1 Pilot Phase

This is the first phase of the project implementation. This phase will act as a benchmark for the development of the in-country proposed technologies in priority sites. The success of the pilot phase will also pave way for other similar projects within the IGAD region It will take place in the first three years following the approval and funding of the project. This will also be an entry point for the local level stakeholders, where, as the process goes on, they will be involved and edified on how to coordinate similar projects which will be implemented in-country. The main infrastructure to be developed will be;

- Three boreholes; two for water supply and one for monitoring in Dhobley sites SO3.3 & 3.5 and Liboi
- Two Earthdams and their supply systems and water points along the systems in Dhobley across the tributaries of Lagh Dera
- Two water pans at sites SO 3.2 & 3.3 in Dhobley
- Three boreholes; two for water supply and one for monitoring in Liboi site KE 9
- Two Earthdams and their supply systems and water points along the systems in Liboi at sites KE 8.1 & 8.2

Several activities will be carried out during this phase, such as;

- Identification of the Unit/Institution responsible for the development, coordination, and management of the works
- Tendering of the works by the two countries involved, followed by evaluation and award of the tenders
- Construction works and supervision of the ongoing works
- Joint operation and maintenance and management of the completed projects, including the pipelines, tanks and associated water-supply structures

5.5.2 Scaling Up Phase

This is the second phase of the implementation of the project. It will involve the extension of the development works to the other proposed sites which are further from the border. The stakeholders, such as the Water Works development agencies which will have been involved in the Pilot Phase will then be mandated to carry out the implementation of the in-country projects. This phase will be carried out for 7 years following the funding and completion of the first phase. The main infrastructure to be developed are;

- 2 Boreholes in Hoosingow; One to be rehabilitated and one to be newly constructed. One will be used for water supply and the other for monitoring
- A water pan at site SO4 in Hoosingow to be rehabilitated to a Haffir Dam
- Four Cascading dams in Modogashe site KE 1.3 and fitted with offtake wells to collect water for supply to Modogashe

- Three boreholes (One for monitoring and two for production) in Gurufa site KE 2 and water pumped to Modogashe
- Two boreholes at site KE 7 in Shantabaq (One for production and one for monitoring)
- One Water Pan in Shantabaq

5.5.2.1 Improvement of Existing Projects

Preceding the implementation of new projects, the already existing but failed or non-functional water structures can be considered. The following can be put into consideration when considering rehabilitation;

- Why is the structure failed or non-functional?
- Can the reason behind it be solved?
- Is it more economical to rejuvenate the existing project or start up a new one?

Once these issues have been factored in and a way forward found, a go-ahead will be given to either rejuvenate the already existing project or develop a new structure.

5.5.2.2 Development of New Projects

In areas where the new projects have been proposed, the following will be done upon approval of the project by the World Bank and disbursement of funds;

- The Institution responsible for the implementation be identified
- Tendering of the works
- Appraisal and award of the tenders
- Actualization of the works (constructions and installations, done under supervision)
- Identifying the management committees and handing over the project to the community

5.6 Monitoring and Evaluation

The performance of the implementation process must be evaluated. This is particularly significant during the pilot phase since lessons learnt in this phase will be used during the scaling-up phase and other transboundary projects. A general system of monitoring and evaluation is therefore provided. This system will track progress against timescales and targeted tasks. It is recommended that reporting on the progress of the project be done quarterly.

Table 15: Pre-Mandate Activities Indicators

	Actions	Indicator	2023	2024	Review Frequency	Description (Indicator definition etc.)
Pre-Mandate Activities	Signing of MoUs	Drafting of MoUs	4 months		Quarterly	A functional MoU consisting of, but not limited to; an Implementation plan, joint management & monitoring plan, financial implications for each country, etc
		Reviews by both countries	12 months			
		Signing of MoUs		1 month		
	Formulation of a transboundary water management unit	Joint Groundwater Transboundary Water Project Management Unit		3 months		Existence of a formalized Transboundary Water management unit

5.6.1 Technical Results Indicators

Each project will have a list of some of the indicators to be monitored. This list only acts as a guide to quality control and should be used in conjunction with the respective country's standard requirements for the construction of the proposed technologies.

5.6.1.1 Pilot Phase (Transboundary Infrastructure)

Table 16: Pilot Phase Result Indicators

	Activity	Action	2024	2025	2026	Review Frequency	Description (Indicator definition etc.)
Pilot Phase Projects	Tendering	Compilation of contracts for the required surveys, works, supply of required materials or tools, setting up of proper database, etc	2 months			Quarterly	1 month will be used to compile tenders while the next will be used to advertise the various jobs and allow for applicants to send their applications. The intensity of the surveys, responsibility to apply for permits and/or licenses and a list of permits and/or licenses should be clearly defined
		Awarding of tenders to qualified consultants	2 months				This period will be designated for reviewing applications and awarding all advertised tenders. This process should be confirmed to be complete by the concerned parties
	Data Sharing Network (in-country or joint)	Establishment of a data-sharing platform to support telemetric devices	3 months				
	Site investigations and borehole construction	Hydrogeological and EIA/ESIA surveys	2 months				The intensity of the EIA/ESIA surveys will be dependent on the details of the contract. Tangible reports in both hard and soft copies Should be presented
		Acquisition of construction permits and licences		2 months			It should be stipulated. Hard copies of licences should be the products
		Drilling, development, test pumping, and water chemical and physical analysis		2 months			Installation of telemetric monitoring devices should be completed for the monitoring borehole during this period.
		Construction of water reticulation systems and any other auxiliary infrastructure		3 months			
		Acquisition of abstraction/water use permits/license		2 months			
	Site investigations and construction of two earth dams	Geotechnical and EIA surveys		2 months		Quarterly	
		Acquisition of construction permits and licenses			2 months		
		Construction of two earth dams			6 months		
		Construction of water reticulation systems and any other auxiliary infrastructure			2 months		
		Acquisition of abstraction/water use permits/license			2 months		

5.6.1.2 Scaling-Up Phase (In Country Priority Infrastructure)

Table 17: Scaling -Up Phase Result Indicators

	Actions	Water Supply Projects		Water Buffering Projects		Review Frequency	Description (Indicator definition etc.)
		2026-2027	2028	2029-2031	2032		
Tendering	Compilation of contracts for the required surveys, works, supply of required materials or tools, setting up of proper database	2 months	2 months	2 months	2 months	Quarterly	1 month will be used to compile tenders while the next will be used to advertise the various jobs and allow for applicants to send their applications. The intensity of the surveys, responsibility to apply for permits and/or licenses, a list of permits and/or licenses, etc., should be clearly defined
	Awarding of tenders to qualified consultants	2 months	1 month	2 months	1 month		This period will be designated for reviewing applications and awarding all advertised tenders
Boreholes	Hydrogeological and EIA/ESIA surveys	3 months	1 month			Quarterly	
	Acquisition of construction permits and licences	2 months	2 months				
	Drilling, development, test pumping, and water chemical and physical analysis	2 months	1 month				
	Construction of water reticulation systems and any other auxiliary infrastructure	6 months	3 months				
	Acquisition of abstraction/water use permits/license	2 months	2 months				
Subsurface Dams	Geotechnical and EIA/ESIA surveys			6 months		Quarterly	
	Acquisition of construction permits and licenses			2 months	1 month		
	Construction of 4 subsurface dams			12 months			
	Construction of water reticulation systems and any other auxiliary infrastructure			8 months			
	Acquisition of abstraction/water use permits/license			2 months			
Water Pans	Geotechnical and EIA surveys				1 month	Quarterly	
	Acquisition of construction permits and licenses				1 month		
	Construction of a water pan				4 months		
	Construction of a water reticulation system and any other auxiliary infrastructure						
	Acquisition of abstraction/water use permits/license				2 months		

5.6.2 Social Economic Results Indicators

Table 18: Social Economic Result Indicators

PDO Level Results Indicators	Unit of Measure	Baseline	Cumulative Target Values			Frequency	Data Source And Data Collection	Description (indicator definition etc.)
			YR 4	YR 5	YR 6			
Increase domestic water supply per HH	Litres	218	229	240	252	Bi-annually	Census by the socio-economist	Increase the amount of water supply per day per household by 5% annually
Households experiencing water-related conflicts	Percentage	27%	25%	23%	21%	Annually	Census by socio-economists	Reduce the number of households experiencing water-related conflicts by at least 6%
Reduce the number of households experiencing livestock deaths due to starvation and water deprivation	Percentage	81%	77%	73%	69%	Annually	Census by socio-economist	Reduce the number of households experiencing the deaths by 4% annually
Increase income from livestock keeping	Dollars	535.7$ per year	541.1$ per year	546.5 $ per year	551.9$ per year	Annually	Census by socio-economist	Increase the income per household per year by 1%
Providing affordable water	Dollars	15$ per month	<14.25$ per month	<13.5 $ per month	<12.75$ per month	Bi-annually	Census by socio-economist	Reduce the monthly water bill by at least 15%
Diversification of management teams	Number	0 or 1 out of 5 committee members	0	1	1	Annually	Census by socio-economist	Increase female participation in management to 20%

5.7 Project Sustainability

5.7.1 Public-Private Partnerships (PPPs)

This is a long-term contract between the private party and a government entity for providing a public asset or service, in which the private party bears significant risk and management responsibility (World Bank, 2022). In both countries, PPPs are recommended for water source and systems management and sustainability.

To design PPPs, there is a joint project management agreement by the public (Regional and central governments) and private sector formed by residents. To build the partnerships, Contractual Arrangements need to be done using the following steps;

- Formation of a Committee of experts to formulate the Agreement form. The Agreement should have;
  - The parties to be involved
  - Statement of Work
  - Terms and Conditions

Appropriate bilateral signatures

  - Duration of Agreement
- Technical Experts Involvement. The experts will review the formulated agreement on the technical parameters included. After the approval of the set
- Enlighten the public on the content of the Agreement and their roles in the project management clearly explained
- The signing of the Agreement by Guarantors from both parties. This will need a neutral party, such as IGAD to preside over the process.
- Copies of the Agreement should then be availed to the members of the public involved.

The water utilities managed by PPPs are performing well in Somalia, such as Shirkada-Adeega-Biyaha-Awdal (SHABA) Water Utility in Somaliland and Galkayo Water Agency (GALWA) in Puntland (UNICEF, 2019).

To determine the performance of a water project public-private partnership, the following parameters need to be considered:

- Access and Coverage (A_c)
- Billing Efficiency (B_e)
- Collection Efficiency (C_e)
- Operational Cost Expenditure (O_c)
- Revenue Water (R_w)

Upon completion of the construction, the project should be handed over to the already established Committees who are the representatives of the public. The Committee collects the money from water sales. The money is used to pay the operators and for the daily running of the project, such as buying fuel for the generators. The extra money collected should then be paid as a levy to the respective levels of governments. In case of a major maintenance issue, the Committee can request the government to help in funding the maintenance cost.

Challenges:

The PPPs processes, however, have a high bureaucracy as they then go through several ministerial, departmental and agencies approval. This issue can be addressed through capacity building at different levels of government on the importance and urgency of improving water supply and facilities in the region.

5.7.2 Institutional Sustainability

The project needs to support institutional sustainability by enhancing the legal and institutional framework of the main institutions that will be set up during and after this project implementation. This will be done by ensuring the relevant institutions, for example, Merti Aquifer Management Committee carries out its mandates efficiently in social, economic, technical, environmental, and monitoring and evaluation sectors. The sustainability will also be enhanced by financial support from the governments of both Kenya and Somalia in running their activities.

The institutional sustainability will also be improved through stakeholder involvement at various levels, from the ministries, water management agencies, state/county governments, and local authorities and communities, and capacity building at different levels. This will guarantee effectiveness in aquifer management, through sharing of the relevant data in a common database that will be developed during the implementation of the project.

5.7.3 Economic and Financial Sustainability

The project intends to increase the water supply in the area. During the construction phase of the project, the locals will be employed in the works. The post-construction phase will involve employment of some people as kiosks attendants and other technical personnel. Increased water supply will also reduce the time taken to get water which can then be used for other economic activities.

Financial stability will be enhanced through capacity building for O&M. The public will be enlightened on the role of water tariffs in the operations and maintenance of the developed structures thus a need to co-operate and adhere to the set tariffs. Improved livelihoods would mean more demand for water thus contributions for O&M increase with improved livelihoods.

5.7.4 Environmental and Social Sustainability

Tactical social and environmental impact assessment studies of the project will be done before the construction. The ESIAs will give guidelines on how to sustain both the social and environmental and ensure compliance with the World Bank environmental and social policies and those of the two neighbouring countries.

6 OPERATION AND MAINTENANCE

6.1 Introduction

Operation and Maintenance (O&M) is critical in improving the performance and efficiency of the water supply systems/infrastructure and ensuring their sustainability. This is done to avoid compromising the integrity of investments made, service operations, the well-being of the projects' beneficiaries (locals), and the development of future projects. The approach emphasizes on both construction and design, and other post-construction activities. These activities may also have social, community, political, institutional, managerial, gender-related, environmental, and financial aspects.

6.2 Water Resources and Systems for O&M

6.2.1 Shallow Wells

A shallow well is dug from ground level to a few meters (less than 15m bgl) targeting the shallow aquifer. The main components include the head wall, extraction system, apron, well lining, and the drain. In the study area, shallow wells have been mainly dug along the laghas, such as Lagh Togwein.

Operation: the shallow wells in the study area are operated by the locals since they draw water mechanically by hand using rope and bucket. However, the proposed shallow wells should be operated by a caretaker/operator and control their usage while maintaining order within the abstraction points.

Table 19: Major problems facing shallow wells

Problem	Probable Cause	Possible solution
Well collapse	Poor construction; Mainly inadequate well-lining and well head	Restoration/improvement of well lining, apron, and head wall
Drying of the well	Falling water level; Recharge is slower than the water extracted	Deepening the well, depending on the well's surrounding material
Siltation due to flooding	Placing the well in a watercourse is risky and may be damaged due to turbulence and force of floodwaters, and objects carried by floodwater	Constructing the well in a safer place and also protecting it from floodwater by building a hydrodynamic wellhead

Maintenance: Some of the tools needed include a ladder, ropes, and buckets to help in well desilting. Masonry tools are also needed to repair the apron and wellhead. The local community should be trained on desilting the well in case it occurs.

