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NBI Technical Reports: Water Resources Management- Groundwater Series

Enhancing conjunctive management of surface and groundwater resources in selected trans-boundary aquifers : Case study for selected shared groundwater bodies in the Nile basin: Mount Elgon Aquifer Final Sada Report

WRM/GWS/-2023-01

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Document Sheet

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The purpose of the technical report series is to support informed stakeholder dialogue and decision making in order to achieve sustainable socio-economic development through equitable utilization of, and benefit from, the shared Nile Basin water resources.

Document	
Citation	NBI Technical Reports – WRM/GWS-2023-01
Title	Enhancing conjunctive management of surface and groundwater resources in selected trans-boundary aquifers : Case study for selected shared groundwater bodies in the Nile basin: Mount Elgon Aquifer Final Sada Report
Series Number	Water Resources Management -Groundwater Series
Date	February 2023
Responsible and Review	
Responsible NBI Center	Nile-Secretariat
Responsible NBI	Dr. Michael Kizza and Dr. Maha Abdelrahim Ismail
Document Review Process	Regional Expert Working Group
Final Version endorsed	Indicate the date of endorsement
Author / Consultant	
Consultant Firm	N/A
Authors	Mr. Michael Owor
Project	UNDP-GEF Project
Funding Source	
Project Name	Enhancing conjunctive management of surface and groundwater resources in selected trans-boundary aquifers: case study for selected shared groundwater bodies in the Nile basin
Project Number	

Executive Summary

The project objective was to enhance knowledge and capacity for sustainable use and management of trans-boundary aquifers and aquifers of regional significance in the Nile Basin. The assignment involved the preparation of the Shared Aquifer Diagnostic Analysis (SADA) report for the Mt Elgon Aquifer system, shared between Uganda and Kenya.

Methodology; The study was largely a review of secondary existing/archived historical datasets and information with limited primary field data collection involving both social and physical science approaches. The collected data was harmonised to characterise the aquifer across the two-shared countries for information management. Social sciences methodology included, in-depth interviews; focus group discussions; field observation; photography; key stakeholder mapping using the snowball technique, or chain referral; reviews of reports, manuscripts and official documentation; and identification of key threats to the management of groundwater resources. Physical sciences methodology included a review of datasets and previous works and information to characterise the physical aspects of the aquifer including areal extent and architecture, hydraulic properties and storage, physiography, climate, vegetation, soils and geology.

Key stakeholders;

- On the Ugandan side were indentified in categories of: primary (directly affected by IWRM activities) and secondary (indirectly affected); and level of engagement, including national, regional, district and community levels; indigeneous gropus (e.g. Bagisu, Sabinyi, and Benet also known as Ndorobo, Musobishiek, or Ogiek).
- The Kenyan side had categories of indigenous groups (e.g. Ogiek, Sengwer, Yaaku Waata, and the Saanya, Sabaot and pastoralists, e.g. Endorois, Turkana, Maasai and Samburu); and local groups working in the region (e.g. Government and intergovernmental institutions, Community and Civil Society Organizations).
- Stakeholder analysis on the Kenyan side was generated based on their importance (primary, secondary, tertiary) and level of influence (low, high to very high) on groundwater resources development and management issues.
- Groundwater management requires the participation and involvement of various stakeholders from the aquifer/local, county/district and national levels.
- Many stakeholders are involved in groundwater usage and management and their opinions should be considered to enhance trans-boundary aquifer management. For example, the indigenous communities have complained of what they called "*systematic discrimination and marginalization*" in accessing resources including but not limited to water.
- Groundwater sources constructed by both the central and local governments are managed by district/county water officers; some water sources constructed by the NGOs or individual people are managed by the people appointed by funders or such communities elect their own water user committees.

Key drivers and pressures; On the aquifer included, agriculture, tourism, mining, manufacturing, trade related activities, water scarcity, climate, population, household needs, industial development, and land degradation.

Shared aquifer characteristics; This was defined over a working area of 37,486 km^2 of the Mt. Elgon aquifer region well beyond the estimated area of about 4,900 km^2 during the IAEA Project No. AF39.

- In Uganda, the aquifer system lies within the Lakes Kyoga and Turkana basins, largely within the two catchments of Awoja and Mpologoma and underlies at least 9 districts of Kapchorwa. Kween, Amudat, Bududa, Bukwo, Bulambuli, Nakapiripirit, Namisindwa and Sironko; on the Kenyan side it is within the Lakes Victoria and Turkana basins and spans four counties, of West Pokot, Busia Trans-Nzoia and Bungoma.

- Physiography of the region is dominated by Mt. Elgon with its craters, deep valleys and ridges and lies from <1,040 masl to over 4,321 masl at the peak of Wagagai; the terrain to the north and east is lower lying and more rugged than the terrain to the east and south which is higher and slopes more gently away from the volcanic massif.
- Climate follows a bimodal pattern with long (heavier) rains from March to May and the short (lighter) rains from October to November, mean annual rainfall is 687 to 2,544 mm. Mean monthly temperatures in the southern part range between 15 °C and 27 °C while at the northern extreme part, is up to 32^{o}C. Mean annual actual evapotranspiration and interception varies between 460 and 1800 mm.
- Rivers on the Kenyan side include Kuywa, Sosio, Kibisi, Sio-Malaba/Malakisi, Ewaso-Rongai Noigamaget and Sabwani, forming the main tributaries of River Nzoia which drains into Lake Victoria. River Suam also originates from the Mt. Elgon slopes. River Nzoia flows southwards to Lake Victoria while River Sipi originates from the northeastern part of Mt. Elgon and flows towards the central Nile Basin.
- Land use and land cover shows that the southern parts of the Mt. Elgon aquifer region is highy cropped and built up. Around Mt. Elgon is a thick tree cover with shrubs towards its peak. The low-lying northern parts of the region is largely covered by shrub and grasslands.
- The soils are >50% underlain by haplic vertisols; other key soil types include haplic ferralsols, eutric gleysols, albic plinthosols, rhodic ferralsols, haplic acrisols, plinthic acrisols, eutric fluvisols, chromic and cambisols.
- The geology is grouped into main lithologic units; (i) volcanic rocks (volcanic lava, tuff, agglomerates, mudflow and nephelinite); (ii) sediments (alluvial and lacustrine sediments, outwash debris and laterite); (iii) gneissic basement (gneiss, granulite, migmatite, charnokite and basement); (iv) intrusive igneous rocks (granite, gabro, diorite, granodiorite, granitoid, pegmatite, fenite and ijolite); (v) extrusive igneous rocks (carbonatite, phonolite, nephelinite, basalt, rhyolite, marble and metasomatic rocks); (vi) meta sedimentary and volcanic rocks (amphibolite, schist, quartzite and metavolcanic rocks); and (vii) sedimentary rocks (sandstone, mudstone, arkose, conglomerate and grit).

Groundwater occurence; Groundwater replenishment originates from the region around the volcanic massif considered to form the recharge area, which discharges to the outlying catchment areas.

- The aquifer is considered a multi-layered hydraulically connected, largely semi-confined aquifer whose lithology is predominantly crystalline rocks, that unconformably overlies the basement complex, which in the highland sections of agglomerate lava forms an aquitard offering the aquifer, semi-confined/ leaky conditions.
- Depth to the water table ranges from ground level to 90 mbgl, with mean and median values of 9.4 and 7 mbgl, respectively.
- The depth of the aquifer is up to 300 mbgl, with mean and median values of 60.5 and 55.6 mbgl, respectively.
- Vertical thickness of the aquifer has mean and median values of 29.9 and 28.0 m, respectively.
- Thicknes of confining layers ranges up to 65.8 m, with mean and median values of 20.4 and 21.0 m, respectively.
- Local residual of rainfall and evaporation on the Kenyan side ranges from 100 to 567 mm yielding an average of approximately 300 mm. Locally, the recharge of the aquifer is generally very low to medium, estimated to vary between 0 to 100 mm/ annum. Regionally, previous works estimate recharge volume for Kenya and Uganda at 230 and 240 km^3/decade, respectively; depth for Kenya and Uganda is 400 and 960 mm/decade, respectively.
- Natural discharge is mainly through spring and stream flows especially on the mountain slopes. This discharge goes untapped in the rainy season and is wasted, yet it has a high potential for becoming a regional water reservoir. There is need to expand and protect more

water sources so that water wastage is controlled and conflicts are reduced among these communities.

- Groundwater infrastructure is mainly gravity flow schemes and protected springs predominantly at higher altitudes on mountain slopes while boreholes and shallow wells are located in the flat plains.
- Regionally, the yield of groundwater boreholes ranges up to 43.3 m^3/hr, with mean and median values of 2.6 and 1.5 m^3/hr, respectively.
- Regionally, the mean and median transmissivity values are 9.7 and 2.4 mbgl, respectively; secondary data for storativity derived from the Kenyan side averages 0.0027.

Conceptual hydrogeological model; The preliminary conceptual hydrogeological model of the Mt. Elgon aquifer system depicts main recharge in the higher volcanic mountain areas, with slopes dominated by runoff and springs, that flow and infiltrate into the low-relief region underlain by deeply weathered and fractured crystalline rocks, forming semi-confined systems, and discharge through alluvial and lacustrine sediments, and wetlands. The region underlain by deeply weathered extrusive igneous rocks and gneissic basement have fairly similar and slightly higher permeability compared to the intrusive igneous rocks which is the most dominant hydrogeological formation.

- ***Socio-economic considerations***; For groundwater development include; population, literacy and poverty; agriculture; tourism; mining; manufacturing; and governance of groundwater resources. Socio-economic pathways (SEPs) is centred on population; education; infrastructure and energy; land use and land cover; agriculture, irrigation infrastructure and industries; water supply and access; industry and trade; and financial services.

Key threats; Key threats to sustainability of shared groundwater aquifers include; overabstraction; decreased recharge; climate change leading to erratic rainfall; increasing pollution levels, poor land use practices and land use/cover change, rapid population growth, inadequate management capacity, inadequate financial support to manage proposed water use stakeholder activities.