Recurrent costs: they are usually very low, which include the payments of caretakers' and WRUAs' wages/salaries. Rehabilitation costs are also low since the community can engage in desilting the wells after a while.

6.2.2 Boreholes

Boreholes are widely used for the abstraction of deep groundwater. Their initial construction costs are usually high and vary according to depth and geology of the area. To ensure longevity, a borehole must be professionally supervised, designed, developed, constructed and installed. After installation, the borehole should be properly maintained.

Operation: the borehole is operated by a caretaker/operator. They control and account for daily water abstractions, monitor water levels in case the demand is higher than the production of the borehole and maintain order within abstraction points.

Maintenance: minor activities may include cleaning the drain or apron slab and maintaining the fence. The water should be tested annually for bacteria, pH, and total dissolved solutes by taking the water samples to the governments' laboratory. In case of rehabilitation or repair of the borehole for instance due to siltation or contamination, it may require that the borehole is opened by qualified professionals and all appliances removed. It may involve activities such as chemical treatment, blowing air, and air pumping and brushing.

Recurrent costs: they are usually relatively low, which include the payments of salaries/wages for the caretakers or watchmen and WRUAs. Rehabilitation costs may however be higher, although it occurs after many years, e.g. 10 years.

6.2.3 Earth Dams and Water Pans

Earth dams are constructed across a water course or river channel while a water pan is constructed in an open ground, to hold surface water below the original ground level.

Maintenance: it is important to install permanent graduated staff gauges to monitor water levels and the amount of silt accumulated in the dam, which is a major problem for these infrastructures thereby affecting the storage capacity of the dam/pan. The measurements are then recorded and filed. Siltation can be solved by desilting the reservoir (at least once a year, in the dry season), and reducing erosion in the catchment area. The construction of a silt trap will reduce the amount of effort for desilting required. Other potential problems that may be encountered are as shown in the table below:

Table 20: Major problems encountered in earth dams and water pans

Problem	Probable Cause	Possible solution
Excessive weed growth	High concentration of nutrients in water	Identifying nutrients' source and controlling access to catchment or dam/pan by animals
Water pollution	Encroachment of livestock in dam/pan Catchment contamination	Fencing dam/pan Controlling access; discouraging open defecation in the catchment
Lack of water in the dam	Absence of inflow Seepage around the dam wall	Inspection of seepage paths and taking measurements to avert seepage by sealing flow path with clay or waterproof plaster on the upstream face of the wall
Wall at the risk of erosion undermining the wall	Turbulent and erosive water spilling over the wall Insufficient protection for the wall's toe	Placing a grouted riprap to create a protective apron on the downstream wall's toe

The maintenance costs are generally low. The caretaker should be equipped to clear unnecessary bushes and maintain the fence. Other tools include wheelbarrows, shovels, hoes and pickaxes for removing silts and also repairing the pan's/dam's walls made of natural material. A spanner is also necessary for taps/valves repair. Spares required may include outlet valves, taps and tap washers.

It is important to build the capacity for the infrastructures' caretakers, and the community on matters concerning hygiene and the protection and rehabilitation of catchments to minimise pollution.

6.2.4 Sub-Surface Dams

Sub-surface dams have a wall constructed for holding back surface water across a sand river. They are a reliable source of water during the dry period since most of the water stored is not lost through evaporation. The infrastructure is usually supplemented by digging shallow wells to improve the quality of the water.

Maintenance: it is the responsibility of the caretaker and the local community to take part in preventing avoidable contamination due to human activities e.g. laundry and invasion by livestock. The caretaker should also ensure the fence is properly maintained, all outlet valves opened and closed monthly, the dam walls inspected for the possibility of cracks, leaks and erosion, and the necessary measures taken to counter this for instance by filling plaster in cracks and grouting to create a protective apron on the wall's downstream toe. Other potential problems that may be encountered are as shown in the table below:

Table 21: Major problems encountered in sub-surface dams

Problem	Probable Cause	Possible solution
No water discharged from the outlet	• Filter drain blockage • Shallow well and sand dam not connected	Excavation & repairing filter drain

Lack of water in the sub-surface dam	• Absence of inflow • Seepage around the dam wall • Faulty draw off pipe (leaking)	Inspection of seepage paths and taking measurements to avert seepage by sealing flow path with clay or waterproof plaster on the upstream face of the wall Fixing the leaky pipe
No water in the sand dam	Siltation (not sands). The sub-surface dam might have also been sited in a sandy-deficient watercourse or wall raised too quickly when constructing the dam resulting in a silty top layer thereby limiting water seepage	Removing silts in case the watercourse has enough sandy material

The caretaker should be equipped to clear bushes. Other tools include wheelbarrows, shovels, hoes and pickaxes for removing silts and also repairing the embankments. A spanner is also necessary for taps/valves repairs. Spares required may include outlet valves, taps and tap washers, which are obtained at a well-provisioned hardware store. A trained mason should be readily available to ensure adequate repairs if there should be any serious damage to the structure, which is beyond the capacity of the trained caretakers.

6.2.5 Infiltration Galleries

They are constructed in combination with other water supply technologies and connected to a shallow well to meet the water demand of the community. The technology essentially prevents the entry of unfiltered water into the system.

Maintenance: The area around the galleries should be kept clean and protected from pollution. The gallery's performance should be done through water level logging in order to take proactive steps in reducing clogging and minimising terminating inflow. Some of the routine maintenance includes cleaning/ unblocking the filter pack, inspecting the water quality by taking the water samples to the laboratory, and testing the gallery's yield. A qualified contractor should be involved in the regular cleaning programme of the gallery. The galleries and their associated equipment should be inspected annually and the spare parts be readily available.

Recurrent costs: payments of caretakers' salaries, water quality testing and replacing galleries' parts such as the filter pack, pump, and the conduit.

6.2.6 Generic Components

6.2.6.1 Storage Tanks

A storage tank temporarily stores water to supply peak demand. It may either be an elevated steel tank, a concrete tank, or a plastic water tank. Some of the major tank components include an inlet pipe, inlet valve, float valve, washout, overflow, manhole/cover, ladder and a ventilation pipe among others. They require little maintenance if properly designed and constructed. However, the potential problems that may be encountered include:

Table 22: Potential problems encountered by storage tanks

Problem	Probable Cause	Possible solution
Tank overflow	• Float valve failure • Blocked gate valve • Pipeline airlock	Replace rubber washer/pin Remove & clear vale (replace if necessary) Inspect the nearest water valve
Tank wall leaks	Wall cracks	Repair on the inside- depending on the type of tank
Roof cracks	Settlement or too much loading on a roof	Seal cracks and add additional support if needed

Technical support should be sought in case of major leaks or if the tank's roof has significant cracks and if there are doubts about the roof's structural integrity.

6.2.6.2 Pipeline

The most common pipe types include PVC and steel pipes. Some of its major components include an intake- structure which abstracts water from the source; a pumping main which conveys water to the tank for storage; distribution lines that branch from the storage tank / main line to other connections; storage tank; pipe supports which provides support for the pipeline above ground level; pipe makers

which mark the paths of buried pipelines; control valves which close or open pipeline; air valves which release air in the pipeline from high points; washouts opened to remove sands, silts, and mud at low points; master meters which measure abstractions, etc.

Operation: reading of water meters (master and individual) should be done. The water consumption has to be checked per the agreed water users.

Maintenance: washouts have to be opened to clear out silts. It is also important to patrol the pipeline to check out for possible leaks, exposed pipes, illegal connections and damaged pipe markers, and pipe supports of pipe covers. The following are the potential problems that may be experienced:

Table 23: Potential problems encountered in pipeline systems

Problem	Probable Cause	Possible solution
Frequent pipeline breakages	• Pipeline laid too shallow hence exposed e.g. due to traffic loading • Wrong pipe class	Replacing or relocating the pipeline, with assistance from a registered water engineer or qualified plumber/ water technician
Pipe lacking water	• Problem in design • Dry source • Closed valve • Blockage – Airlock	Inspect the pipeline from the intake and check if water reaches various points. A qualified water engineer or plumber/ water technician should be consulted
Poor quality of water	• Raw water polluted • Faulty treatment • Possible bust hence introducing sediments/pollutants	Check out the problem source and find a suitable solution Conduct water quality test if appropriate
Low pressure	Very high consumption, bursts, pipe deposition/blockage, pipe constrictions	Check out if the maintenance solution will solve low pressure through rationing, or is a problem related to design. A qualified water engineer or plumber/ water technician should be consulted

Common materials and spare parts required for pipelines include valves, taps and washers, glue, threading tape, fittings for suitable diameters, and pipe lengths for diameters common in the project. They should be obtained from a well-provisioned hardware.

6.2.6.3 Water Treatment

The most common method of water treatment is chlorination, which may either be flow chlorination or batch chlorination. In flow chlorination, the water is treated by continuously mixing small amounts of chlorine into a freshwater flow and mixed by turbulence at the point where the water enters the reservoir. On the other hand, in batch chlorination, chlorine is mixed with clean water in the reservoir while restricting any flows for about half an hour for disinfection to occur, before opening the outlets and it usually happened in every new fill into the reservoir.

Operation: chlorination must always consider the amount of water in the reservoir and its quality in order to adjust the doses. Refilling of a fresh solution of chlorine has to be done weekly in the chlorinators at intervals, depending on water usage. Steel tanks should be checked for any corrosions and be repainted annually.

Maintenance: cleaning the chloride salts has to be done regularly, including adjusting the chlorinators. The chlorine solution's housing tank has to be also maintained and cleaned, and the hoses replaced in case they are affected by the chlorine. The utensils and hand gloves used in chlorine preparation have to be also replaced once in a while.

Organization: a caretaker, who may as well be the water operator, is selected by the water committee and trained in a state or county water facility. Chlorine should be obtained in sufficient amounts from a recognized and registered health department laboratory.

Recurrent Costs: they are usually low, and mainly involve the purchase of chlorine compound, monitoring and paying the caretaker's salaries. Other minor costs include the purchase of spare parts, hoses and rubber gloves.

6.2.6.4 Abstraction Points

These are the points where water users fetch water directed from a water source. It may be either a water kiosk, a public stand post having one or several taps, or a water trough. A water trough is usually located several metres away from a public stand post or a water kiosk to provide water for livestock. In the study area, the infrastructure projects are to be constructed to serve the local community and the pastoralists as they move along these migratory routes, hence expected to serve a large number of people and livestock. Some stand posts may have a regulating valve connected to the mains to control water flow. It is necessary to fence the stand post to keep livestock away, and also have a water meter to monitor abstractions.

Operation: the caretaker is in charge of the operations in the abstraction points which include cleaning, controlling the quantity of water abstracted, and collecting the fees charged. The fees charged (tariffs) should be set at a standard cost depending on quantity and usage, and should also be affordable to the community. The money collected will help in the maintenance of these structures. The tap site has to be cleaned every day and the drain inspected. Apart from fetching water at the stand post, other domestic activities such as washing clothes, bathing, etc. should be restricted from the abstraction point's premises. In case of water conflicts that may arise among the locals on ground levels, the water operators shall help in solving the conflicts hence helping in promoting peace among both the local community and the outsider communities sharing the water resource.

Maintenance: it is recommended to clean the drain and trough occasionally and ensure there is no stagnant water within the compound. The fence should also be maintained and large cracks in the structures repaired. The tubing, as well as the rubber washer, may as well need to be replaced after some time.

Recurrent Costs: they are usually low, which include the payments of caretakers' salaries and other minor repairs such as taps, pipes, wall, column, drain, or apron.

6.2.6.5 Solar Powered Pump Systems

These systems are preferred because they utilize green energy (solar energy) and are reliable in the rural setup where electricity access is a challenge. Their low operational costs also make it appealing to the rural areas. They are however prone to human interference through vandalism and are very sensitive if repaired by unqualified technicians.

Operation: the operator/caretaker who is in control of the water infrastructure such as a borehole or shallow well operates the system.

Maintenance: minimal maintenance is required. The solar-powered pump system experiences a few technical issues if well installed. Minor maintenance activities include dusting the control unit and panels weekly if the system is in a dusty environment. There are safety features installed to the submersible pump and the control unit to protect it in case problems arise. An experienced and qualified water technician will be required to repair the system in case of technicalities. The exposed terminals on the inverter or panels should be inspected regularly for corrosions or damage.

Table 24: Potential problems encountered in solar-powered pump systems

Problem	Probable Cause	Possible solution
Low or no power/ slow motor (less water pumped	Wet or corroded terminals; inadequate sun; corroded or wet terminals	Clean, dry or replace terminals
System turning on & off	Poorly installed regulator/inverter	Install away from water/sunshine
Water leakage from discharge head (mono-pump)	Pump gland seal leakage	Slightly tighten the pump gland nuts

Recurrent costs: A submersible pump may last for at least ten years if properly installed and operated as per the manufacturer's instructions. High-quality solar panels take long before replacement if well installed and not tampered with, and may have a manufacturer's guarantee of even up to 20 years.

6.3 Community Participation in Management, O&M

Following recent trends in water management and budget and resource constraints, a participatory monitory approach should involve the local community, who are the main and direct beneficiaries. This helps in strengthening the participatory approach in the sustainable management of the water resource in the area. Through the formation of Water Resources Users Association (WRUA) in Kenya, there is collaborative management of water resources at the sub-county level and ensures that beneficiaries of the water resource are fully and actively involved in all aspects of planning, development, and efficient utilization and management of water resources.

During the field study phase, it was found that there exists some form of local organization in the management of water resources in the Kenyan part. These organizations are however less formalized and have limited skills needed in the operation and maintenance of different water infrastructure technologies. The community management approach mainly aims at enhancing sustainability and reliability of the water infrastructure, improving the community's health and social well-being, improving confidence and problem-solving capacities for further development activities, reducing the investment and operation costs for the infrastructure and promoting gender-sensitive solutions.

The local communities in both Kenya and Somalia may not necessarily have a homogeneous status or way of life. It is important to recognize differences such as literacy levels, people living in the centre and at the peripheries, social status, and the vulnerable groups such as children, the aged, women, and persons living with disabilities to promote community-based management.

Proper maintenance of the water infrastructure can only be assured if the community has acquired ownership and commitment to address issues properly. Following this, these aspects will contribute to the establishment of proper operation and maintenance:

- ✓ Good workmanship during the construction of the water infrastructure.
- ✓ Full involvement of the community to ensure operation, management and maintenance after completion of the project.
- ✓ Presence of a trained professional near the water infrastructure to ensure adequate repairs if there should be any serious damage to the structure, beyond the capacity of the trained caretakers.
- ✓ Proper linkage between the local community, local administration, and the governmental sector to ensure technical and advisory assistance for the community.

6.3.1 Staffing and Technical Assistance in O&M

The management committee

They are elected from the local community in a new term, during the General Meetings by the Water Resource Users Association (WRUA), and are in control of WRUA management. They give directions to the water bearers on how they shall accomplish their roles. They establish a finance sub-committee, an audit/monitoring sub-committee, and a finance sub-committee. They also authorise all money disbursed on WRUA's behalf, run project accounts, recruit staff, ensure auditing of projects, engage in conflict resolution, and are actively involved in planning and implementation of water projects through activities such as membership registration, tariff setting, metering, etc.

Office Bearers- Comprises of the chairperson, secretary and treasurer (all under WRUA).

Chairperson: presides over all meetings and files all WRUA's returns annually with the registering authority. S/he ensures all project activities run smoothly and ensures the enforcement of by-laws.

Secretary: Deals with all correspondence of WRUA. S/he is responsible for issuing notices convening all meetings and shall keep the meetings' minutes and preserve records for future reference.

Treasurer: Receives and dispenses funds as directed by the committee, and ensures proper documentation of all transactions for received payments (e.g. Tariffs collected) and expenditures. All transactions must be recorded and receipts well-kept for future references. Such records include salaries of the water committee, water payments, and procurement costs.

Ordinary Committee Members- The selected members deputise the office bearers. They represent the water users and present their views at committee meetings. They monitor the office bearer's activities and in case of any mismanagement, they report. They also ensure committee meetings and mandates occur transparently and disseminate information and decisions from the committee meetings to the water users.

Procurement Sub-Committee- The selected members are non-members of finance or monitoring sub-committees and are tasked with procuring all items needed by the WRUA under the approval of the management committee and ensuring they are of high quantity and quality.

Monitoring and Evaluation Sub-Committee- the selected member is responsible for monitoring funds and other resources usage; providing independent reports as needed; ensuring works and services are of high standards; ensuring implementation milestones are within schedule and, that all information relevant to other sub-committees is openly displayed and discussed.

Financial Sub-Committee- The selected members ensure all financial records are updated; are responsible for financial bookkeeping; approval of all financial transactions; preparation of monthly accounts statements; availing all transactions to WRUA members; and, ensure safety of accounts, cash balances and documents.

Auditors- They analyse the utilization of resources occasionally and are assigned to control the use including results achievement. It is usually done at the end of a fiscal year or the end of a project phase. The auditors also collect debts, ensure maintenance of the book of accounts, and present audit reports to the committee members.

Operators- They are the caretakers selected by the water committee for a given period to control/operate community infrastructure. Apart from this, they also monitor water usage, do minor repairs and maintenance activities e.g. lubrication; report for any spare part needed or major maintenance required; ensure safety of the machines; and, maintain order within abstraction points among other activities. They are the overall managers at the water points and receive payments (tariffs) from the water users.

Technicians- These are the trained and skilled personnel tasked with relevant practical and training background in servicing and repairing these water supply technologies. They may either be internal (from within the local community) to perform fewer complex tasks or external if more technical expertise is required. They may perform plumbing, electrical, mechanical, and other engineering works depending on their expertise background. Only a qualified technician should undertake the repairs in case of a major breakdown or service required. The technician's contacts should always be with the water operator in the event of any services needed.

WRUA's Meetings may either be committee meetings, sub-committee meetings, annual general meetings (AGMs), or special general meetings.

Committee meetings- held by the project committee members regularly, for instance monthly, to mainly discuss the project's administration.

Sub-committee meetings- held by the sub-committee to discuss certain matters regarding the project.

Annual General Meetings- held annually by the committee to inform members about the accounts of the project and the project's progress. Election of new members is also done during the meeting.

Special general meetings- often seen as extra-ordinary meetings, they are held when special business is to be discussed by members.

6.3.2 Capacity Building for O&M

Capacity building for the local community is important for sustainable O&M of water infrastructure. This touches on technical matters, management, planning and budgeting. It requires leadership training while reviewing the community's development history which builds the community's trust

and confidence. Management skills should also comprise conflict handling which usually exists either among the local communities or with other outsiders.

Sub-standard performance of water supply systems in the study area has been a result of inadequate O&M and management skills and inadequate technicians among the communities which have paralysed water supply systems in some parts of the study area. Most water committee members expressed the need to improve their management capacities since they have very little basic training for instance in book/record keeping, tariff management, and conflict management. The existing organizations should be more formalized and promoted by enhancing their capacities in water resources management and other technical activities such as electrical, mechanical, plumbing repairs, and maintenance, which is generally low.

It is important to enhance the aspect of practical management tools for the water committees and conduct recurrent and periodic training to refresh their skills with the existing and new technologies. The training programmes and supporting material should consider the beneficiaries' way of life and literacy levels. Partnerships between the communities and external agencies are important in improving and supporting the management, and, operations and maintenance capacities of the communities. The local Technical Vocational Training Centres in partnership with various Government agencies, county/state governments, Water Works Development Agencies, Non-Governmental Organizations and the private sector should be further supported with material and technical training expertise for the locals in O&M. The training shall be done by the water experts from these institutions in conjunction with the Water Users Association in activities related to water management, operation, monitoring (Dynamic water levels, water quality and discharge monitoring), and maintenance.

6.3.3 Women Participation in O&M

The water management committee in the study area is the decision-maker on water planning and management issues at the local level and is dominated by men. Women have been side-lined in decision-making processes in the community on issues concerning water resources, despite them being the principal water users. They are mainly responsible for fetching water for their homesteads which has been mainly attributed to the community's way of life and are regarded as the water and sanitation managers at household levels.

Gender balance ought to be considered during the design, construction, operation, and maintenance of water infrastructure since the side-lining of women in water development projects hamper effective use in management structures and facility designs of water supply projects. Gender stereotypes that women cannot engage in technical maintenance and repair have been recently confronted and research has shown that they may become better repair and maintenance staff than men due to their regular visits to the abstraction points; easier communication between female users and maintenance staff; their greater sensitivity to social pressure from other women to perform well; the significance of health aspects; and, their training in modern technology in acknowledgement of their old skills in managing domestic water supply systems.2 Many water development projects established in recent years by USAID have shown an immense positive correlation between women's level of participation and the success of the project objectives (FAO and UNICEF, 2012). The unsustainability of various water projects in different areas of the world has been as a result of excluding women in the planning activities for these projects.3 The World Bank did a study in fifteen countries which showed that the success of water projects is attained when executed with gender sensitivity.4

Recently, there have been better opportunities for women to be trained for technical O&M jobs going beyond water resources management in the Region. Such efforts ought to be improved and their involvement in O&M be more prevalent in the study area. This should also touch on improving

[2] FAO, UNICEF. 2012 A Trainer's Manual for Community Managed Water Supplies in Kenya

[3] Regmi, S.C & Fawcett, B. (1999). Integrating gender needs into drinking water projects in Nepal. Gender and Development, 7.3: 62-72.

[4] Gross,B., van Wijk, C. & Mukherjee, N. (2000). Linking Sustainability with Demand, Genders and Poverty: A study in community-managed water supply projects in 15 countries. Washington, D.C.: The World Bank.

their capacities through management training which will also improve their self-confidence and social status. The existing gender policies should also be further strengthened to encourage gender balance and women empowerment. Nevertheless, some societies uphold barriers that have to be appreciated in designing organisational schemes.

6.4 Tariffs

A tariff is a price set on goods or services for the consumers. Tariffs should be set fairly and rationally to support the project's O&M costs, such as repairs, and payroll payments e.g. for management and technical teams, spare parts purchases, or for future infrastructure expansion of the project. The main purpose of this is to support the provision of quality water services to consumers and not to benefit from rates. The pricing schemes used in water projects include:

Flat Rate per household- it may either be annually or monthly and is usually easy to implement. The rate is usually fixed regardless of the consumption rates by the households which differ. For instance, the cost of water per household per month for domestic use is charged at $15 in Liboi and $5 in Arbajahan.

Flat Rate per unit volume- depends on the amount of water fetched in a standpipe or water kiosk by the water user. Water in most parts of the study area was charged at a fixed price for a uniform container, such as a 20-litre jerry can. The tariff is usually fixed at a rate for each cubic metre of water for metered connections like in Habaswein Township, where water is charged at 100 per cubic meter.

Charge per unit of livestock- varies with the type of livestock. For instance, in Arbajahan, camels had a different rate from shoats or cattle per head at Kshs 10, Kshs 2, and Kshs 4 respectively.

Block Tariff- increases with an increase in the total volume of water consumed at a given range. For instance, $0.2 is charged for water consumed between 0-4.9m^3 monthly, and increases to $0.4 for water consumed between 5.0-19.9m^3 monthly. This enables charging of low tariffs for small consumers (pro-poor structure) and vice versa, hence encouraging water efficiency through reducing its consumption by its users.

In Somalia, community water is managed by the private sector, mostly by NGOs, who offer water at no cost to the locals, although in urban centres such as Kismayo, there is a flat rate per unit volume tariffs set at about $1 to $1.3 per cubic metre. It is therefore important that the government of Somalia impose setting tariffs to cater for O&M costs for community water projects. In Kenya, the tariffs at the community level are collected by the water operators and managed by the water committees.

The basis of setting tariffs should involve direct discussion with the water users to come up with an affordable rate in a manner that is fair, justifiable and easy to control. It should also consider schools and the vulnerable groups consisting of the aged and people living with disability by excluding them from water payments. In setting up a tariff structure, the costs to be covered should be specified for instance the recurrent costs such as the water attendant's salary, spare parts, chemicals, energy costs, etc. which will depend on the governments' policies and strategies and community arrangements for cost recovery. Other running costs such as electricity bills if connected to the national grid, water treatment in sub-surface dams, etc. will as well be included in the calculations to determine the tariffs.

A case example for setting tariffs for domestic water supply from a solar-powered borehole is as illustrated below:

*i) Operator's Monthly salary (**S**): $100 = $1200 per year*

*ii) Monthly maintenance Cost (**M**): $150 = $1800 per year*

(Technicians, spare parts etc)

iii) Current replacement cost of pump =$ 10,000

Approximate lifespan before replacement =10 years

Approximate interest Rate =10% per annum

*Annuity (**A**) =$1627*

(Amount saved annually to replace pump)

*Number of households (**N**) =200*

*Annual Household Tariff(**H**): **H= (S+M+A)/N***

***H**= (1200+1800+1627)/200*

H= $23.13 per year

Inflation may be considered in the calculations and adjusted accordingly. For instance, an 8% inflation on the calculations above per annum would require raising $21589 i.e., (10,000*(1+0.8) ^10) in the tenth year for the pump's replacement hence an extra amount has to be saved annually to keep up with inflation.

Apart from inflation, other factors to be considered in revising the tariff include the changing cost structure, demand patterns and the need to increase funds for further expanding the water infrastructure. Delays in adjustments may seriously affect the financial sustainability of the project hence it is important to review the tariff levels and structure for instance, annually for piped systems. The tariffs will be paid to the water operator or water committee.

To optimize and reduce the O&M costs, it is recommended to make use of renewable sources of energy such as solar; increase spare parts availability at an affordable price; apply economies of scale for larger systems (which reduces consumer's cost); involve water users in preventive maintenance activities; installation of systematic leakage control; adopting a firm maintenance culture within the local community and professional staff; and, having proper and functional administrative and financial control mechanisms.

7 GROUNDWATER MANAGEMENT AND MONITORING PLAN

7.1 Introduction

The Merti provides the majority of the water supply in the region it spans. Insufficient management strategies and water resources monitoring, for both surface water and groundwater, within the Merti area is a major setback for the sustainability of the resource. Improper management practices will lead to further deterioration and depletion on a regional scale that is currently experienced at the local scale within the abstraction points.

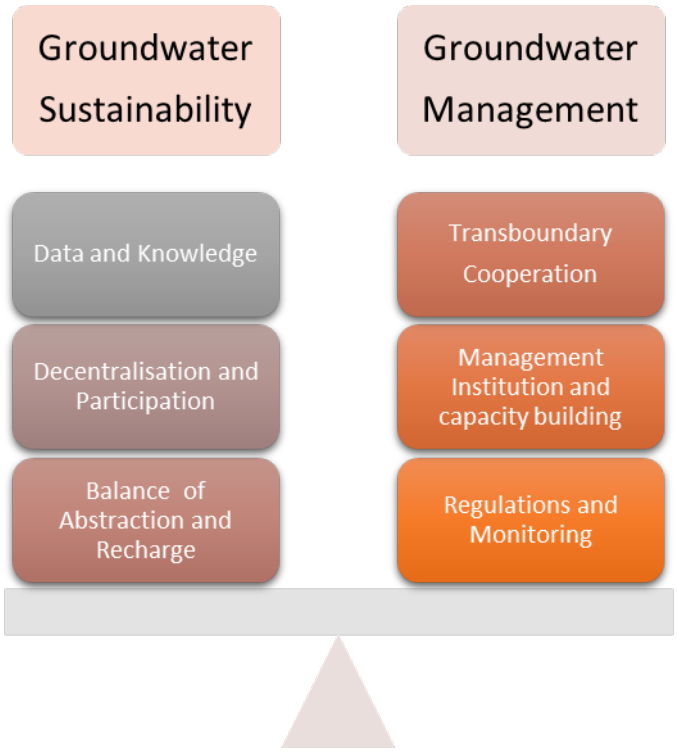

Figure 3: Balance of Sustainability of the Merti with Management

7.2 Integrated Water Resource Management (IWRM)

Conjunctive use of surface water and groundwater through coordinated development and management of water, land and related resources, will maximize the resultant economic and social welfare equitably without compromising the sustainability of vital ecosystems.