Groundwater demand and abstraction; Current and projected groundwater abstraction is based on various usage; agriculture and livestck watering, domestic use and health purposes, rural water supply, different commercial industry uses, and ecosystem support. Demand for water from rain and groundwater for agricultural production is high especially in the dry seasons, leading to conflicts between the communities in the area. Priority is often given to water resources utilization and development for domestic water supply for both human consumption and livestock.

Groundwater monitoring; Groundwater monitoring at 6 stations had; at Serere daily groundwater levels from 0.7 to 9.9 mbgl with mean and median values of 6.5 and 6.7 mbgl, respectively; at Soroti daily levels vary between 4.8 and 8.6 mbgl, with mean and median of 6.9 and 7.0 mbgl, respectively; at Moroto Prisons daily levels from 8.0 to 13.5 mbgl with mean and median values of 10.4 mbgl, respectively; at Pallisa daily levels from 8.9 to 13.9 mbgl with mean and median values of 11.5 and 11.4 mbgl, respectively; at Kangole daily levels from 6.1 to 12.4 mbgl, mean and median values are 8.9 and 9.1 mbgl, respectively; at Bungoma, monthly levels vary from 7.2 to 33.6 mbgl, with mean and median of 18.1 and 17.4 mbgl, respectively.

Baseline water quality; Parameters include physico-chemical (alkalinity, pH, hardness, EC, TDS) and chemical (total Fe and F), and chemical (F and NO_3) constituents in groundwater at well completion, in addition to major chemical consitituents (e.g. Ca, Mg, Na, K, HCO_3, SO_4, Cl and NO_3). Groundwater is largely fresh with a TDS of <1,000 mg/l.

P*olicy, legal and institutional framework*; Existing groundwater management policies and mandates in each of the two-shared countries is different and require harmonisation and include;

- Kenyan policies and legislation; Kenyan related policies and plans; Kenyan groundwater governance Kenyan regulation and controls; Kenyan institutional and organisational arrangements; and Kenyan monitoring.
- Ugandan policy and legal framework; Ugandan water resources management framework; Ugandan institutional context.
- Other reflections included the governance conditions of the Mt. Elgon aquifer, and gender considerations.

Identified gaps; Gaps are identified in the shared Mt. Elgon aquifers management, in terms of measure, problem and required policy change. A causal chain analysis summarised the types of cause and major risks to the Mt. Elgon aquifer in terms of (a) immediate or primary causes, (b) underlying or fundamental causes, and (c) root causes. A SWOT matrix of the SADA contribution identified the strengths, weaknesses, opportunities and threats to the Mt. Elgon aquifer.

- Access to and availability of surface water is limited in most areas within the Mt. Elgon aquifer system due to rainfall seasonality as a result of climatic changes, water pollution, long distance for access, and limited safe water supply by the water supply companies; utilization of groundwater resources thus remains the key solution to fill the existing accessibility gaps.

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Acronyms

AWMZ	Albert Water Management Zone
BMZ	The Federal Ministry for Economic Cooperation and Development
CAAC	Catchment Area Advisory Committee
CAO	Chief Administrative Officers
CBO	Community Based Organization
CBWRM	Catchment Based Water Resources Management
CCD	Climate Change Department
C-DLB	Chairperson District Land Board
CDO	Community Development Officers
CFA	Community Forest Association
CIDP	County Integrated Development Plan
Client	Nile-SEC
CMC	Catchment Management Committee
CMO	Catchment Management Organisations
CMP	Catchment Management Plan
CMS	Catchment Management Secretariat
COVID-19	Corona Virus Disease - 2019
CSF	Catchment Stakeholder Forum
CSO	Civil Society Organisation
CTC	Catchment Technical Committee
D&DP	Donor and Development Partners
DAIMWfAP	Department of Agricultural Infrastructure, Mechanisation, and Water for Agricultural Production
DCDO	District Community Development Officer
DDP	District Development Plan
DEA	Directorate of Environmental Affairs
DEA-RWO	DEA Regional Wetlands Office
DEdO	District Education Officer
DEO	District Environment Officers
DESS	Department of Environmental Support Services
DFO	District Forest Officer
DGSM	Directorate of Geological Survey and Mines
DHD	District Health Department
DLG	District Local government
DNRO	District Natural Resources Officer
DPO	District Production Officer
DPP	Directorate of Physical Planning
D-PP	District Physical Planner
DRC	Democratic Republic of Congo
DWD	Uganda Directorate of Water Development
DWO	District Water Officers
DWRM	Uganda Directorate of Water Resources Management
DWSSC	District Water and Sanitation Coordination Committee
ECOTRUST	The Environmental Conservation Trust of Uganda
EMCA	Environmental Management and Co-ordination Act
ENRM	Environmental Natural Resources Management
ENSAPT	Eastern Nile Subsidiary Action Programme Team
EU	European Union
FAO	Food and Agricultural Organization
FBO	Faith Based Organization
FGD	Focus Group Discussions
FSSD	Forestry Sector Support Department
GDS	Government Deconcentrated Structures

GEF	Global Environment Facility
GFS	Gravity flow scheme
GIS	Geographical Information System
GOK	Government of Kenya
GRACE	Gravity Recovery and Climate
GW/SW	Groundwater/Surface water
IC	International Consultant
ICRAF	International Council for Research in Agroforestry
IGRAC	International Groundwater Resources Assessment Centre
ITWAD	International Transboundary Water Affairs Department
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
KADILAC	Kapchorwa District Landcare Chapter (KADILAC)
KFS	Kenya Forest Service
KfW	Kreditanstalt für Wiederaufbau
KWMZ	Kyoga Water Management Zone
L.sum	Lumpsum
LC5	Local Council 5
LG-S	Local Government Structures
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
masl	metres above sea level
mbgl	metres below ground level
MDAs	Ministries, Departments and Agencies
MEMD	Ministry of Energy and Mineral Development
MFPED	Ministry of Finance, Planning and Economic Development
MLG	Ministry of Local Government
MOH	Ministry of Health
MoLHUD	Ministry of Lands, Housing and Urban development
MoTIC	Ministry of Trade, Industry and Cooperatives
MoTWA	Ministry of Tourism, Wildlife and Antiquities
MWE	Ministry of Water and Environment, Uganda
NAADS	National Agricultural Advisory Services
NaFORRI	National Forestry Resources Research Institute
NBI	Nile Basin Initiative
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NELSAP CU	Nile Equatorial Lakes Subsidiary Action Program Coordination Unit
NEMA	National Environment Management Authority
NEMA-RO	NEMA Regional Office
NFA	National Forestry Authority
NFA-SO	NFA Sector Office
NGO	Non-governmental Organization
Nile-COM	Nile Council of Ministers
Nile-SEC	Nile Basin Initiative Secretariat
Nile-TAC	Nile Basin Technical Advisory Committee
NRD	Natural Resources Departments
NRM	Natural Resources Management
NWRA	National Water Resources Assessment
NWSC	National Water and Sewerage Corporation
O&M	Operation & Maintenance
OPM	Office of the Prime Minister
PIBID	Presidential Initiative on Banana Industrial Development
PRA	Participatory Rural Appraisal
PS	Physical Sciences Consultant
PSFU	Private Sector Foundation of Uganda

RAIN	RAIN-Uganda
RDC	Resident District Commissioners
RED	Renewable Energy Department
RWRC3	Rural Water Regional Center -3
RWSSD	Rural Water Supply and Sanitation Department
RWTSUs	Regional Wetlands Technical Support Units
SADA	Shared Aquifer Diagnostic Analysis
SAP	Strategic Action Program
SAS	Senior Assistant Secretary
SC	Social Sciences Consultant
SDG	Sustainable Development Goals
SEP	Stakeholder Engagement Plan
SVIP	Sironko Valley Integrated Projects (SVIP)
TBA	Trans-boundary aquifers
ToR	Terms of Reference
TSU	Technical Support Units
UBOS	Uganda Bureau of Statistics
UFA	Uganda Forestry Authority
UIA	Uganda Investment Authority
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNMA	Uganda National Meteorological Authority
UNWMZ	Upper Nile Water Management Zone
UO	Umbrella Organisations
UWA	Uganda Wildlife Authority
UWASNET	Uganda Water and Sanitation NGO Network
UWS-E	Umbrella of Water and Sanitation East
UWSSD	Urban Water Supply and Sewerage Services Department
VWMZ	Victoria Water Management Zone
WB	World Bank
WfP	Water for Production
WfPD	Water for Production Department
WfPRC-E	Water for Production Regional Centre East
WMD	Wetlands Management Department
WMZ	Water Management Zone
WQMD	Water Quality Management Department
WRA	Water Resources Assessment
WRA	Kenya Water Resources Authority
WRMAD	Water Resources Monitoring & Assessment
WRPRD	Water Resources Planning & Regulation
WRUA	Water Resource Users Association
WSDF	Water Supply Development Facilities
WSDF-E	Water and Sanitation Development Facility East
WSDF	Water Supply Development Facilities
WSGS	Water and Sanitation Gender Strategy
WSRB	Water Services Regulatory Board
WUC	Water User Committees
ZARDI	Zonal Agricultural Research and Development Institute

1. INTRODUCTION

1.1 Watershed/ designation of study area

The study is of the Mt. Elgon aquifer region shared within the Lakes Victoria and Turkana basins in Kenya, and Lakes Kyoga and Turkana basins in Uganda.

1.2 Personnel undertaking study

The study involves Mr. Anthony Mark Kyalirizo, the physical science consultant on the Ugandan side; Dr. Tom Ogwang, the social science consultant on the Ugandan side; Mr. Sospeter Simiyu Wekesa, the physical science consultant on the Kenyan side; Mr. Maurice Ogoma, the social science consultant on the Kenyan side; and, Dr. Michael Owor, the international consultant for the Mt. Elgon aquifer.

1.3 Purpose of study

The Nile Basin Initiative (NBI) is a cooperative arrangement initiated and led by the Nile riparian countries to promote joint development, protection and management of the common Nile Basin water resources. One of the key result areas NBI Secretariat (Nile-SEC) implemented Basin Wide Program focuses on is trans-boundary groundwater aquifers. With the financial support of the Global Environment Facility (GEF) through United Nations Development Program (UNDP), the Nile-SEC is implementing its first groundwater study project with the objective of enhancing knowledge and capacity for sustainable use and management of trans-boundary aquifers and aquifers of regional significance in the Nile Basin. This project has five components aiming at strengthening the overall water resources management nationally and basin-wide.

Along the Nile basin countries, reliance on groundwater is rapidly increasing due to the increased demand over water supply. There is ample evidence that groundwater recharge in the Nile basin is under threat. This is partly attributed to climate change, high rainfall variability, and land use/land cover changes leading to declining amount of surface/ground water interaction in different areas. The interaction between groundwater and surface water systems (e.g. rivers, wetlands, lakes) has not been adequately considered within the Nile basin. The threats on trans-boundary aquifers are more severe because of lack of common groundwater governance and management mechanisms. Therefore, it is of vital importance to build and expand on the understanding of groundwater resources characteristics through detailed investigation, mapping and assessment of the Nile basin aquifer systems. This project will also enhance the understanding of the implications of impacts of potential climate change scenarios on the overall basin surface and groundwater resources in the Nile. The socioeconomic context is similarly an important issue in groundwater management for sustainable use and protection that needs to be properly addressed through stakeholders' engagement in a participatory approach for adequate groundwater management systems.

1.4 Project objectives

The project objective is to enhance knowledge and capacity for sustainable use and management of trans-boundary aquifers and aquifers of regional significance in the Nile Basin. Specific objectives include to:

- Improve knowledge and understanding of groundwater resources in the Nile Basin;
- Strengthen overall water resources management nationally and basin-wide;
- Respond to climate change impacts through effective risk-reduction adaptation measures - e.g. conjunctive use and management of surface water and groundwater;
- Ensure a healthy ecosystem and strengthened livelihood.

The project comprises the following five (5) components:

- Component 1: Furthering knowledge and understanding about availability of groundwater resources in the selected aquifers underlying watersheds in the sub-basins of the Eastern Nile and the Nile Equatorial lakes;
- Component 2: Development of action plans on groundwater resources governance, management, and protection for inclusion in national, sub-basin frameworks: – also including consideration of surface water/groundwater resources conjunctive use;
- Component 3: Targeted pilot projects to explore conjunctive use of surface and ground waters, and links to biodiversity conservation and climate change adaptation;
- Component 4: Further strengthening capacity to address groundwater issues at the national and regional levels;
- Component 5: Communications and awareness raising;

The current study involves Component 1 on furthering knowledge and understanding about availability of groundwater resources in the selected aquifers underlying watersheds in the sub-basins of the Eastern Nile and the Nile Equatorial lakes. Three aquifer areas were chosen for the current intervention, namely the Kagera aquifer shared among Burundi, Rwanda, Tanzania and Uganda; the Mt. Elgon aquifer shared between Kenya and Uganda; and the Gedaref-Adigrat aquifer shared between Ethiopia and Sudan. The aquifers are located in diverse ecological zones ranging between arid, semi-arid and tropical. This assignment will aim at fostering current mutual understanding for the groundwater flow regime and mechanism of recharge, policies, management systems, community engagement and sustainable development plans for effective utilization and protection from over abstraction, depletion and pollution.

1.5 Consultancy/assignment objectives

- To undertake a Shared Aquifer Diagnostic Analysis (SADA) and produce a report that serves as baseline fact-based representation of current status of the aquifer's threats (immediate causes, root causes), use/abstraction; surface-groundwater connection, socio economics, with gender disaggregated data collection factoring also climate change and extreme climate events;
- To support preparation of the harmonized and a standardized groundwater knowledgebase (geo-data base and maps) for the Mt Elgon aquifer system by providing data in the relevant formats.

1.6 Consultancy/assignment scope

- Develop conceptual framework and plan the SADA study;
- Identify the data needs and tools/resources required;
- Supervise national consultants from Kenya and Uganda who will collect relevant information on groundwater management in the countries, and specifically, data and information for the Mt Elgon aquifer;
- Carry out a review of the existing data and/or prior hydrogeological related assessment reports that are available;
- Conduct analysis of the aquifer;
- Provide assessment reports, including hydrogeological maps with recommendations for suitable groundwater interventions as adaptive measures based on the findings of the assessments;
- Provide an updated knowledge/information with maps of groundwater distribution and availability by conducting groundwater assessments for the Mt. Elgon shared aquifer;
- Carry out stakeholder consultations with regional experts, national officials and local officials;
- Conduct workshops/trainings (the training content to be delivered by the consultants, National Focal Institution will coordinate local level engagement of stakeholders). Conduct two aquifer level workshops in the shared aquifer area in Kenya and Uganda. Workshop participants will be selected maintaining gender balance involving national and regional stakeholders;
- In carrying out the above tasks, the consultant is expected to work very closely with local staff in Kenya and Uganda, of the national/local authorities to ensure skills transfer/capacity building.

1.7 Assignment outputs

The consultant shall prepare:

1) A Shared Aquifers Diagnostic Analysis report (SADA) for the Mt. Elgon shared aquifer that serves as baseline fact-based analysis of current status of the aquifer, historical trends in resource availability, existing governance mechanisms at national and cross-border levels and threats that the aquifer faces. The consultant shall submit all data and information collected together with the report;
2) Conduct two workshops in the shared Mt. Elgon Aquifer area in Kenya and Uganda.

1.8 Expected outcome of assignment

The expected outcome of the assignment is an improved understanding and knowledge of groundwater in the Mt. Elgon Aquifer system. This also includes identifying the types of pressures on groundwater, and building upon the existing information knowledge base.

1.9 Report contents

The Mount Elgon Aquifer Final SADA Report C report includes contributions from the social sciences and physical sciences national final SADA C reports of Kenya and Uganda. This report provides a summary of the study approach; stakeholders identified and their level of engagement in groundwater management; drivers and pressures on the aquifer; shared aquifer characteristics,

socio-economic considerations for groundwater development; existing groundwater management policies and mandates; impacts of changes in use; availability and quality of groundwater on resource-dependent communities and the environment, providing policy, legal and institutional responses to the challenges ahead.

1.10 Methods

The assessment of a shared groundwater system is conceptualised in terms of (i) data collection, (ii) harmonisation, (iii) aquifer characterisation including general assessment and indicator-based assessment, and (iv) information management (Kukuric et al., 2015; IGRAC and UNESCO-IHP, 2015) (Fig. 1.1): The study is largely based on a review of existing historical/archived datasets at both national and aquifer levels. Some limited physical and social sciences fieldwork was conducted at aquifer level with the aim of verifying and filling gaps in the existing datasets.

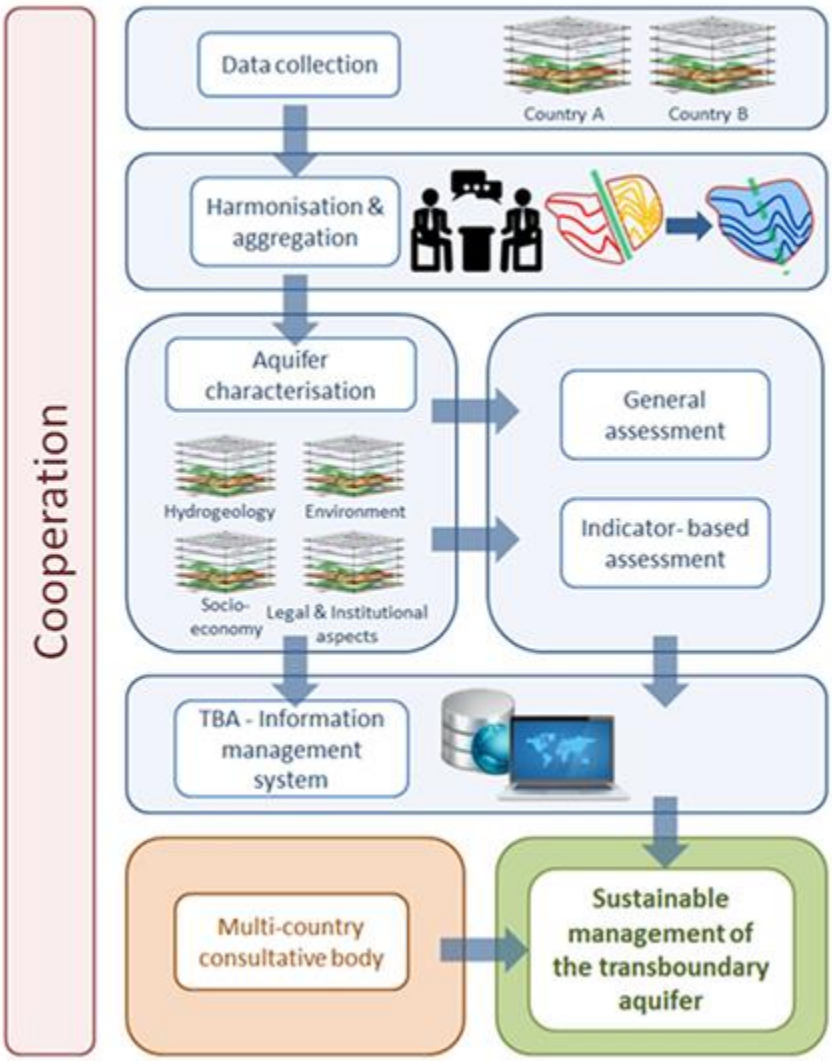


***Figure 1.1**: An illustration of the conceptual framework (after IGRAC and UNESCO-IHP, 2015).*

The social sciences study adopted a combination of data collection techniques namely; in-depth interviews, focus group discussions, observation, photography, desktop reviews, and validation workshop. Purposive and convenience sampling methods were used to identify stakeholders. A total of 84 respondents took part in the Ugandan study. In-depth interviews were used to obtain data from the key respondents at the district level, including the chief administrative officers, district water officers, natural resources officers, district environment officers, district planners, community development officers. Focus group discussions were used during the interface with the local communities regarding water use and maintenance, and other related water issues. Similarly, focus discussion groups were also used while meeting the indigenous groups. This was the best method as it allowed the groups to interact in their natural environment without any fear since they knew themselves. The method also gave them the confidence to speak freely since their problems are similar in many ways. The review process aided to identify the indigenous groups and local communities around the Mt. Elgon aquifer. Key government policy documents on groundwater and their effectiveness were also consulted. Other sources of documents included peer reviewed journals, and reports by NGOs.