The development of the Merti Aquifer should encompass a long-term management strategy for the entire Ewaso Ng'iro basin. Catchment areas for surface water; and Aquifer for groundwater monitoring and management should be prioritized within the IWRM framework for the shared resource, Merti, by Kenya and Somalia. Management, strategies, programmes, financing arrangements and control of the Merti should be designed for the whole Ewaso Ng'iro basin and cooperation agreements signed by the riparian states.

Development of the TBA management plan has taken various steps in the course of the study which include:

- Appreciation of knowledge of the Merti during the launch of the study and the desk review phase during the study.
- Technical and diplomatic contact between the riparian states during field mapping of the aquifer and conventions held by the states in inaugural meetings hosted by the IGAD secretariat with delegates from the riparian states.

  During this phase, the following steps are proposed for the management plan:
- Incorporating a joint action plan toward sustainable management of the Merti aquifer.
- Strengthening and extending activities of existing organisations for transboundary water management to the Merti aquifer.

- Signing agreements by the riparian states guided by the UN laws on transboundary aquifers.

Strategizing for management of water resources in the region within the IWRM framework should consider:

- Public participation
- Water resource quality, quantity and setting
- Water conservation and resource protection
- Water resource use
- Coordination of land and water resources management
- Legal & institutional setup, and set objectives for the riparian states

It is important to note that any groundwater management strategy or plan is ultimately subordinate to the IWRM & WE (Water Efficiency) Plan. The principal activities in respect of groundwater in the Plan are: –

- To improve monitoring and data collection networks;
- To ensure a balance in abstraction and recharge by implementing artificial groundwater recharge (MAR) and catchment protection programmes;
- To characterise the use of the Merti according to the water parameters;
- Prepare project designs for aquifer exploitation;
- To identify Ground Conservation Areas (GCA).

7.2.1 Catchment Management

Set objectives for the management defined catchment areas in the Ewaso Ng'iro basin should include but are not limited to:

- ✓ Ensure a resilient catchment through community engagement and promoting integrated, sustainable land management which benefits the rural economy
- ✓ Improve water use management for both surface and groundwater
- ✓ Improve water level management, reduce flood risk and preserve and protect water resources
- ✓ Secure better soil conservation and water quality
- ✓ Create extensive habitat connectivity and species resilience
- ✓ Ensure good partnership governance and develop a robust evidence base

7.2.2 Groundwater Management

Sustainable and efficient water use at all times can be guaranteed by measures that ensure continuous supply meeting demand, good water quality, aquifer protection and efficient water use.

Uncontrolled exploitation and poor planning of the Merti have shown localised impacts observed in settlement areas of towns around central Merti where water levels have declined over time. A strategic plan for the management of the Merti alongside catchment management should include plans agreed by the riparian states.

The groundwater management plan should be objective to:

- ✓ Define groundwater use for the Merti (for human consumption, agricultural and industrial use) and quantify current abstraction.
- ✓ Develop comprehensive hypothetical groundwater demand and projection.
- ✓ Define water equitable allocation principles applicable to the Merti region.
- ✓ Develop a groundwater-management model for estimating the spatial and temporal distribution of pumping related drawdowns; the effects of pumping on surface water are critical for ecosystems.
- ✓ Develop potential adverse impacts from development to meet demand.
- ✓ Solutions for the Groundwater-Management Model to ensure sustainability.
- ✓ Prioritise the alignment, centralisation and accessibility of data and information of the Merti by the riparian states.
- ✓ Develop a groundwater monitoring plan

Equity, ecological sustainability and socio-economic development to be the ground basis for developing a joint management strategy for the Merti.

7.3 Data Management

IGAD should formulate data-sharing protocols for WRA and the Ministry of Water, Sanitation and Irrigation in Kenya; and, the Ministry of Energy Water Resources in partnership with SWALIM in Somalia and establish a database for existing and collected data for the entire Merti catchment area.

The goal of data management is to inform specified needs to set joint objectives for monitoring programmes and regulation of groundwater development.

7.3.1 Data Sources

Sources of data availed for management of the Merti and its catchment include:

- Water managers from respective riparian states, WRA in Kenya and the Ministry of Energy and Water Resources Government of Somalia.
- Monitoring stations from hydrometeorological and groundwater monitoring stations through the entire catchment.
- Remote sensed hydrometeorological data including precipitation and evapotranspiration.

Collection and handling of monitoring information should follow the structures set in the riparian states and be shared with a formulated joint committee discussed under subchapter 7.5.6.

Automated relay in monitoring information should be considered with a constant real-time update that should be stored in a centralised database during the implementation of monitoring programmes.

7.3.2 Data Handling

Accurate data collected in a quality-controlled manner using appropriate statistical tools and communicated in a timely and understandable fashion require considerable investment in knowledge and equipment to ensure the desired return on investment. Existing structures in data collection, handling and management will be improved where need be. Steps for handling data in the Merti catchment area include:

1. First archiving the existing and monitoring data at respective riparian states.
2. Validation of the data
3. Data storage for collected and validated data in a manner that they are accessible and complete concerning all prioritised parameters. A sufficient amount of extra data necessary for interpretation should also be included.
4. Data analysis and interpretation in a clear set out analysis strategy towards achieving set objectives. Generally, data will be stored on computers and the data analysis, mostly a statistical operation, can make use of generic software packages and/or GIS.
5. Data exchange for modelling purposes for the entire basin for the sustainability of the resource. Agreements and management strategies, discussed elsewhere in the report, should be set.
6. Reporting of resultant information (e.g., GIS maps) in outlined protocols helps develop management measures and water use characteristics.

7.3.3 Dissemination and Access to Information

There is a need for a standard to exchange digital data within the set up joint institutions. A database should be the basis for the definition of such a standard. Ideal common data storage systems for ease importation to modelling and analysis should be set up. The data exchange programme should be included in the legal arrangements signed by Kenya and Somalia.

Information from the analysed data should be shared across the stakeholders freely to make informed decisions in managing, developing and protecting the Merti and its catchment. Information should be shared to:

1. Water resources managers to make informed decisions in forming legislation instruments
2. Consultants and professionals tasked with studying and developing the resource

3. The public/users should be equipped with water quality information to make informed decisions in their investments involving the water sector.

7.4 Monitoring Programmes

Groundwater monitoring is required for an accurate evaluation of the current condition of groundwater resources as well as a credible prediction of future change. There could be no successful groundwater management without an accurate assessment and projection. Monitoring of water resources within the Merti aquifer should take an integrated approach.

Groundwater monitoring network plays an important role in:

- Assessing groundwater conditions, volumes, recharge rates and saline intrusion
- Managing groundwater, including groundwater access, allocations and extraction, protecting aquifers and bores
- Providing data for the development of groundwater sharing plans

Water resources monitoring mainly involves:

- Resource monitoring (quantity, quality, recharge, discharge)
- Compliance monitoring (well spacing, abstractions, water quality according to prescribed standards)
- Catchment monitoring
- Pollution containment monitoring e.g. From mines, landfills, agricultural land use

7.4.1 Review and Critique of Monitoring Network

There have been efforts to install surface water and groundwater monitoring stations in Kenya and Somalia.

Somalia: FAO-SWALIM has installed several monitoring stations along Rivers Juba and Shebelle and their tributaries and in various boreholes in Somalia for planning and sustainable development and management of water resources.

Kenya: The UNHCR agency installed 20 telemetric gadgets within the Merti aquifer in 2013, and real-time data was transmitted online. However, out of the 20 installed telemetric gadgets, only 9 were still relaying data by 2017. This calls for the installation of a proper monitoring system and management.

Recently, a tremendous amount of work was undertaken with WB support under the KWSCRP in Kenya for a national hydrometric station network design and installation of automated telemetric gadgets in boreholes and shallow wells.

There are still gaps in groundwater monitoring by the riparian Member States. Insufficient hydrological and telemetric monitoring stations to ensure sustainable management of water resources is a threat to future socioeconomic sustainability in the region.

One surface water monitoring station on a tributary of Ewaso Ng'iro River under Capital Projects funded by GoK.

There are no records for recent precipitation monitoring by the riparian countries. Free source remote sensed data is used in assessments from the Climate Hazard Group InfraRed Precipitation with Stations (CHIRPS) dataset developed to support the United States Agency for International Development Famine Early Warning Systems Network (FEWS NET). Hydrometeorological monitoring is limited to an insufficient number of monitoring stations in the region.

The majority of the installed monitoring stations are non-operational. The installed stations only cover a small geographical area not representative of the whole hydrogeological basin. The existing monitoring stations should be relaunched for both surface and groundwater with new monitoring networks set up and their data integrated into a transboundary monitoring database.

7.4.2 Water Resources Monitoring Strategies

Focus should be placed on the collection of hydrometeorological data and monitoring especially in catchment areas, to quantify available surface water within the basin under natural conditions, in both space and time to assess the probable recharge.

A network of piezometers should be distributed across the aquifer to monitor the known pressure, deterioration of water levels and water quality. Networks to include monitoring the impact of land use on the Merti (stations within the refugee camps and irrigated areas by the Merti).

7.4.2.1 Catchment Monitoring

Hydrometeorological Monitoring

A comprehensive hydrometeorological monitoring network design for the Ewaso Ng'iro basin is proposed to characterise all aspects of surface water within the basin and their interaction with groundwater. These characteristics comprise aspects of water balance and their quantification will provide a basis for regulations on abstraction regimes. This will also help in:

- Improving water resource planning and management from surface water and groundwater monitoring
- Flood disaster risk management from assessed flood-prone areas from prehistoric and elevation data sets
- Drought risk management
- Catchment areas protection by assessing soil erosion and sediment transport
- Water quality management and pollution

Design for monitoring stations should be undertaken which often follows:

1. Defining stream flow and surface water level stations. Existing stations, like those reviewed in sub-chapter 7.4.1, established at key locations can provide a strong starting point for the network.
2. Identifying how the core hydrologic monitoring stations achieve regional and national benefits based on the defined water management service needs. Supplement the design to fill gaps for more site-specific regional service needs such as locations that require water quality and sediment monitoring.
3. Review and revise stations based on consultation with relevant water management stakeholders with regards to how the design achieves the national service needs.

Hydrometeorological data collected, and assessed for comparison with past data to enable prognosis of future essential in the planning of existing water resources are:

1. Precipitation
2. Streamflow data
3. Evaporation data

7.4.2.2 Groundwater Monitoring

A properly designed monitoring strategy to consider the drawdown levels, water static level, abstraction levels and the water quality parameters are being constituted based on the area coverage of the Merti aquifer area, points of recharge into the aquifer, and the areas of perceived and known high abstractions.

Existing monitoring strategies tend to focus attention primarily on identifying and controlling the consequences of groundwater quality deterioration and not on the preventive protection of groundwater quality. An early warning monitoring strategy is therefore needed, which detects groundwater quality problems before massive groundwater quality degradation occurs. This strategy supports sustainable groundwater quality management and protection policies and helps to identify human impacts when they are still controllable.

In line with the available budget and resource constraints, a participatory aquifer monitoring approach involving all stakeholders: Ministry of Energy and Water Resources, Somalia; WRA, Kenya; the local community who are direct beneficiaries; and various levels of government should be undertaken.

The design of the monitoring strategy considers the drawdown levels, static water level, abstraction levels and the water quality parameters. It is constituted based on the area coverage of the Merti aquifer, points of recharge into the aquifer, and the areas of perceived high abstractions.

The operators should be trained by the NGOs/GoK in conjunction with WRA and Somali counterparts and the Water Users Association. They should be derived from the local communities to enhance the sense of community participation and be trained on the use of various equipment.

Drilling of boreholes purely dedicated for monitoring should be executed upstream and downstream of the Merti aquifer to monitor the trend in terms of water quality and water level.

Monitoring should also be instituted in some of the existing production boreholes in the area of interest based on the above factors to determine the dynamic aquifer conditions. This is important as static water (in dedicated monitoring boreholes) may not reflect the absolute conditions of the aquifer. Monitoring of production boreholes especially the rates of drawdown and recovery may help indicate aquifer response to production and thus address any fears of aquifer depletion due to over-abstraction at a local level. When evaluating the dynamic water conditions in a production well, it is important to evaluate the performance of the well to correct any changes associated with inefficiencies of parts of the borehole infrastructure.

Strict enforcement of proper development of newly drilled boreholes, Installation of airlines, to allow for periodic monitoring of the wells.

7.4.2.2.1 Identification of Monitoring Wells

Criteria for selecting monitoring wells are:

1. Geographical distribution -Monitoring wells should be distributed across the entire aquifer.
2. Areas proposed by managing institutions - Monitoring wells' locations should be aligned with areas identified by managing institutions in the respective riparian countries. WRA from Kenya, for instance, shall be involved in the installation of the water infrastructure as per their proposed groundwater monitoring network.
3. Areas where the most pressure is experienced – In areas around the axis of the Merti, Urban centres and areas around refugee camps where large amounts of water are abstracted.
4. Conservation zones – Areas designated by the water managing institutions for groundwater recharge purposes. They include; wetlands and catchments areas.

After identification of the monitoring well, preferably newly drilled non-production wells in the proposed locations in addition to the existing monitoring wells in the entire Merti aquifer should be undertaken. The wells are to be equipped with telemetric and water quality monitoring equipment to ensure there is enough knowledge of the aquifer state for proper planning and management.

Variations in the following parameters should be monitored spatially and over time:

i. Water Levels
ii. Water Quality

7.4.2.2.2 Water Levels Monitoring

Groundwater levels can be monitored by taking water level readings manually. This however means that very little information is collected, because only one reading is done per manual reading.

Much better is to install divers, which can take water level measurements at a very high interval (for example every half an hour). This means that far more information about the fluctuation of the groundwater levels is collected, such as: how quickly the groundwater responds to rainfall, what is the annual variation in groundwater levels, is there a daily fluctuation etc.

Because the divers measure the total pressure (both air pressure and water pressure), a baro-diver should be used as well in an office. The moments of measurement in the baro-diver and the groundwater level diver must be the same.

The monitoring devices comprise of water quality and levels probe attached at the end of an electronic unit which uses an available GSM network to relay the data to a server.

For water level monitoring, two probes should be used i.e., one probe is immersed in the borehole below the lowest possible drawdown level to measure the water pressure while the other is suspended at a shallow depth below the ground level to measure the atmospheric pressure. The difference in water pressure and the air pressure gives the pressure of the water column above the probe which is converted to the length of the water column above the probe.