On the Kenyan side, data collection for the study was conducted through focus group discussions with various stakeholders at the county and the local levels. There were also key Informant Interviews with managers of groundwater resources within the counties that share the Mt. Elgon Aquifer. The study aimed to generate information on local and indigenous social context and their dependence on groundwater, the constraints they face in accessing groundwater, and challenges and opportunities for women and men in establishing sustainable livelihoods using groundwater supply. This was conducted through;

i. Describing the main social context of the indigenous people depending on the Mt. Elgon aquifer and their concerns on using groundwater supply;
ii. Understanding the state of the current social referral system for groundwater;
iii. Collecting existing information on national and county level information on groundwater management in the country and Mt. Elgon aquifer including current use, civil and social involvement and engagement in management of indigenous communities;
iv. Engaging stakeholders at different levels (aquifer, local, county and national) through public forums, and workshops to provide information they have, assist in the identification of knowledge gaps, and receive information on the lacking areas for purposes of capacity building on sustainable utilization and management of the groundwater within the Mt. Elgon aquifer;
v. Skills transfer and capacity building between the consultants, and local staff while undertaking the tasks of the assignment within the Mt. Elgon aquifer.

1.11 Stakeholders involved in groundwater management

1.11.1 Stakeholder identification on the Ugandan section

Primary and secondary stakeholders

Stakeholder engagement is a key element in sustainable management and utilisation of natural resources and is accorded great priority in IWRM. It even becomes more important when

transboundary water resources including trans-boundary aquifers are involved. This section therefore, presents a synopsis of the stakeholders who are likely to be involved in the sustainable development of the Mt. Elgon Aquifer.

The proposed list of stakeholders was generated from the existing structure of the water and environment sector and also from literature of similar studies previously undertaken in the project area. It was assumed that the same players exist and are still relevant to the current study. On a broad scale, the stakeholders were categorised according to their level of engagement, including such as national level, regional level, community level. At a more local level, existing literature categorises stakeholders into primary and secondary stakeholders depending on the level of influence and interest in IWRM issues.

Primary stakeholders were considered as those directly affected by IWRM activities at sub-county/micro catchment level and these include; women and youth groups, Water User Committees, farmer groups, fishermen, small based businesses, small based processors/small cottage industries/cooperatives/private sector, government/private institutions; schools, health centres and large-scale processors.

These were categorized as intermediary stakeholders operating at sub-county level among which include sub-county leaders; LC3, CDO, sub-county chief, cultural leaders, CBO/FBOs, NGOs, and local media channels.

Details of categories and ranking of stakeholders are presented in Annexes 10.8 and 10.9 of this report. However, because the existing literature does not exhaustively cover all the districts under current study, additionally, the stakeholder profile may have changed over time hence the need for field verification to update the proposed list of stakeholders.

Indigenous stakeholders in the Ugandan section

The Elgon region has three main groups of people that live in the mountain ecosystem and they include the Bagisu, the Sabinyi and a rare small group of people who live in the forest area and rely on its ecosystem for their survival called the Benet. The Benet also called (Ndorobo, Musobishiek, or Ogiek) are a group of indigenous people who have occupied the slopes of Mt. Elgon for a very long time. They have mixed livelihoods, they are pastoralists (rare goats and cows), hunters and gatherers. The Benet describe their territory to extend from as far as Sironko river in the west, continuing eastwards through Suam river into Kenya, then cross Lwakhakha river right back into Uganda to reach Manafwa river. The fact that their original territory is covered and bordered by surface water bodies, makes them vital stakeholders in the management of groundwater.

In an undated document titled "*Mt. Elgon Benet Indigenous Ogiek, Statement of Grievances*", the group claimed that "the situation of the Benet is sufficiently credible to indicate a pressing problem requiring the attention of the government. The government is further urged to take corrective measures as needed in the spirit of constructive dialogue and cooperation". The Benet were agro-pastoralists and passionate about their cattle to the extent that they swore by it (*Ntoya Tanyi*). They were also hunters and fruit gatherers. Their main food was milk, blood extracted from the cows, meat, fruits, and honey.

During the colonial time, the creation of the boundary between Uganda and Kenya drastically altered the administrative structure of the region. People who were hitherto in one unit found themselves in two countries, i.e. the area between Suam River and Kisawai River became Kenya but originally under the *prophet* based in Uganda. These "*prophets*" were scrapped and replaced with colonial administrators. In addition, all the territories that belonged to the Benet under their "*prophet*" was declared a gazetted area, effectively rendering them landless.

The action which had the most profound impact on the Benet during the colonial era was the creation of Mount Elgon Crown Forest in 1937. This in essence dismantled the traditional land tenure system of the Benet area, and turned the Benet's communal land into a public protected area. This was done without consulting the Benet and against their will. During the push for independence in 1961, a war broke out between the Sabiny and Bagisu commonly referred to as the "*Coffee War*". In their quest to attain district status or secede from Bugisu, no coffee was allowed to cross over to the other side from Sebei. The Bagisu came to fight but were defeated. In retaliation, they directed that any Sabiny or people related to them should leave their part of territory. The Benet who were high in the mountains were affected and so moved eastwards (from Manafwa River to Yembek). This formed the Kwoti Benet. The others were the Benet from the Benet area, and finally the Yatui Benet.

Despite many of these problems beginning during the colonial period, the Benet have primarily blamed the post independent governments for a myriad of actions which have allegedly exacerbated their suffering. The document asserted that they have been marginalized and discriminated against for a long time. They also claimed that governments at all levels have been making decisions on their behalf without consulting them. That they have been effectively excluded which has contributed to their low social, economic and political standing compared with other communities in the region and beyond.

According to the Africa Legal Officer[1] at Minority Rights Group Africa representing the group to regain their lost land, the Benet land issue dates way back to 1936. This is around the period when the colonial administration had control over Uganda and gazetted the mountain and the forest into a central government forest reserve. Subsequently, upon independence, in 1963 the government turned it into a national park. Gazetting their lands led to reduction in size of the land they used for cultivating their food. They were forced to appeal to government to be give more land for cultivation and also maintain their life in the forest.

However, their plea to regain their land has not been a success as indicated by their legal representative. The government of Uganda signed a memorandum of understanding to give back their land however, the Uganda Wildlife Authority has stood in the way of this directive. The Benet therefore, remain a place where they keep demanding for land which according to them is their rightful inheritance.

[1] Eunice Nsikak Olembo, Africa Legal Officer at Minority Rights Group Africa. 'Five decades down the line, we shall not relent…' https://minorityrights.org/2020/08/27/we-shall-not-relent/

The Benet also have another interesting feature about their group. They have been found in a place of conflict with their neighbors which led to their division. In 1961, there was a civil unrest between the Benet, and their neighbors (Sabinyi and Bagisu), around the period Uganda gained her independence. Their displacement from the forest reserve led to their breakup. The group was separated into three to form the Kwot Benet, Benet and Yatui Benet, however, all the three kept their original identity of the Benet Ogeik.

Indigenous people such as the Benet have a right to access good quality water because they depend on the same ecosystem as other ethnic groups in the Elgon sub-region. The case they have against UWA clearly indicates their vulnerability in terms of power to repossess land which once belonged to them. It is therefore, such experiences which makes a study on their involvement in governance of groundwater resources paramount.

Administrative level stakeholders

A number of stakeholders are involved in the management of water resources in the country and these are described at different levels of responsibility, including government and intergovernmental institutions. At the national level, the Ministry of Water and Environment Water Resource Committee is the lead institution which oversee water usage and management in Uganda. The ministry provides the policy frame work and development of water in the country. Within the ministry, there is the Directorate of Water Resources Management (DWRM) which is responsible for implementing the water laws in the country, policies, plans and regulations, monitoring water quality and quantity and transboundary water resources. They do this through providing a knowledge base and analytical tools for water management. They also carry out water resource planning and allocation in the country, catchment planning and manage stakeholder involvement. Water management plans include regional investment plans, water strategic investment plans, water management zone investment plans and catchment investment plans. Still within the ministry another important body is known as the Directorate of Water Development (DWD). This particular arm of the ministry is responsible for water development and water services mostly in urban areas with its main focus on investment preparation and implementation. Then there is the Directorate of Environmental Affairs (DEA). The directorate for Environmental affairs is responsible for ensuring that environmental resources are properly managed.

At district level are officials involved in the management of water resources and they include the following; the Local Council Five chairpersons, Secretaries for production and agriculture, Chief Administrative Officers, Women representatives to the district, industrialists (e.g. irrigation, and mineral water), District Water Officers/National Environment Management Authority, water management zones (based in Mbale), and Non-governmental organizations (NGOs) whose activities are implemented within the district and at the site level of the water resource. At the Sub-county level, are the Local Council 3 Chairpersons, the councilors (council), women representatives to the sub county, Sub county chiefs, Community Development Officers, industrialists, Faith and Community Based Organizations. Non-governmental organizations whose activities are implemented within the sub county and at the site level of the water resource. These offices are important because they are closer to the water points which are consumed by the people.

The lowest level of water management and use takes place at the parish/village levels. These are the end points where water is consumed at the domestic level for home consumption, irrigation

and for animals. In the study area, people such as pastoral and agro-pastoral groups, farmer groups or farmer associations, and livestock groups, depend and rely on water to support their livelihoods since agriculture is the main socio-economic activities of the people living in Mt. Elgon aquifer area. Within these parishes and villages, there are community water users, Local Council I & IIs, women, men, youth, water user communities, schools, health facilities, and churches/mosques.

1.11.2 Stakeholder identification on the Kenyan section

The method used in mapping stakeholders within the Mt. Elgon aquifer for the study was through literature review on previous works that has been done on groundwater in the region, and noting the stakeholders who were involved. The snowball technique, or chain referral was also used to identify more stakeholders.

Key indigenous groups in the Kenyan section

In Kenya, 79,000 people are hunter gatherers and considered indigenous people. They include the Ogiek, Sengwer, Yaaku Waata, and the Saanya. There are also indigenous tribes including the Sabaot and pastoralists like the Endorois, Turkana, Maasai and Samburu. The people who are considered as indigenous people in Kenya are hunter-gatherers, some fishing villages and small farming communities, and nomadic herders. The indigenous peoples in the Kenyan Mt. Elgon aquifer area include the Ogiek indigenous peoples with a population of approximately 18,000 people. Approximately 3000 Ogiek people still live in the ancestral lands in Chepkitale on Mount Elgon. The ecosystem supports a rich variety of vegetation. The Ogiek graze their cattle, sheep and goats on the high Chepkitale moorland of Mt Elgon and into the forests below that circle the mountain, forests where they also gather honey. Their clans, council of elders, by-laws, and indigenous knowledge ensure the continued well-being of the environment on which they depend. The indigenous Sabaot tribe who are also known as the '*Elgon Maasai*' and other local communities, e.g. Nandi, Pokot, Marakwet and Sengwer live in the catchment area.

The issues facing the indigenous groups in Mt. Elgon region are land rights, insecurity, poor provision of services, discrimination and exclusion, and low political representation. Women belonging to indigenous communities particularly face harder time especially with exclusion and representation because of internal community prejudices and being part of marginalized and minority groups. Given the scarcity of surface water, access to water for these groups is becoming a challenge. With no private lands to their name, and their secluded nature of life, the use of groundwater for their water needs has not been fully exploited. Kenya has provisions for the protection of indigenous people in different policy and legislative instruments of different sectors. However, the country does not have a specific legislation on indigenous people.

Local Groups Working in the Region

Various methods were used to for mapping stakeholders within the Mt. Elgon aquifer. Literature review on previous work that has been done on groundwater in the region was used, and noting the stakeholders who were involved. The snowball technique, or chain referral was used to identify more stakeholders during the project field visits. Additional stakeholders were identified during local and national level workshops. The stakeholders who are involved in groundwater management within the Mt. Elgon Aquifer include;

Government and intergovernmental institutions

i. County Departments of Environment, Water Resources and Tourism in Bungoma, Trans Nzoia and Busia Counties
ii. Water Resources Authority (WRA) – The mandate of WRA is to protect, conserve, control and regulate use of water resources through the establishment of a national water resource strategy. WRA is also responsible for formulation and enforcement of standards, procedures and regulation for the management and use of water resources; policy development; planning and issuing of water abstraction permits; and setting and collecting permits and water use fees.
iii. National Environment Management Authority (NEMA) – NEMA exercises general supervision and coordination over all matters relating to the environment and issues a wide range of environmental licenses and permits under various environmental regulations. NEMA ensures that Environmental and Social Impact Assessment (ESIA) is conducted for relevant projects including relevant groundwater projects that might have environmental and/or social impacts in accordance with Environmental Management and Coordination Act (EMCA) of 1999.
iv. Lake Basin Development Authority (LBDA) – LBDA enhances socio-economic development and spurs regional development through sustainable utilization and conservation of natural resources through overall planning, co-ordination, implementation and monitoring and evaluation of development projects and programmes within the Lake Victoria basin. The authority implements community development projects including boreholes drilling within the basin.
v. Lake Victoria South Water Works Development Agency – The Agency is responsible for efficient and economical provision of water and sanitation services within its area of jurisdiction as authorized by the Water Services Provision License and mandated by Section 68 of the Water Act 2016.
vi. Water Services Regulatory Board – Approves tariffs, monitor and enforce water services standards and issue licenses to Water Service Providers. The set tariffs are supposed to be paid even for borehole water that has been piped and connected to homes and institutions
vii. Nzoia Water and Sanitation Company (NZOWASCO) – NZOWASCO is responsible for provision of water and sewerage services within the Counties of Bungoma, Trans Nzoia, Kakamega and Busia although the company is fully owned by the County governments of Bungoma and Trans Nzoia. The company also utilizes groundwater by drilling boreholes within the counties.
viii. Kenya Forest Service (KFS) – KFS is responsible for conservation, protection and management of public forests and forest reserves including water catchment areas within the Mt. Elgon aquifer.
ix. Nile Basin Initiative (NBI) - Conservation and management of shared water resources of the Nile River Basin. Currently involved in the development and implementation of the Angololo project in the Sio-Siteko transboundary area.
x. Ministry of Education: Local educational institutions e.g. schools and vocational training colleges. Most educational institutions are dependent on ground water and almost all have sunk boreholes within their compounds for institutional use.
xi. Ministry of Interior and Co-ordination of the National Government: chiefs and village elders are critical for local mobilization and dissemination of government policies at the

local scale through chiefs' *barazas* and local meetings. They also provide security and enhance conflict resolution for local project development.

xii. Kenya Forestry Research Institute (KFRI) – KEFRI conducts studies on natural regeneration and research on appropriate tree species for specific ecological zones.

Community and Civil Society Organizations

i. Water Resource Users Associations (WRUA) are the local water co-management institutions representing the local communities who are using the water resources. Their opinion is sought by WRA before approving the sinking of boreholes.

ii. Community Forest Associations (CFA) – They are organizations which are run by community members as co-management structures for the conservation of the Mt. Elgon Forest. Their main contribution to the aquifer region is on carrying out conservation activities which contribute to recharge of the aquifer. Some of the activities of CFAs within the Mt. Elgon aquifer region include tree nursery establishment, tree planting, and protection of forests from collection of fuel wood, and grazing; assisting in research and education purposes, establishing nature-based enterprises. Cheptais CFA is also part of the Tree Establishment and Livelihoods Improvement Scheme programme.

iii. Center for International Forestry Research (CIFOR) - – conducts research on forest and landscape management.

iv. Water Mission - provides safe water through groundwater exploration and construction of boreholes in Bungoma and Trans Nzoia counties.

v. The Green Belt Movement – involved in conservation through promotion of tree planting;

vi. Basin Water Resource Committee (BWRC) – BWRC are the catchment area advisory committee of WRA whose members are drawn from stakeholders within the basin and aim to achieve wide stakeholder participation in the management of water resources at the basin level. They are responsible for promoting conservation of water catchment in collaboration with WRA.

vii. World Vision – involved in upgrading of boreholes in Trans-Nzoia, Busia and Bungoma counties through installing solar powered pumps, storage tanks and water kiosks. They are also involved in conducting water analysis for the boreholes that they have helped in developing twice a year.

viii. Korean International Cooperation Agency (KOICA) – which has been responsible for upgrading a number of hand pumps to electric pumped boreholes. They are also responsible for implementation of gravity water schemes. They are planning on contributing to the development of water master plan for Bungoma County;

ix. The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) – An international development company responsible for promoting youth employment in western Kenya's agri-food sector. The company also supports transboundary water cooperation in the Nile Basin.

1.11.3 Stakeholders Analysis

Matrices indicating the ranking of the stakeholders on the Ugandan (Table 1.1) and Kenyan (Table 1.2) sides were generated based on their importance and level of influence on groundwater resources development and management issues.

Table 1.1*: A matrix ranking the stakeholders on the Ugandan side of the Mt. Elgon aquifer region.*

Stakeholder	Rank	Level of influence
Ministry of Water and Environment - Water resource committee	Primary	Very High
Directorate of Water Resources Management	Primary	Very High
Directorate of Water Development	Primary	Very High
Directorate of Environmental Affairs	Primary	High
The Ministry of Agriculture, Animal Industry and Fisheries	Primary	Very High
The Ministry of Tourism, Trade and Industry	Tertiary	Low
Ministry of Energy and Mineral Development	Tertiary	Low
National Water and Sewerage Corporation (NWSC)	Primary	Very High
National Environment Management Authority	Primary	Very High
National Forestry Authority	Tertiary	Low
GIZ	Tertiary	Low
European Union	Primary	High
BTC	Primary	High
UNDP	Tertiary	Low
Australian Development Agency	Tertiary	Low
Local Communities	Primary	Very High
Faith based organizations (FBOs)	Secondary	Low
Nile Basin Initiative (NBI)	Primary	High

***Table 1.2**: A matrix ranking the stakeholders on the Kenyan side of the Mt. Elgon aquifer region.*

Stakeholder	Role/function(s)	Rank	Level of influence/ impact on GW resources
Water Resources Authority (WRA)	Protection, conservation, control and regulation of water resources.	Primary	Very High
County Departments of Environment, Water and Irrigation, Health, Agriculture, Public Works, Interior	Implementation of government policies in line ministries, sectors or departments.	Primary	Very High
Water Resources User Associations (WRUA)	Collective management of water resources and resolution of conflicts of water resources use.	Primary	Very High
National Environment Management Authority	Ensures compliance with the provisions of EIA regulations in GW projects development.	Primary	Very High
Kenya Meteorological Department (KMD)	Provides meteorological and climatological services to include agriculture and water resources management and the private sector	Secondary	High