Existing and newly constructed production boreholes should be equipped with meters with automatic switches to monitor and regulate abstraction from the Merti.

Instruments for water level monitoring include Level Measurement Devices, Telemetric devices, Piezometers, etc.

Parameters monitored include ***Static Water Level and Abstraction Levels.***

Figure 4: Groundwater Monitoring Divers

7.4.2.2.3 Water Quality Monitoring

For water quality monitoring, the device has an electrical conductivity probe that is installed along with the raiser main of the borehole. Temperature conditions are also measured by all the probes (pressure and EC) simultaneously. Data collection by the device is user-defined and relayed to a server from where it could be accessed in real-time.

Groundwater sampling should be carried out. It is advised to do this once every three months. Both the boreholes in town and the main borehole out of town that is used for water trucking should be sampled.

There are quite a few requirements for groundwater sampling:

1. Before you take water samples, you need to know which parameters you want to have analysed. Because different parameters require different types of bottles (glass or plastic), different amounts of volumes, or mixed with an acid or not. Things that should be analysed are:
   - Macro chemistry (including nitrate, nitrite and ammonium), both cations and anions
   - Heavy metals
   - Volatile aromatic compounds
   - Volatile chlorinated hydrocarbons
   - Mineral oil
2. A sampling device is needed for the small piezometer at infiltration sites, for example, a tube that fits into the piezometer with a non-return valve or a foot valve for the piezometers
3. Requirements Lab

Water samples taken should be sent to a certified lab, with good recommendations. It should be able to analyse the needed parameters. It might be that different labs are needed for different types of analysis. For some analysis, glass bottles might be needed, or acid liquid has to be added to the samples. Exact requirements have to be discussed with the lab so that the data collected is of good quality.

The following water quality data should be monitored: ***Electrical Conductivity, Total dissolved solids, pH, salinity & Temperature.***

7.4.3 Groundwater Monitoring Focus Areas

The Merti aquifer should be divided into five areas for monitoring;

1. the main aquifer
2. the points of recharge and upstream area,
3. the area within Dadaab axis
4. at the fringes of the aquifer
5. and in Somalia.

Monitoring wells should be established at all these locations to efficiently monitor the Merti aquifer in this area. More often the existing boreholes can also be monitored.

Monitoring should comprise:

(i) Bi-weekly Static and Dynamic water levels.

(ii) Annual water quality analysis.

Additionally, river levels and discharge of Ewaso Ngiro and Lagh Dera rivers should be monitored by the establishment of gauging stations along its channel. Rainfall occurrence and variations should also be monitored by establishing rain gauges at different points to analyse their effects on groundwater. To investigate the direct recharge by infiltration of precipitation, meteorological stations should be installed at different locations more often in areas where the monitoring wells are located.

7.4.3.1 Main aquifer

It is important to monitor the main aquifer body, as here most water is stored and most abstraction takes place, and as such is the most important part. It is proposed to monitor all along the axis of the main aquifer, starting upstream of Habaswein to Liboi and Somalia.

7.4.3.2 Points of Recharge and Upstream Areas

This occurs in areas of Habaswein, Sericho and Hadado south in the west at the mouth of Ewaso Ng'iro River which forms the main recharge to the Merti aquifer.

7.4.3.3 The Dadaab Axis Area

The main points of interest are the, IFO, Dagahaley, Hagadera and Dadaab. These are largely viewed as the most abstracted areas within the aquifer. It is therefore imperative that at least one monitoring well be established in each area. A comparison of the results should then be done with the data results from the recharge point and inferences made on the aquifer behaviour.

7.4.3.4 The Aquifer End Fringes

This occurs at the southern borders of the Merti aquifer. Monitoring wells in different locations should be established in this area to monitor the aquifer parameters within this area and the observations made be compared with the rest of other observations wells.

7.4.3.5 Somalia Abstraction

Additionally, in this study, it is proposed to add several monitoring wells in Somalia at places of abstraction. This includes the towns of Dhobley, Hoosingo, Tabda and Haga Liban (towards Afmadow), as well as monitoring in the coastal zone.

A map showing a comprehensive monitoring network for groundwater is shown below (Figure 5 and Table 25). This map includes 29 boreholes, spread over the greater Merti Aquifer, including the locations mentioned above. It is recommended that this monitoring network is fully implemented, to follow developments in quantity and quality.

Table 25: Names and locations of monitoring wells to install monitoring equipment.

Number	Long	Lat	Location	Type
MM001	40.284	0.192	Dagahaley BH6	Dadaab Axis
MM002	40.310	0.063	Dadaab BH2	Dadaab Axis
MM003	40.306	0.118	Ifo2	Dadaab Axis
MM004	40.362	0.006	Hagadera BH3	Dadaab Axis
MM005	40.579	-0.174	Welmerer	Fringe Monitoring
MM006	40.097	0.076	Abakailey BH	Fringe Monitoring
MM007	39.326	0.901	Skanska BH3	Fringe Monitoring
MM008	39.652	0.473	Shanta-Abaq BH1	Fringe Monitoring
MM009	39.930	0.245	Ali Karsadhe BH	Fringe Monitoring
MM010	39.492	1.012	Habaswein WS BH1	Main aquifer
MM011	40.873	0.352	Liboi BH1	Main aquifer
MM012	39.848	0.492	Meri BH1	Main aquifer
MM013	39.713	0.638	Abakore BH3	Main aquifer
MM014	40.512	0.189	Maleyley BH1	Main aquifer
MM015	39.567	0.840	Dilmanyale New BH	Main aquifer

MM016	39.580	0.654	Baraki BH2	Main aquifer
MM017	40.120	0.344	Sabuli BH	Main aquifer
MM018	40.065	1.743	Wajir	Other
MM019	41.333	0.300	Tabda	Somalia
MM020	39.119	1.170	Sericho BH	Recharge area
MM021	38.669	1.056	Merti BH	Recharge area
MM022	38.059	2.281	St Paul's BH	Recharge area
MM023	38.610	1.731	Yamicha BH	Upstream aquifer
MM024	39.069	1.406	Alango BH	Upstream aquifer
MM025	39.007	2.077	Arba Jahan BH2	Upstream aquifer
MM026	41.025	0.405	Dhobley 1	Somalia
MM027	41.270	-0.172	Hosingo 1	Somalia
MM028	41.983	0.250	Haga Liban	Somalia
MM029	42.223	-0.466	Qot Qot 3	Somalia

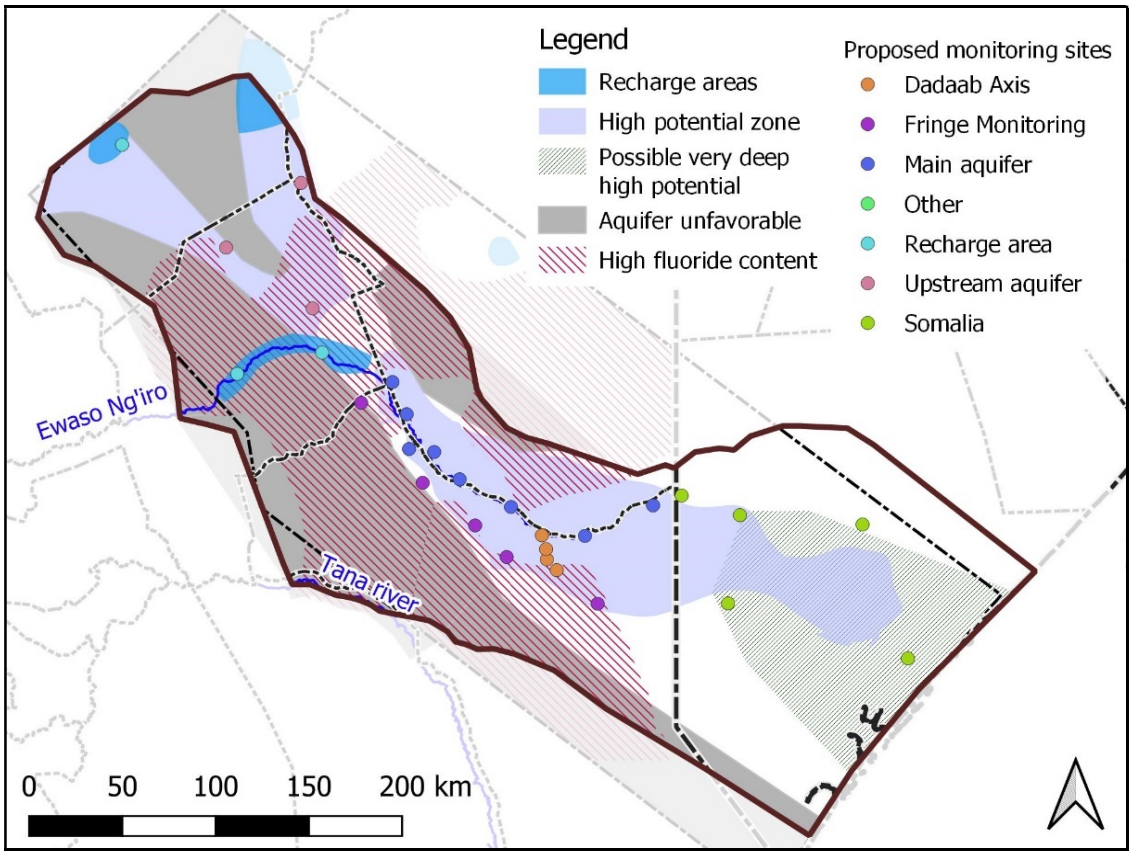

Figure 5: Comprehensive monitoring network, targeting different aspects of the aquifer.

7.4.4 Groundwater Protection

7.4.4.1 Conservation Zones

The protection of these water resources recharge zones acts as a source of replenishing the aquifer as stipulated in sections 123 and 124 WRA Rules 2007.

To protect groundwater from pollution, control measures should be implemented. These measures should coincide with the WRA Rules section (81-92) regulations provided by the Ministry of Energy and Water Resources, Somalia. These protection measures include; proper discharge of effluent and

poisonous substances. The point and non-point Information discharge zones should be well known and should not interfere with the water quality.

7.4.4.2 Waste and Waste Water Treatment Management

With increased water supply. Groundwater is vulnerable to pollution.

7.4.5 Monitoring Management and Link to Strategy

All monitoring boreholes should link to a single database. The monitoring information should be transferred from the monitoring personnel to the WRUA directly through the CAAC members from the area and/or through the facilitating NGO or UNHCR department. Information from WRUA to WRA regional office is passed through the sub-region and vice versa. The sharing of information between the regional office and the CAAC members is through the regular (quarterly) meetings, letters or any other forum where CAAC members can interact with WRMA staff. Similarly, Somali counterparts of government and local agencies need to be involved. Moreover, a transboundary agreement needs to be made between the Kenyan and Somalian institutions on the sharing and use of groundwater data, solidified by the signing of an MoU.

Through these organizations, the data can be accessed when necessary for monthly and annual comparisons to establish the behaviour of the aquifer over a certain period and inform strategy at key moments during the development and exploitation phase.

Specifically, at such key moments it must be established whether water levels are rising, dropping or whether they are stable, and when a water level drop is observed it needs the seriousness of the drop needs to be established; whether it is a minor drop that only gives rise to increased alertness or whether serious aquifer depletion is taking place. Keep in mind that to properly assess such changes, first a baseline needs to be established with monitoring over a few years to properly account for normal seasonal and interannual variation.

Over time, the monitoring measurements form the base for the development of management strategies for the sustainable use of (ground)water resources. Monitoring reports should be produced quarterly, and report on short term as well as long term changes accounting for seasonal and interannual variability. These monitoring reports should then be linked to quarterly strategies, and give input for abstraction policy.

7.5 Joint Coordination Actions and Institutional Arrangements

Management of the Merti is dependent on the successful drawing-up and implementation of policies, strategies and their relation to institutional aspects and cooperation by the riparian states. The socio-economic conditions of Kenya and Somalia should be considered when drafting the management plans.

Joint management of the Merti and its catchment could be achieved in two ways:

1. Establishment of joint bodies/committees of experts with representatives from the Riparian States from different sectors as discussed in later sub-chapter 7.5.6. The joint body will plan for equitable utilisation of the Merti.
2. Cooperation in management and development is organized without established joint bodies. Water managers should then meet on regular basis to agree on set objectives for planning and developing the shared resource by the individual countries. Shared objectives for protection and ensuring sustainability, discussed in earlier sub-chapters, should be set with agreed implementation plans to be carried out by the individual states. Kenya and Somalia should hence agree on where to undertake the meetings and facilitate data sharing without involving joint set institutions. Since the implementation of activities for the shared resource is to be implemented under national water strategies, it is difficult to track specific numbers.[5]

7.5.1 Joint Concerted Action Plan and Programmes

Water resources managers from the riparian states should agree on quantified management targets. Regulations, guidelines and codes of practices could be instituted for the specific needs of the Merti

[5] Funding and Financing of Transboundary Water Cooperation and Basin Development, 2021. UNECE

to ensure its sustainability over the long term. The plan could be derived from existing national and regional programmes or set the preconditions for establishing such national and regional plans.

These set targets and objectives for the Merti should be approved at the ministerial level and the riparian states agree on mutual assistance, instituted in legal arrangements to be signed by Kenya and Somalia.

Derived from study outcomes, the plan should at a minimum include:

1. Zoning the Merti based on quality and pressures experienced.
2. Groundwater abstractions and regulation for socio-economic needs.
3. Characterising the use of Merti based on quality and pressures experienced in the specific zones.
4. Catchment and wetland protection zones to ensure water balance for the Merti.
5. Economic activities and their transboundary impacts on groundwater quality and quantity. Specifically, pastoralism activities and their groundwater use. Land carrying capacity should be defined and specific regulations set.

7.5.2 Legal Setup

7.5.2.1 International Laws for Shared Resources

Both Kenya and Somalia are members of the UN. This makes the riparian states accustomed to adhering to the UN's International Laws including the "shared natural resources" laws of TBAs. The law applies to:

a) Utilization of transboundary aquifers or aquifer systems;
b) Other activities that have or are likely to have an impact upon such aquifers or aquifer systems; and
c) Measures for the protection, preservation and management of such aquifers or aquifer systems

In Article 21(3) of the UN Watercourses Convention, it is stated that 'Watercourse States shall, at the request of any of them, consult to arrive at mutually agreeable measures and methods to prevent reduce & control pollution of an international watercourse, such as a) Setting joint water quality objectives and criteria; b) Establishing techniques and practices to address pollution from point and non-point sources; c) Establishing lists of substances the introduction of which into the waters of an international watercourse is to be prohibited, limited, investigated or monitored.