Lake Basin Development Authority (LBDA)	Supporting community development projects.	Tertiary	Low
Lake Victoria South Water Works Development Agency	Provision of water services, technical services and capacity building	Secondary	High
Water Services Regulatory Board	Approval of tariffs, monitoring and enforcement of water services standards, and licensing of Water Service Providers.	Secondary	High
NZOWASCO	Provision of municipal water services/supply	Tertiary	Low
Community Forest Associations (CFA)	Conservation and management of adjacent catchment area forests.	Primary	Very High
Kenya Water Towers Agency (KWTA)	Protection, rehabilitation, conservation and sustainable management of water towers.	Primary	Very High
CIFOR	Research/project funding and resource mobilization	Tertiary	Low
GIZ	Project funding/ resource mobilization	Tertiary	Low
Water Mission	Development and supply of GW resources, project funding/resource mobilization	Primary	Very High
World Vision	Project funding/ resource mobilization	Primary	High
The Green Belt Movement	Afforestation/ re-afforestation	Tertiary	Low
Korean International Cooperation Agency (KOICA)	Project funding/ resource mobilization	Tertiary	High
Local Communities	Provision of local resources (e.g. land), consumption of water services	Primary	Very High
Faith based organizations (FBOs)	Project funding/ resource mobilization	Secondary	Low
Community Groundwater Management Committees	Local management of community boreholes	Primary	Very High
Kenya Forest Service (KFS)	Protection and Conservation of water towers and catchment forests	Primary	Very High
Nile Basin Initiative (NBI)	Development and management of trans-boundary water resources	Primary	High
Ministry of Education e.g. Local educational institutions e.g. schools and vocational training colleges	Boreholes development and consumption of water resources.	Primary	Very High

2. DRIVERS AND PRESSURES ON THE AQUIFER

2.1 Agriculture

The coffee-banana system is predominant in the Elgon region. There is barley, maize, wheat and Irish potatoes especially in the Sebei districts. Livestock activities such as cattle rearing, poultry keeping, apiary, and pig rearing are also common in the Sebei areas of Kapchorwa, Kween and Bukwo. On the slopes of the Benet resettlement area in Kapchorwa, one finds a patchwork of horticultural crops such as assorted greens, pumpkin, peppers, other assorted vegetables and a few stands of eucalyptus. The Bugisu areas are mainly focusing on coffee, banana, Irish potatoes, peas, beans, fruits and other horticultural crops as the main crops. In the lowlands groundnuts, maize, sorghum, millet, cotton, soya beans, sweet potatoes, sunflower, and rice are common. There is a good road network between the districts and with the borders to Kenya with two main border posts at Suam in Bukwo and Lwakhaka, which has dramatically increased access to markets and contributed to increased cash-crop production.

2.2 Tourism

The region is located around the Mt. Elgon which is a gazetted national park whose beautiful scenery is the primary attraction. The park also has a diversity of animal species among which are buffaloes, tinny antelopes, forest monkeys and elephants plus a number of fauna species found in the park. This mountain is a significant watershed for a number of rivers such as River Sipi that forms the renowned spectacular Sipi falls. The park as well is habitat to more than 299 bird species with a couple of them not being seen in any other part of Uganda. Some other tourist attractions within this park are the very old cave paintings near the trailhead found at Budadiri, stunning caves plus the hot springs inside the crater, in addition to the renowned Imbalu dances plus ceremonies conducted by the native people during their initiation ceremonies.

2.3 Mining

With reports of vermiculite in Mbale, limestone in Kapchorwa, gold in Bukwo, and phosphates in Manafwa and Namisindwa districts, the region has a good investment potential in the mining sector. Already factories like Tororo cement are deriving their raw materials from the region. There are geological reports of the presence of rare earth minerals such as calcite, magnetite, flourapophyllite, natrolite and philipsite located within the Sipi caves and Manafwa district.

2.4 Manufacturing

Manufacturing with the two coffee unions in the area, the potential to add value on coffee in the region is enormous. Mbale also presents various manufacturing opportunities with a large industrial base to serve the region and the neighbouring districts and countries. Also coupled with a thriving agricultural industry, the potential to manufacture agro-related products for both domestic consumption and export to Kenya and Southern Sudan is enormous.

2.5 Trade related activities

The presence of the Suam and Lwakhaka border posts gives the region a strategic location to trade in agriculture commodities between Uganda and Kenya. This also makes the area a well-situated place for internal trade with the neighbouring districts of Karamoja, Bukedi, Teso, and Lango (UIA Elgon Investment Profile, 2018).

2.6 Water scarcity

Water scarcity is a big problem within the counties that are sharing the Mt. Elgon aquifer. The surface waters that are available within the region, are too polluted to be safely consumed by the local people. Piped water from government water service providers does not reach a big percentage of the population, which makes it impossible for hundreds of thousands of people to have access to good quality and quantity of water. The available sources are also very far away from some communities. In this case, water scarcity manifests as an issue of distance. In some communities, like Cheptais, women and children have to walk over 10 km to get access to clean water. People who live in Bungoma west and Busia have to walk to the springs in Cheptais to be able to access water. In many of the areas where there is no good water supply, the country governments of Trans-Nzoia and Bungoma have been running a programme since 2013, to drill boreholes for use by individual home owners, schools, and even medical facilities. Water scarcity and exploitation of groundwater resources is brought about because of key drivers and pressures.

2.7 Climate

Climate change has caused irregular weather patterns within the counties that are within the Mt. Elgon Aquifer region. There are prolonged periods of drought that have resulted in more pressure being exerted in the existing surface water sources. As such, institutions, commercial businesses, commercial buildings and homeowners, have had to rely on groundwater resources through drilling boreholes and shallow wells, while others also use spring water. During prolonged periods of intensive drought, there are also shallow wells and some boreholes which dry up. This has necessitated people to drill deeper boreholes which serve as either primary or alternative sources of water.

2.8 Population

Population pressure is also a concern in Bungoma, Trans-Nzoia and Busia counties, which are found within the aquifer region. The current rate of population growth in Kenya and number of people within these counties is surpassing the water resources that are available, and this puts immense pressure on the groundwater resources, to supplement, or in some cases, be the primary sources of water servicing thousands of people within one community. According to the 2019 population census, Trans Nzoia County has a population of 990,341 people with a population density of 397 people per square km and an annual growth rate of 4.2%. Bungoma County has a population of 1,670,570 people, and Busia County, which Teso North is part of, has a population of 893,681 people within 1,695 square km. High population, coupled with diminishing surface water and inaccessibility of piped water in many areas, has led to pressure on groundwater, because they are seen as the most viable and feasible options for getting water to water scarce areas.

The population densities in the aquifer area, are amongst the highest in the Kyoga Water Management Zone of Uganda, especially around Mount Elgon, in Mbale, Bududa, and

Namisindwa districts The growing population in the area exerts increasing pressure on water and land resources, resulting in increasing degradation of the environment. The high population growth of 3.2% also leads to increased exploitation and destruction of ecosystem resources. According to the 2019/2020 National Household Survey the Elgon sub-region population was estimated by Uganda population Census analytical report 2014 at approximately 1.7 million people representing 5% of the total population in Uganda (UBOS, 2014). Given the growth in population in the country in general and as represented by the UBOS website, it is correct to assume that the population in the Elgon Sub-region has increased over the past years. Table 2.1 represents the population of the sub-region per district broken down to represent males and females.

***Table 2.1**: Population of Elgon sub-region by district on the Ugandan side.*

District	Males	Females	Total
Bukwo	44, 770	44,483	89,253
Kapchorwa	51,169	53,441	104,610
Kween	48,579	47,044	95,623
Bududa	105,938	105,745	211,683
Bulambuli	85,837	91,485	177,322
Manafwa	171,745	181,119	352,864
Mbale	237,610	255,194	492,804
Sironko	121,989	124,547	246,536
Total	**867,637**	**903,058**	**1,770,695**

***Source:** UBOS, 2014 National Population and Housing Census*

2.9 Household Needs

The main uses of groundwater within the Mt. Elgon aquifer are household chores including drinking after purification, washing clothes, utensils, the house, and other household items. Tied to high population, the needs of people are so many and requires an ample supply of water. Usually, women are the ones in charge of household management, meaning they are directly responsible for sourcing for water for home consumption. According to the women in the studied counties and sub-counties, they face great challenges in their quest for water for use in households. They are forced to walk very long distances to secure the water. There are children who do not get to go to school because of the search for water, others end up being late for school because they had to go and get water to use in the homesteads. Groundwater is a resource that provides refuge for these people because they get access to clean water, to use in their households as opposed to polluted and contaminated surface water. County governments of Busia and Trans-Nzoia drill boreholes and place them in public institutions like schools and hospitals, and also in market places to ensure that everyone has access to the water from the communities. There are also people, water vendors, who have made a business of selling water to people who do not have access to the boreholes and cannot walk such long distances to access them. The water is sold at KES 20 - 25 for a 20 litre jerrican.

2.10 Industrial Development

Industrial development is not considered a great challenge to groundwater abstraction in the Mt. Elgon aquifer region because there are not many industries or factories within this region. However, there is immense pressure from the commercial sector. Offices and businesses need a constant supply of water which cannot be provided by government allocated piped water. Therefore, a bigger percentage of the companies and businesses which are found in the region has drilled boreholes to service their water needs. As a result, a lot of pressure is put on groundwater resources.

2.11 Land Degradation

Land degradation is significant in the southern reaches of the aquifer area and the most affected areas (hot spots) are the slopes of Mt. Elgon in Bududa, Manafwa and Namisindwa districts. Key issues related to land degradation are the escalating soil erosion and declining soil fertility. The degradation has arisen basically because of the intensive utilisation of land for farming, poor farming methods, deforestation, bush farming and overgrazing characteristic on the upland and mountainous landscapes of Bududa, Manafwa and Namisindwa. Land degradation has had a negative impact on food production and food security due to declining soil productivity.

3. SHARED AQUIFER CHARACTERISTICS

3.1 Regional extent and architecture of aquifer system

Mt. Elgon aquifer is a trans-boundary aquifer (TBA) shared between Kenya and Uganda (Fig. 3.1), with an estimated area of about 4,900 km^2 (IGRAC, 2021), and ~85% lying within the Nile Basin. The boundaries of the aquifer system were delineated during the IAEA Project No. AF39, covering the middle to upper sections of Mount Elgon and excluding its foot slopes (IGAD, 2011). The aquifer extends from Mt. Elgon which is a solitary extinct volcano straddling the Kenya-Uganda border. This assignment used a working area 8,500 km^2 of the Mt. Elgon aquifer region to determine the properties of the aquifer system.

On the Ugandan side, the aquifer lies within the Lakes Kyoga and Turkana basins and underlies at least 9 districts of Kapchorwa and Kween (fully within the aquifer region), others including Amudat, Bududa, Bukwo, Bulambuli, Nakapiripirit, Namisindwa and Sironko, which span largely two catchments of Awoja and Mpologoma. Sub-catchments that are wholly within the aquifer region include Sipi, Muyembe, Simu-Sisi, Lwakhakha and Upper Manafwa. The sub-catchments that are partially within the aquifer region include, Muchilmakat, Chebonet-Atari, Kelim, Sironko, Taboki, Lake Okolitorom, Namatala, and Middle Manafwa.

On the Kenyan side the aquifer region is within the Lakes Victoria and Turkana basins and spans four Counties, West Pokot, Busia Trans-Nzoia (sub-counties of Endebes and Saboti) and Bungoma (sub-counties of Mt. Elgon, Sirisia, Kimilili and Kabuchai). The greater region includes Trans Nzoia, Busia, West Pokot, and Bungoma Counties. It covers the areas of Kacheliba, Kapenguria, Endebes, Kitale, Saboti, Kiminini, Kaptama, Kapsokwany, Kimilili, Chwele, Webuye, Sirisia, Lwakhaha, Malaba, and Bungoma.

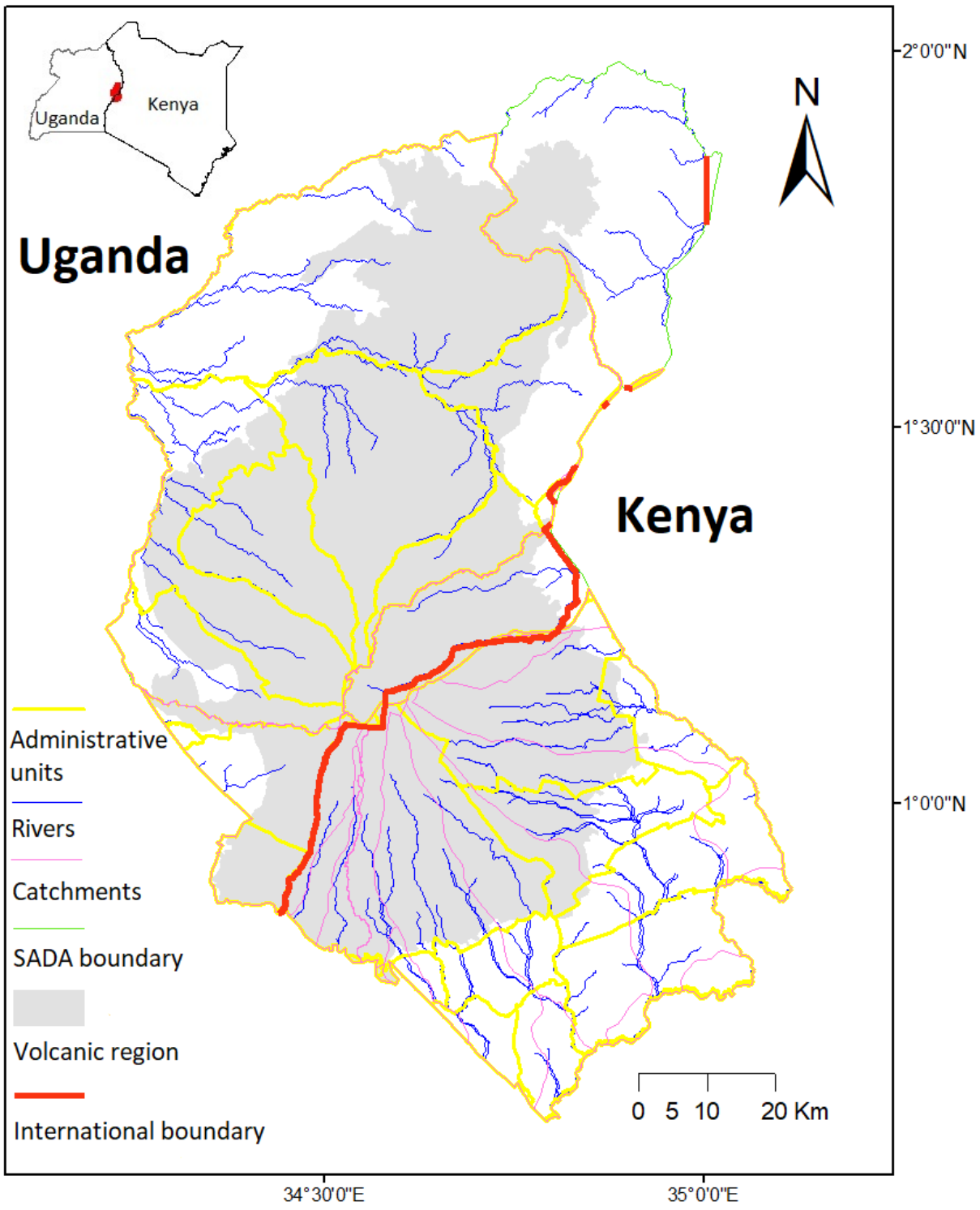


***Figure 3.1**: Location of Mount Elgon aquifer system in the drainage basins across the border between Uganda and Kenya; Inset is the map of Uganda and Kenya.*

3.2 Physiography and climate

3.2.1 Physiography and geomorphology

Mt. Elgon is a solitary extinct Pliocene shield volcano with one of the largest craters in the world, about 8 km in width, located in the western part of Kenya, in Trans Nzoia County and bisected by the Kenya Uganda border. (Fig. 3.2). A digital terrain model was generated from the 12.5m resolution ALOS PALSAR DEM (ASF, 2022). The southern edge of the aquifer extent is marked by Mount Elgon at the border between Uganda and Kenya. Mount Elgon with its craters, deep valleys and ridges rise to the highest peak in the area forming an undulating topography. Mount Kadam lies within the northern extreme portion of the aquifer boundary between Amudat and Nakapiripirit districts. The altitude of the region ranges from less than 1,040 m above sea level (masl) to over 4,321 masl at the peak of Wagagai. Much of the aquifer area lies at an altitude ranging from 1042 to 4279 masl. The rest of the area in between the two mountain ranges, lies between 938 and 1156 masl (Awoja CMP, 2017; Mpologoma CMP). Cross sections drawn north to south and east to west of the physiography of the Mount Elgon aquifer region derived from Google Earth Pro show that the terrain to the north and east is lower lying and more rugged than the terrain to the east and south which is higher and slopes more gently away from the volcanic massif (Fig. 3.3).

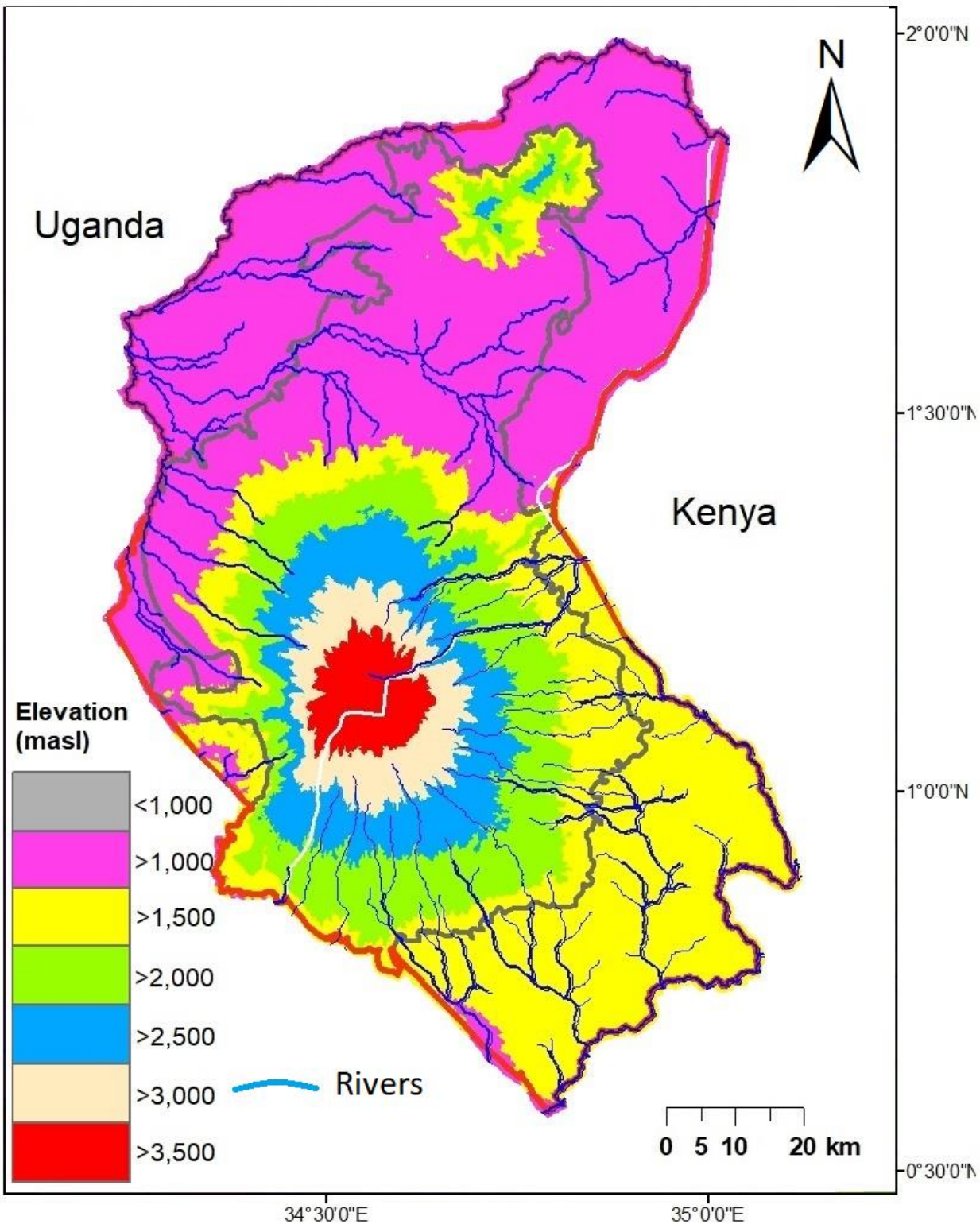


***Figure 3.2**: The digital terrain model of the Mount Elgon aquifer region shared between Uganda and Kenya derived from the 12.5m resolution ALOS PALSAR DEM (ASF, 2022).*