The riparian states should therefore construct agreements of joint commissions in instituting TB basin institutions with TB coordination in monitoring and managing the Merti aquifer.

The riparian states are equally supportive of the IGAD's Regional Water Policy and Protocol which outlines the need for a common approach to water resources management, the need for cooperation frameworks, the need for joint planning and collaborative management and the importance of resolving conflicts.

7.5.2.2 National Laws with regards to TB Waters

(i) Kenya

Constitution of Kenya: The constitution of Kenya lacks specific provisions for managing transboundary natural resources although has important provisions relating to the management of the environment and natural resources. The State is charged with the obligation to, inter alia ensure sustainable exploitation, utilization, management and conservation of the environment and natural resources, and ensure the equitable sharing of the accruing benefits.

Water Act No 43, 2016: The Water Act 2016 regulates water resources management; water harvesting and storage; and water supply and sanitation services. The Act recognizes that water-related functions are a shared responsibility between the national government and the county government. Hence, the Act defines roles and responsibilities for the management, development and regulation of water resources and water services in the country.

(ii) Somalia

National Water Act (No. 49 of 2011): This Act makes provision for the conservation and development of water resources in Somalia. There are no specific provisions for the management of TBA, however, the act provides for objectives and principles for equitable exploitation of water

resources in a sustainable manner highlighting institutional arrangements and their duties; and regulations concerning water resources.

National Water Resource Strategy 2021-2015: Somalia's government recognises its dependence on shared water resources including the Juba and Shabelle rivers, the Merti aquifer and deep groundwaters found across the country. Catchments of these water resources are all based on rainfall occurring in upstream neighbours and flowing into downstream Somalia and providing water for agriculture, drinking water and ecosystem services. Somalia, therefore, recognises the need for management and development within a regional context in their Water Resources Strategies. Challenges in the water sector are to be addressed in joint problem solving and opportunity development with the riparian states in line with the UN's Laws on International watercourses.

7.5.3 Governments' Position in TBA Water Management

Kenya

A Directorate of Transboundary Waters under the Ministry of Water, Sanitation and Irrigation handles the management of transboundary river basins in Kenya.

Somalia

Despite Somalia's current status in the management of transboundary water resources (disadvantaged in institutional capacity), it recognises its downstream position as being a catalyst for cooperation with riparian partners who are more experienced in transboundary watercourse management and views this as a key area for strengthening under their Water Resources Strategy. The strategy, therefore, aims to develop conducive and principled approaches to developing and improving relationships with these partners. [6]

7.5.4 Stakeholder Participation

Crafting management plans for the Merti involves a wide range of national, regional and local level stakeholders. In the first phase, these would be across Kenya and Somalia.

Table 26: Stakeholders to be Involved in Management Plans

Level	Kenya	Somalia
National	Office of the President: Ministry of Water, Sanitation and Irrigation; Ministry of Environment and Natural Resources; Ministry of Lands; Ministry of Devolution- Dept. of N. Kenya and other Arid Lands; Ministry of Foreign Affairs	Office of the President; Ministry of Energy and Water Resources; Ministry of Public Works; Ministry of Environment; Ministry of Planning, Investment and Economic Development; Ministry of Foreign Affairs and International Cooperation.
	Water Resources Authority (WRA)	
	National Environmental Management Authority (NEMA)	
Regional	County Governments of Garissa, Wajir and Isiolo	State Government of Juba Hoose
	WRA Sub-Regional Office	State Director General of water
	Northern Water Works Development Agency (NWWDA); Ewaso Ngiro North Catchment Area (ENNCA)	SWALIM- Somalia Water and Land Information Management
	NGOs	NGOs
	Religious Organisations	Religious Organisations
Local	Water Resources Users Association (WRUA); Water Users Association (WRUA)	District Government: District Water Officer
	Catchment Area Advisory Committee (CAAC)	Water User Associations & Committees.

Roles of the managing institutions concerning water resources management will be maintained and their duties extended to national joint cooperation in managing Merti TBA within the proposed institutional structures or without the setting of the joint institutions as discussed in the later sub-chapter 7.5.6.

[6] National Water Resource Strategy- 2021-2025, Ministry of Energy and Water Resources, Federal Government of Somalia.

7.5.5 Legal Arrangements

A common line of action is to be agreed upon and signed upon by the Riparian States to form a foundation for negotiation in the protection and management of the Merti to ensure its sustainability. The legal instrument, treaty or MoU, should recognise the importance of the Merti in alleviating poverty, acknowledge the rights and duties of the riparian states sharing the aquifer, appreciate achievements of the improvement of the scientific knowledge of the Merti, highlight the importance of cooperative management of the Merti in improving the management of the shared resource.

Goals of the binding documents, treaty or MoU, should include but not be limited to:

- ✓ Cooperation in joint management of the Merti and its catchment
- ✓ Cooperation in joint financing of managing the Merti and its catchment- Depending on the cooperation agreements, either by forming a joint body or management without such institutions, joint implementations plans and strategies will be agreed upon and a funding mechanism for implementation devised, especially where monitoring, protection and rehabilitation of the Merti TBA and its catchment
- ✓ Cooperation in the implementation plan
- ✓ Coordination for the development of joint studies
- ✓ Development of a hydrogeologic database and groundwater flow model
- ✓ Setup of a comprehensive monitoring network to process, analyse, and validate data
- ✓ Analysis of the socio-economic activities and status of the region to ensure equity in development planning
- ✓ Formulation of proposals for optimization and consultation mechanisms for the development and enforce codes of practice in the assessment and development of the Merti
- ✓ Enforcement of development regulations: borehole design, well spacing and abstraction limits

7.5.6 Joint Institutions and Coordination Mechanism

Coordination-based organisations are proposed to coordinate activities implemented in the individual countries.

Managing institutions for the Merti and its catchment should include:

III. Merti Aquifer Management Committee (MAMCo)
IV. Merti Catchment Technical Secretariat

Existing managing institutions in Kenya and Somalia should constitute the jointly proposed institutions with their mandates extended for TBA management and cooperation. The main activities of the organisations will be data and information acquisition, analysis and exchange (including modelling a basin's hydrology or environmental status and related decision-support tools) and the development of joint basin management plans. Implementation plans including development, management and maintenance of infrastructures, for various development projects will be carried out by individual countries. The overall proposed joint institutional structures are presented in Figure 6.

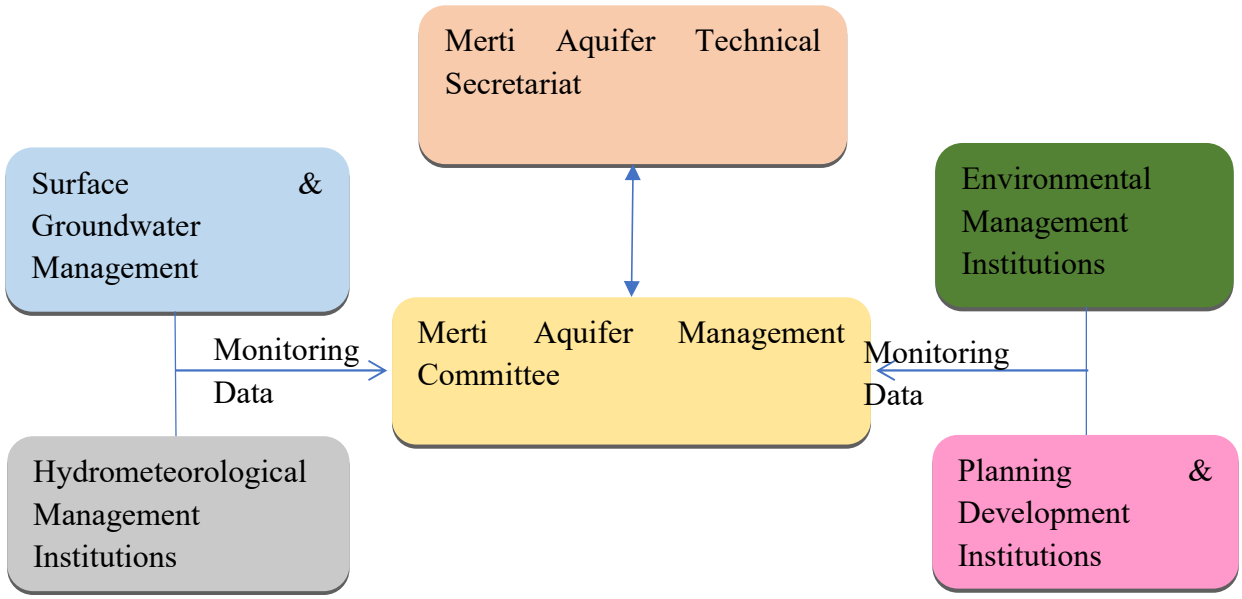

Figure 6: Merti TBA Management Institutions

Merti Aquifer Management Committee (MAMCo)- this committee should constitute water experts from both Kenya and Somalia. MAMCo will plan for the management and development of the Merti and its entire basin, deciding on the planning vision, objectives and key issues, identifying options and considering alternative scenarios. These plans should conform to those of national and regional governments in Kenya and Somalia. Key experts in the committee will constitute Hydrogeologists, Engineers and Socio-economist. It may also include legal and international relations experts.

MAMCo will:

- Harmonise management and monitoring plans for the Merti and its catchment.
- Coordinate implementation plans for development strategies set by the Riparian states
- Water resources conservation, use and allocation
- Formulate pollution control and management plan
- Harmonise legislation and regulations instruments (e.g., abstraction permits, protection areas) for the Merti and its catchment.
- Aid in the delineation of protection of wetlands and mountain ranges, habitats and ecosystems important for the sustainability of the Merti.
- Establish, support and facilitate an institutional framework for effective stakeholder participation in catchment management, development and planning including training and capacity building of stakeholders within the Merti catchment.
- Analyse monitoring data to inform monitoring programmes of the status of the catchment and water resources for purposes of regulation and planning.

Merti Catchment Technical Secretariat- The main duty of the secretariat will be to coordinate MAMCo. The secretariat will constitute technical representatives from various ministerial institutions from the riparian states including: -

a) *Surface and Groundwater management institutions:* WRA in Kenya; Ministry of Energy Water Resources and; SWALIM in Somalia. These institutions inform on groundwater conditions from the monitoring programmes in both countries.
b) *Hydrometeorological Management institutions:* Inform on hydrometeorological information from monitoring programmes. MAMCo will partner with representatives from Hydrometeorological Departments from Kenya and Somalia in acquiring Hydrometeorological information.

c) *Environmental institutions:* NEMA in Kenya and Ministry of Environment Somalia to provide information to inform adaptation to environmental changes. They will also provide information on pollution that will be incorporated in the planning for the catchment. These institutions demarcate wetlands and catchment areas. Enforcement of catchment protection regulations should be stressed for the Merti catchment.

d) *Planning and development institutions:* development of water resources within the Merti should complement regional and national development strategies for both Kenya and Somalia. MAMCo will collaborate with both the Ministries of Planning and regional governments in Kenya and Somalia to plan for implementable sustainable activities for the Merti. These institutions include development partners i.e., World Bank, other financial institutions, NGOs, etc.

The purpose of the Secretariat is to bring technical data, information, knowledge and experience of the sector programs and projects in the catchment to the planning process. To take responsibility for operationalizing and in some cases implementing programs and projects in the agreed plan.

This will be achieved through regular meetings held, by-annual, to share data and information and coordinate MAMCo in planning for the Merti and its catchment.

7.5.7 Financial Arrangements

Source of financing to implement the management plans include: -

- Kenya and Somalia Governments- Core financiers.
- Financial Institutions: World Bank, JICA, GTZ, AfDB, local banks etc. in form of public loans and grants.
- Private Institutions: NGOs, etc.
- Tariffs- sale of service, sale of data, project management fees, user polluter fees etc.

Costs arising from the management of Merti TBA include:

- Core costs of cooperation
- Cost of programme activities including high-level meetings
- Cost due to implementation of management programmes
- Preparation of strategic plans and related documents
- Implementation of strategic plans and specific activities defined in them
- Management and maintenance of infrastructural projects owned by the joint bodies i.e., Dhobley and Liboi TB projects.
- Development of infrastructure projects within the context of Merti Catchment management and investment plans i.e., buffering projects.

Governments of the riparian states should form the core financing bodies for the management of Merti TBA. Since activities of the existing managing institutions are extended to the formed committees, the governments should be keen on financing the costs occurring due to the existence of the joint institutions. These costs include: -

- Costs of meetings- of the joint body's governing bodies, such as a Council of Ministers or a Meeting of Heads of State;
- Staff salaries and offices including office materials;
- Communication costs; and, other items that ensure the functioning of a joint body.

The funding should be part of the regular budget. Each country should finance their requirements under the provision of the agreed action plans.

Financial institutions i.e., World Bank, JICA, GTZ, AfDB, local banks etc (through the implementation of this study and programmes that complement activities proposed for the management of the shared resource) should also finance i.e., installation of monitoring devices to boreholes proposed.

8 IMPLEMENTATION BUDGET

Before the commencement of the various project components, tendering should be done to determine the most competent contractors for the different project components and the best prices in the bidding process. Items to be incorporated in the costing table together with the various BoQs have been appended in this report.

8.1 Project Preparation Workshops Budget

The project will incur costs in workshops and forums in the different activities which will be carried out. This will include but is not limited to the following:

- Launching the proposed projects
- Bringing the two States on board
- Project implementation arrangements
- Formation of the implementing and management institution (salaries, O&M)

8.2 Workshops for Strengthening the Existing Groundwater Governance Policies

This will involve the two-member countries and costs for the workshops. This will include but is not limited to travel, accommodation, and conference hall fees.

8.3 Formulation and Validation of Policies and Strategic Plans in Governance, Management and Development in the Merti TBA by the Two States

This will involve the two-member states and delegates have to be catered for in terms of their accommodation, conference halls, travel, stationary, writing and printing material among others which have to be costed.

8.4 Capacity Building

The success of any project depends to a great extent on the capacity of the community in the project area and hence their capacity to run and manage the project upon kick-off has to be boosted through some of the following which has to be costed:

- Awareness creation
- Establishment of resilient institutions
- Strengthening/establishing centres of excellence
- Initiation of Short Courses
- Common conceptual groundwater centre

8.5 Women Empowerment

Women being pillars of the society should be given priorities in water development projects and in the project area they should be recognized through the provision of the following which should be accounted for in the budget:

- Workshop/seminars
- Creating awareness
- Training facilities
- Staff/labour costs for trainers
- Mentorship programs
- Setting up gender-balanced hiring panels

8.6 Shared Vision

In the formulation of a vision to serve the two countries, the following activities are foreseen and should be factored into the costs of the project:

- Meeting venues
- Travel costs for stakeholders
- Accommodation
- Convening meetings
- Awareness and mobilization

8.7 Groundwater Monitoring

This is a necessity for any groundwater project to be successful and the following activities are foreseen and should be costed in the final budget for the project:

- Designation and construction of proper landfills
- Facilitation for pollution monitoring experts
- Fee for consultancy services
- Mobilization and travel
- Technical staff
- Procurement of telemetric devices, transmitters, and receivers
- Real-time database servers
- Installation labour
- O&M
- Public awareness of groundwater
- Educating the public on taming waste discharge

8.8 Public Awareness of Groundwater

This is a necessity in the project area since some of the projects are done without the knowledge of many stakeholders and since the aquifer is a key resource in the project area, any activities on it should be made public. The following are some of the postulated costs during this activity:

- Mobilization
- Meeting venues costs
- Travel costs for delegates
- Accommodation
- Convening meetings
- Awareness and mobilization

8.9 Joint Groundwater Management Plan

For a joint management plan the following should be carried out and their costs budgeted for;

- Baseline survey
- Mobilization
- Meeting venues
- Travel costs
- Accommodation
- Salaries & allowances
- Resource assessments and characterization per country
- Afforestation & reforestation programmes
- Erosion control mechanisms
- Protection & fencing of endangered catchments
- Meetings & forums
- Formation & strengthening of institutions
- Creating awareness through media mainstream
- Joint research
- Procurement of monitoring devices
- Construction & installation

8.10 Data and Information Management & Sharing

For a smooth-running ground or surface water project there should be data sharing and for this to be achieved the following which should be budgeted for should be practised between the two Merti TBA countries:

- Establishment of a harmonized database

- Training personnel- hydrogeologists, WRUAs
- Sharing & hosting data online

8.11 Private Sector Engagement

The private sector stakeholders are major players in groundwater development in the Merti TBA and should be involved in the project through the development of the water supply project and GW data/information sharing. Their involvement will have to be discussed in conferences and workshops and the costs of such events will be an expense and should be factored into the budget. Items to be factored in include but are not limited to the following:

- Conferences/Workshops
- Networking for a centralized database

8.12 Pilot Phase

The initial phase of the project will involve the priority projects which have been selected based on a criterion resolved through several stakeholders' workshops and include the following;

- Boreholes (Three boreholes in each country where one of the three will be a monitoring borehole while the other two will serve the purpose of water supply in the project area)
- Earth dams (Two earth dams will be constructed in each country with full infrastructure for easier water consumption by the local community together with their livestock)
- Water Pans (Two water pans are proposed in Dhobley for recharge)

8.13 The Scaling-up phase

This will involve the In-country projects which have been selected through a criterion agreed upon by the client, stakeholders and the consultant. The projects include the following and should be costed wholesomely (All the project components should be factored in as presented in the BoQs and the costing table)

- Boreholes
- Shallow Wells
- MAR
- Sand Dams

8.14 Full Implementation Budget

The cumulative cost for the entire project is approximated at USD 18,308,385.52 .

9 RISKS AND UNCERTAINTIES

9.1 Risks

The proposed initiative could face certain risks and possibilities. Below are some of the situations that would result in the project's implementation.

Table 27: Implementation Risks and Mitigation

Technical Risks	Mitigations
Borehole associated risks	***Borehole associated mitigations***
The groundwater table is bound to lower if the aquifer recharge rate is lower than abstraction rate.	Installation of a master meter and a piezometer in a borehole to monitor groundwater abstraction and facilitate regular measurement of static water level
Land subsidence caused by over-abstraction of Merti, with its friable to semi-consolidated geology.	Concurrently employing managed aquifer recharge (MAR) methods to fill rock matrix after groundwater abstraction, with periodic monitoring in boreholes through telemetric devices to check groundwater levels.
Saline water up-coning caused by over-pumping of boreholes.	Coordinating pumping in all boreholes among the operations and management staff to ensure the process is carried out consecutively.
Shrinking of the resource leading to lower borehole yield or saline water up coning.	Periodic monitoring of the boreholes and aquifer by geologists for correct progress on resource management.
Alteration in water quality due to exposure to pathogens and water pollution.	Mobilizing the operations and management to always treat water in storage before distribution to consumers, while observing National Environmental Management Authority (NEMA) guidelines.
Ongoing adverse climatic effects that would alter groundwater recharge, leading to drying up of the aquifer	Implementing environmental conservation programs in catchment areas with the help of SWALIM, SCMPs and local communities.
Water Pans associated risks	***Water pans associated mitigations***
Soil erosion and siltation affects the depth of water pans.	Construction of sand/silt traps at least 20m upstream of the water pans from the highest water points.
Alteration in water quality due to algal growth, water pollution and pathogens	Mobilizing the operations and management to always treat water in storage before distribution to consumers.
Loss of vegetation cover and biodiversity during land clearing.	Reforestation of the exposed areas around the site.
Mechanical erosion from the impact of overgrazing near the banks causes erosion and deposition in the water pan.	With the help of SCMPS, emphasis on regulations that prevent overgrazing of the area around water pans as well as land reclamation of the area.
Dam associated risks	***Dam associated mitigations***
Disruption of ecosystems in proposed sites from clearance and construction activities.	Implementing afforestation around the dam to restore the ecosystem and ensure species are protected.
According to the area's geology, slope insatiability may occur due to land subsidence and cause demerits in the dam	Ensure engineering designs include reinforcements in case of such a scenario with approval from the National Water Harvesting and Storage Authority.
Adverse climatic changes affect rainfall patterns and consecutively groundwater recharge, which leads to drying up of the reservoir.	With the help of SCMPS, implementation of reforestation programmes and catchment protection to reverse the climatic change.
Health and sanitation risks	***Health, sanitation and safety mitigations***
Introduction of animal waste in water pans which pollutes the water or accelerates weed growth.	Regulated water treatment to kill bacteria and suppress weed growth.

Stagnant water poses health risks to families living around the water pans since the water provides breeding grounds for mosquitoes and waterborne disease vectors.	Regulated water treatment to destroy disease vectors and kill mosquito larvae.
Political/ Community conflict risks	***Political/Community conflict risks***
Unplanned settlements by private investors in the region will increase the number of consumers.	The operations and management staff to ensure water consumption is monitored for overall aquifer conservation.
Conflict between the local community and the regional development agencies i.e. Ewaso Ng'iro North Development Agency for fear of resource depletion.	With proper policies and management system, Merti TBA will boost peace, adequate water supply and socioeconomic growth
Conflict between local clans/communities over dominance of water resources.	Mobilizing peace and socioeconomic harmony through community leaders and elders to ensure the resources benefit all local members.
Tension between local natives and refugees on the possibility of aquifer shrinking due to increased consumers	Installation of telemetric stations in the proposed projects for tracking and the data disseminated to relevant authorities such as Operations and management staff, WRA, SCMPs, NWWDA, Basin management and county government in Kenya, Ministry of Environment (Environment Agency), SWALIM- Somalia Water and Land Information Management and Lower Juba State Government in Somalia
Peace disruption resulting from political differences among local communities, where water access points are mostly targeted.	Mobilization of 24hours/7days security from different authorities in the area, including SWALIM, WRA, Kenya Police Force and county commissioners
Aquifer management problems rooting from undefined communication channels regarding Merti TBA between Kenya and Somalia.	Capacity building of the operation and management staff and stakeholders to ensure both countries understand the vision for Merti aquifer development for both governments.
Private groundwater abstraction projects in/nearby proposed sites, competing for the resource.	Enforcement of groundwater regulations by stakeholders to protect the aquifer in proposed sites.

9.2 Opportunities

- **Poverty reduction and equity** – Communal responsibility for water governance and coordination between different uses ought to help overcome inequality in access to water, which is a basic necessity for life quality. Access to water points provides advantages for vulnerable groups (refugees, women and children) such as economic and education opportunities.
- **Deficiency in meeting water demand** – The current water supply in the region is quite far from meeting the water demand. Implementation of this initiative will be the pilot for more projects in the region aimed at meeting the demand.
- **Joint development programmes between Kenya and Somalia** – Successful operation of joint management of Merti aquifer between the countries could open up opportunities for improvement of economic developments such as convenient trading sessions, education centres and resource conservation programmes.
- **Key to data scarcity** - collection of accurate socioeconomics, well logs, water use, water demand and monitoring data through technical specialists besides operation and management team to solve the issue of data scarcity in the region. Creating an accurate and well-informed database regarding the Merti TBA provides enough information to enhance communication among stakeholders to exchange ideas and grow the region in future projects.
- **Shared vision** – Kenya and Somalia share several mutual challenges such as water scarcity, environmental pollution, flooding during rainfall seasons, famine, drought, inadequate health facilities among others. Improving water supply and management within this area will stimulate the growth of all other sectors. These processes will be reinforced by acquiring accurate data and information regarding the resource.

- **Conflict resolution and improved international peace/ relations –** fieldwork study showed that the root cause of conflicts in the region is access to water provision points and pasture fields. The groundwater initiative will reduce water scarcity. Consequently reducing conflicts over the few available resources. Moreover, promoting peace and cooperation will reduce political, cultural and social conflicts and build trust among the communities.
- **Up scaling of the joint management system** – to other sectors from groundwater such as infrastructure, economy and education for the region. Different sectors advance from benefits of readily available, well-managed water such as education, health, crop irrigation and regional meat processing plants to boost income diversification.
- **Creating multifunctional resilience programmes** with representatives from both Kenya and Somalia which aim at capacity building of the economies to withstand calamities or communities' development.
- **Multi-track diplomacy** - development of different initiatives at different levels in the society including conflict resolution, economic, educational, healthcare and cultural by various stakeholders to improve peace and stability.
- Development of water infrastructure along migration routes, to fend for livestock and traders. Migration routes play a key role in the income made by communities living in Merti TBA zone, and developing water infrastructure along them will promote revenue increase and improve living standards.
- Capacity building of community members after project implementation will be carried out by various stakeholders to provide a forum for further training, exchanging of different experiences for both countries and education among themselves on various techniques regarding similar issues.

9.2.1 Joint Trans Boundary Aquifer Management Measures

Establishing an MoU - due to differences in groundwater governing policies between the two countries, an MoU should be formed to accommodate stakeholders from both countries while strengthening coordination in the management and development of TBA.

Empowerment and education of locals - organization of training camps for locals to educate them on various water management issues such as environmental hygiene, water recycling, water pollution and general knowledge to empower them. It creates a foundation of understanding for further innovations for their benefit.

Capacity building - HoAGWI operations and maintenance team ought to undergo capacity building to refine skills in data collection, customer service, peace building and management of infrastructure.

Knowledge exchange- operations and maintenance (O&M) teams from both countries should frequently communicate to update and inform each other on trends in climate projections, impending natural calamities, water infrastructure and problem solutions.

Monitoring - O&M from both countries be duty-bound to monitoring of constructed infrastructure, its management, groundwater consumption of both humans and livestock, pollution, siltation and collection of tariffs. All these details are to be recorded and possibly uploaded to the database.

Dissemination of data - dissemination of data collected from both countries should be included in the MoU to govern the process of uploading to a common database and defining grounds of access and use among stakeholders. This will fortify trust and transparency regarding the aquifer and infrastructure.

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APPENDICES

Appendix 1: Pre-Mandate Activities and Project Management

PRE-MANDATE ACTIVITIES AND PROJECT MANAGEMENT COSTS FOR THE TWO COUNTRIES							
Main activity	**Activity description**	**Location**	**Sub Activity Description**	**Unit Cost (USD)**	**Pilot phase/Once or annually**	**Scaling up phase**	**Pilot Phase Total Costs, (USD)**
Pre-Mandate activities	High level meetings	Kenya		180,000.00	1		180,000.00
		Somalia		180,000.00	1		180,000.00
Project management	Project Management Unit at IGAD	IGAD		500,000.00	1		500,000.00
	Joint cross-border steering committee	Project		250,000.00	1		250,000.00
	Multi-stakeholder forum	Kenya		50,000.00	1		50,000.00
		Somalia		50,000.00	1		50,000.00
	Project Implementation unit	Kenya		250,000.00	1		250,000.00
		Somalia		250,000.00	1		250,000.00
	Preparation of strategic plans and related documents	Kenya		50,000.00	1		50,000.00
		Somalia		50,000.00	1		50,000.00
	Implementation of strategic plans and specific activities defined in them	Kenya		50,000.00	1		50,000.00
		Somalia		50,000.00	1		50,000.00
	Cost due to implementation of Groundwater management programmes(Monitoring)	Kenya		50,000.00	1		50,000.00
		Somalia		50,000.00	1		50,000.00
	Formulation and validation of legal instruments, treaties and MoU's,	Kenya		50,000.00	1		50,000.00
		Somalia		50,000.00	1		50,000.00
	Public Awareness on GW	Kenya	Mobilization	60,000.00	1		60,000.00

			Meeting Venues Costs	1,000.00	1		1,000.00
			Travel Costs for Delegates	12,000.00	1		12,000.00
			Accommodation	4,000.00	1		4,000.00
			Convening Meetings	2,000.00	1		2,000.00
			Awareness and Mobilization	2,000.00	1		2,000.00
		Somalia	Mobilization	60,000.00	1		60,000.00
			Meeting Venues Costs	1,000.00	1		1,000.00
			Travel Costs for Delegates	12,000.00	1		12,000.00
			Accommodation	4,000.00	1		4,000.00
			Convening Meetings	2,000.00	1		2,000.00
			Awareness and Mobilization	2,000.00	1		2,000.00
	Women Empowerment Process	Kenya	Workshop/Seminars	3,000.00	1		3,000.00
			Creating Awareness	7,000.00	1		7,000.00
			Training Facilities	500,000.00	1		500,000.00
			Staffs/Labour Costs for Trainers	10,000.00	1		10,000.00
			Mentorship Programmes	8,000.00	1		8,000.00
			Setting up Gender Balanced Hiring Panels	8,000.00	1		8,000.00
		Somalia	Workshop/Seminars	3,000.00	1		3,000.00
			Creating Awareness	7,000.00	1		7,000.00
			Training Facilities	500,000.00	1		500,000.00

			Staffs/Labour Costs for Trainers	10,000.00	1		10,000.00
			Mentorship Programmes	8,000.00	1		8,000.00
			Setting up Gender Balanced Hiring Panels	8,000.00	1		8,000.00
	Public-Private Sector Engagement	Kenya	Conferences/Workshops	200,000.00	1		200,000.00
			Database Networking	30,000.00	1		30,000.00
		Somalia	Conferences/Workshops	200,000.00	1		200,000.00
			Database Networking	30,000.00	1		30,000.00
	Data and Information Management & Sharing	Kenya and Somalia	Establishment of Harmonized Database	80,000.00	1		80,000.00
			Training Personel	15,000.00	1		15,000.00
			Sharing and Hosting of Database	70,000.00	1		70,000.00
	Joint Groundwater Management Plan	Project	Baseline survey	4,000.00	1		4,000.00
			Mobilization	10,000.00	1		10,000.00
			Meeting venues	2,000.00	1		2,000.00
			Travel Costs	12,000.00	1		12,000.00
			Accommodation	3,000.00	1		3,000.00
			Resource Assessments and Characterization per Country	50,000.00	1		50,000.00
			Afforestation & Reforestation Programmes	100,000.00	1		100,000.00
			Erosion Control Mechanisms	30,000.00	1		30,000.00
			Protection & Fencing of Endangered Catchments	30,000.00	1		30,000.00
			Meetings & Forums	4,000.00	1		4,000.00

			Formation & Strengthening of Institutions	100,000.00	1		100,000.00
			Creating Awareness through Media Mainstreams	20,000.00	1		20,000.00
			Joint research	30,000.00	1		30,000.00
			Procurement of Monitoring Devices	200.00	1		200.00
	Groundwater monitoring	Kenya	Designation and Construction of Proper Landfills	2,000.00	1		2,000.00
			Facilitation for Pollution Monitoring Experts	6,000.00	1		6,000.00
			Fee for Consultancy Services	5,000.00	1		5,000.00
			Technical Staff	43,000.00	1		43,000.00
			Budget for Telemetric Devices, Transmitters and Receivers	60,000.00	1		60,000.00
			Real-Time Database Servers	5,000.00	1		5,000.00
			Installation Labour	6,000.00	1		6,000.00
			O&M	20,000.00	1		20,000.00
			Educating the Public on Taming Waste Discharge	2,000.00	1		2,000.00
		Somalia	Designation and Construction of Proper Landfills	2,000.00	1		2,000.00
			Facilitation for Pollution Monitoring Experts	6,000.00	1		6,000.00
			Fee for Consultancy Services	5,000.00	1		5,000.00
			Technical Staff	43,000.00	1		43,000.00
			Budget for Telemetric Devices, Transmitters and Receivers	60,000.00	1		60,000.00
			Real-Time Database Servers	5,000.00	1		5,000.00
			Installation Labour	6,000.00	1		6,000.00

			O&M	20,000.00	1		20,000.00
			Public Awareness on GW	2,000.00	1		2,000.00
			Educating the Public on Taming Waste Discharge	2,000.00	1		2,000.00
	Development of a Shared Vision	Project	Meeting Venues	30,000.00	1		30,000.00
			Travel Costs for Stakeholders	12,000.00	1		12,000.00
			Accommodation	3,000.00	1		3,000.00
			Convening Meetings	30,000.00	1		30,000.00
			Awareness and Mobilization	50,000.00	1		50,000.00
Baseline survey	Baseline survey	Kenya		20,000.00	1		20,000.00
		Somalia		20,000.00	1		20,000.00
	Water resources investigations	Kenya		120,000.00	1		120,000.00
		Somalia		220,000.00	1		220,000.00
	Tendering process	Kenya		50,000.00	1		50,000.00
		Somalia		50,000.00	1		50,000.00
GRAND TOTAL							**5,269,200.00**

Appendix 2: Costing of the Priority Sites

CAPITAL COSTS FOR THE RECOMMENDED INFRASTRUCTURES IN THE TWO COUNTRIES				
Site ID	**Infrastructure**	**No. of Infrastructures**	**Components**	**Cost(USD)**
Dhobley 1 SO 3.3, 3.5	Boreholes	3	Borehole drilling, development and test pumping	147,732.00
			Electromechanical works	112,551.10
			Raising Main	69,953.00
			Elevated steel tank	60,440.60
			Distribution Pipeline	67,259.00
			Telemetric Devices and Installation	6,590.00
			2 Water Kiosks	18,704.07
Sub-Total				**483,229.77**
Dhobley 2 SO 3.2 &3.3	Water Pans (Haffir Dam)	2	Water Pan of 85,000m3 - SO3.2	167,030.20
			Water Pan of 160,600m3 - SO3.3	167,030.20
			Protected Shallow Well Water System	8,216.88
			Solar Pumping System	8,931.32
			Caretaker room	5,027.92
			Camel Trough	1,844.58
			Sheep Trough	1,439.29
			Elevated Water Tank with Generator Room Underneath	13,449.24
			Communal Water point	2,117.00
			Single Pit Latrine	2,596.51
Sub-Total				**377,683.14**
Dhobley 3,SO 3.2, 3.3	Earth Dams	2	Dam 1 of 68,000m3	190,972.50
			Dam 2 of 72,000m3	280,860.00
			Protected Shallow Well Water System	9,021.00
			Fence and Gate	1,840.00
			Solar Pumping System	8,941.00
			Caretaker room	1,230.00
			Camel Trough	2,095.00
			Sheep Trough	4,500.00
			Elevated Water Tank with Generator Room Underneath	16,200.00
			Communal Water point	2,095.00
			Single pit laterine	3,966.00
Sub-Total				**521,720.50**
Liboi 1,KE 9	Boreholes	3	Borehole drilling,development and test pumnig	147,732.00

			Electromechanical works	112,551.10
			Raising Main	69,953.00
			Elevated steel tanks	60,440.60
			Distribution Pipeline	67,259.00
			Telemetric Devices and Installation	65,000.00
			2 Water Kiosks	18,704.07
Liboi 2,KE 8.1 ,8.2	Earth Dam	2	Dam 1 of 42,000m3	168,200.00
			Dam 2 of 42,000m3	168,200.00
			Protected Shallow Well Water System	12,434.00
			Fence and Gate	1,720.00
			Solar Pumping System	12,400.00
			Caretaker room	1,120.00
			Camel Trough	2,015.00
			Sheep Trough	3,409.00
			Single Pit Latrine	3,210.00
Sub Total				**914,347.77**
In Country Priority Projects				
Hoosingow 1 SO 4	Water Pan (Haffir Dam)	2	Haffir Dam of 68,000m3	381,955.00
			Protected Shallow Well Water System	6,788.00
			Solar Pumping System	8,941.00
			Camel Trough	1,845.00
			Sheep Trough	1,394.00
			Elevated Water Tank with Generator Room Underneath	16,800.00
			Communal Water point	2,095.00
			Borehole Camera Inspection	1,120.00
			Single Pit Latrine	3,699.00
Sub-Total				**424,637.00**
Hoosingow 2	Boreholes	2	Solar Pumping System	8,931.00
			Reinstallation of Pumps	8,000.00
			Borehole Camera Inspection	1,000.00
			Camel Trough	1,845.00
			Sheep Trough	1,394.00
			Single Pit Latrine	2,597.00
			Fencing	1,802.00
			Telemetric Devices and Installation	67,500.00
			Communal Water point	1,020.00
Sub-Total				**94,089.00**
Modogashe KE 1.3	Sub-Surface Dams	4	Construction of SSD Dam 1	99,694.00
			Construction of SSD Dam 2	116,443.00

			Construction of SSD Dam 3	99,694.00
			Construction of SSD Dam 4	116,443.00
			Solar System and Fence	142,805.12
			15m3 Elevated Tank	19,917.34
			Power House	33,598.54
			Camel Trough	1,844.58
			Sheep/Goat Trough	1,394.49
			Rising Main	140,074.00
			Elevated Steel Tank	61,635.10
			Distribution Pipeline	46,915.05
			3 Water Kiosks	18,704.07
Sub-Total				**899,162.29**
Gurufa, KE 2	Borehole	3	Borehole drilling, development and test pumping	145,580.00
			Electromechanical works	71,084.00
			Raising Main	79,337.00
			Elevated steel tanks	61,635.00
			Distribution Pipeline	40,150.00
			Water Kiosks	11,240.00
Sub-Total				**409,026.00**
Shantabaq, KE 7	Borehole	2	Borehole drilling, development and test pumping	177,744.00
			Electromechanical works	79,098.00
			Raising Main	84,473.00
			Elevated steel tanks	61,635.50
			Distribution Pipeline	50,159.50
			Water Kiosks	12,469.38
Sub-Total				**465,579.38**
KE 6.2	Water pan	1	Water Pan 75900m3 Capacity	167,030.20
			Sheep Trough	8,216.88
			Camel/Cattle Trough	8,931.32
			Shallow well	1,394.49
			Communal Water Point	1,844.58
			Single Pit Latrine	1,019.66
			Fencing	2,596.51
Sub-Total				**191,033.64**

Appendix 3: Costing of the Alternative Projects

Alternative Projects				
Tabda 1	Earth Dam	1	Dam 1 of 68,000m3	190,972.50
			Dam 2 of 72,000m3	280,860.00
			Protected Shallow Well Water System	9,021.00
			Fence and Gate	1,840.00
			Solar Pumping System	1,390.00
			Caretaker room	1,235.00
			Camel Trough	2,095.00
			Sheep Trough	3,699.00
			Elevated Water Tank with Generator Room Underneath	16,200.00
Sub-Total				**513,368.50**
Tabda 2,Bills Qooqani 1 SO7	Borehole	1	Drilling and Installation of Borehole	103,534.00
			Construction of 50m3 elevated water tank	28,498.00
			Construction of 30m3 elevated water tank	18,072.00
			Construction of Generator Room with store	15,785.00
			Construction of water kiosk at borehole site	13,656.00
			Water purification system	70,000.00
Sub-Total				**249,545.00**
Bilis Qooqani 2 S08	Earth Dam	1	Haffir Dam of 68,000m3	165,035.00
			Protected Shallow Well Water System	8,217.00
			Solar Pumping System	8,931.00
			Camel Trough	1,845.00
			Sheep Trough	1,394.00
			Elevated Water Tank with Generator Room Underneath	13,449.00
			Communal Water point	1,050.00
			Single pit laterine	2,597.00
Sub Total				**452,033.00**
Arbajahan KE 3	Borehole	1	Borehole drilling development and test pumping	147,732.00
			Electromechanical works	139,551.10
			Rising main	89,666.00
			Elevated steel tank	60,940.60
			Distrubution pipeline	185,237.25
			2 No water kiosk	12,469.38
Sub Total				**635,596.33**
Gurufa 2	Water pan	1	Water pan construction	167,030.20
			Shallow well	8,216.88
			Solar system	8,931.32

			Sheep trough	1,394.49
			Camel cattle /trough	1,844.58
			15m3 elevated tank	13,449.24
			Communinal water point	1,019.66
			Single pit latrine	2,596.51
Sub Total				**204,482.88**
Habaswein KE4.1,4.2,4.3	Water pans	3	Water pan construction	501,090.60
			Shallow well	24,650.64
			Solar system	26,793.96
			Sheep trough	4,183.47
			Camel cattle /trough	5,533.74
			15m3 elevated tank	40,347.72
			Communinal water point	3,058.98
			Single pit latrine	7,789.53
Sub Total				**613,448.64**
Abakore KE6.1	Water pan	1	Water pan construction	167,030.20
			Shallow well	8,216.88
			Solar system	8,931.32
			Sheep trough	1,394.49
			Camel cattle /trough	1,844.58
			15m3 elevated tank	13,449.24
			Communinal water point	1,019.66
			Single pit latrine	2,596.51
Sub Total				**37,452.68**
Ademasajida KE5.1	Groundwater Development	1	Borehole drilling development and test pumping	147,732.00
			Electromechanical works	139,551.10
			Rising main	89,666.00
			Elevated steel tank	60,940.60
			Distrubution pipeline	185,237.25
			2 No water kiosk	12,469.38
Sub Total				**635,596.33**
Habaswein KE5.2	Groundwater Development	1	Borehole drilling development and test pumping	147,732.00
			Electromechanical works	139,551.10
			Rising main	89,666.00
			Elevated steel tank	60,940.60
			Distrubution pipeline	185,237.25
			2 No water kiosk	12,469.38
Sub Total				**635,596.33**
Abakore KE6.3	Groundwater	1	Borehole drilling development and test pumping	147,732.00

	Development		Electromechanical works	139,551.10
			Rising main	89,666.00
			Elevated steel tank	60,940.60
			Distribution pipeline	185,237.25
			2 No water kiosk	12,469.38
Sub Total				**635,596.33**
Eldera KE1.1	Sub-surface dams	1	Construction	99,694.00
			Solar system and fence	142,805.12
			elevated tank	19,917.34
			Power house	33,598.54
			Camel trough	1,844.58
			Sheep/goat trough	1,394.49
			Rising main	140,074.00
			Distribution pipeline	11,728.75
			Water kiosk	6,234.69
Sub Total				**457,291.51**
Barkuke KE 1.2	Sub-surface dams	1	Construction	99,694.00
			Solar system and fence	142,805.12
			elevated tank	19,917.34
			Power house	33,598.54
			Camel trough	1,844.58
			Sheep/goat trough	1,394.49
			Rising main	140,074.00
			Distribution pipeline	11,728.75
			Water kiosk	6,234.69
Sub Total				**457,291.51**