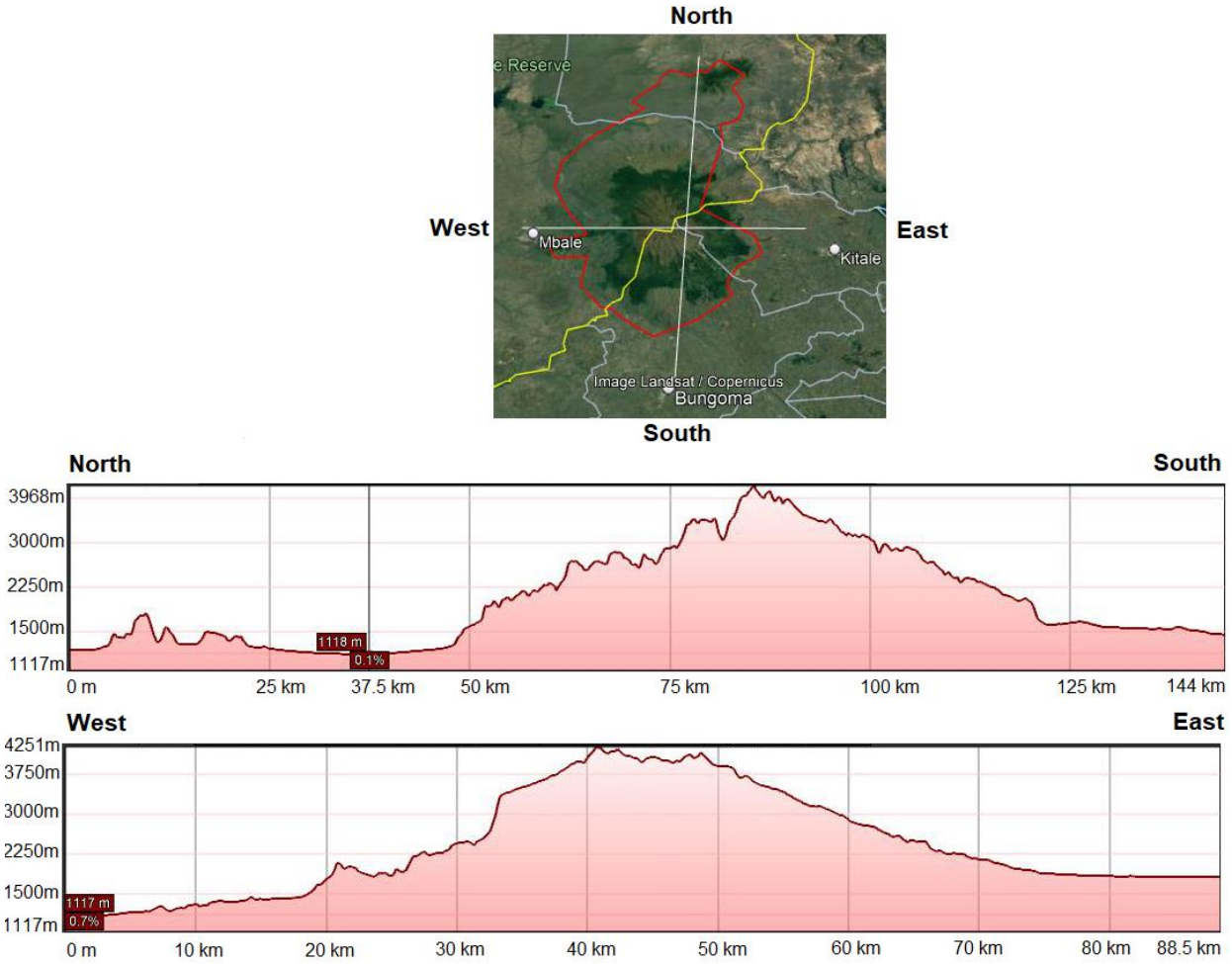


***Figure 3.3**: Cross sections of the physiography drawn north to south and east to west of the Mount Elgon aquifer region shared between Uganda and Kenya derived from Google Earth Pro.*

3.2.2 Climate and drainage

The area being within the Inter Tropical Climatic Zone (ITCZ) experiences four seasons annually. The long (heavier) rain seasons normally stretch from March to May and the short (lighter) rains from October to November. Dry seasons occur in the months of January to February and June to September. There is more rainfall in the foothill zones of Mount Elgon, with an average of 1,270 mm the minimum recorded being 1,016 mm and the maximum 1,549 mm. This region lies largely within the highland climatic zone having an average annual rainfall of 1500 mm. The climate of the region is highland equatorial with an annual rainfall of 700 to 1,800 mm. Despite being just 2^{o} from the Equator, the altitude results in the area having a relatively mild climate, with annual patterns dominated with rainfall rather than radiation. Much of the area is well-watered with the exception of Amudat and Nakapiripirit districts in Uganda and can support rain-fed agriculture, although seasonality varies across the southern and the northern parts of the aquifer region where seasonal droughts are a common feature. The aquifer area around Mt. Elgon experiences high bimodal annual rainfall of between 1500 and 2000 mm. At the Mt. Elgon foothills and slopes, rainfall decreases from south to north with the northern slopes falling within the rain shadow of

the mountain. The northern part of the area in Amudat and Nakapiripirit districts of the Karamoja sub-region, generally experience erratic rainfall whose annual mean is 745 mm which is not conducive for crop production. Stations in eastern Uganda show mean annual rainfall (1991-2020) from 727 mm in Kotido to the north to 2126 mm in Buginyana within the Mt. Elgon aquifer region (Fig. 3.4 left). Figure 3.4 (bottom) illustrates 44 rainfall stations located partly on the Kenyan side (Fig. 3.5a) with daily records from 1931-2004. Mean monthyl rainfall ranges from 17.5 to 63.8 mm with a mean values of 39.1 mm. On the Kenyan side rain falls throughout the year in the region (Fig. 3.6). The month with the most rains April, with an average rainfall of 180 mm. The month with the least rain is January, with an average rainfall of 33 mm. A wet day is one with at least 1 mm of liquid or liquid-equivalent precipitation. The chance of wet days varies very significantly throughout the year. The wetter season lasts 7.9 months, from March to November, with a greater than 43% chance of a given day being a wet day. The month with the most wet days in Bungoma is August, with an average of 21.4 days. The drier season lasts 4 months, from November March. The month with the fewest wet days is January. Annual rainfall amount increases in the direction of the great lakes region. The high rainfall amount and the distribution over the area give an indication of the potential of groundwater recharge in the area. Across the Mt. Elgon aquifer region, mean annual precipitation over a period of 2010 – 2020 using 0.05° resolution satellite imagery and rain gauge observations (CHIRPS, 2022) ranges from 687 to 2,544 mm per annum with higher precipitation received on the southern parts of the region (Fig. 3.7).

The mean monthly temperatures in the southern part of the aquifer area, range between 15 °C and 27 °C while those at the northern extreme part, may go up to 32^{o}C. The forests of the Mt. Elgon National Park are the main potential groundwater recharge areas within the aquifer region. The annual temperature recorded on the Kenyan side varies between 0°C and 32°C due to different levels of altitude, with the highest peak of Mt. Elgon recording slightly less than 0°C. The average wind speed is 6.1 km/hr. In the last decade, the region experienced increasing variability in rainfall and temperature patterns that have influenced changes in agricultural seasons. Stations in eastern Uganda show mean monthly (1991-2020) minimum temperatures ranging from 13.9 ^{o}C in Buginyana to mean monthly (1991-2020) maximum temperatures of 30.5 ^{o}C in Soroti (Fig. 3.4 right). On the Kenyan side February is the warmest month of the year. The temperature in February averages 22.2 °C (Fig. 3.8). The lowest average temperatures in the year occur in July, when it is around 18.7 °C. The hot season lasts for 2.2 months, from January 14 to March 21, with an average daily high temperature above 28°C. The hottest month of the year is in February, with an average high of 29°C and low of 16°C. The cool season lasts for 4.2 months, from May to September, with an average daily high temperature below 26°C. The coldest month of the year in the region is August, with an average low of 14°C and high of 25°C.

Data on evapotranspiration was extracted at a 100m resolution from WAPOR (2021) - The FAO portal to monitor water productivity through open access of remotely sensed derived data. The actual evapotranspiration and interception (*ETIa*) is the sum of the soil evaporation (*E*), canopy transpiration (*T*), and evaporation from rainfall intercepted by leaves (*I*). The value of each pixel represents the *ETIa* in a given year (2015-2020). Mean annual actual evapotranspiration and interception varies between 460 and 1800 mm (Fig. 3.9). The mountain tops have the lowest water loss through evapotranspiration partly due to lack of vegetation with the humid cropped region to the south having the highest losses.

Rivers on the Kenyan side include Kuywa, Sosio, Kibisi, Sio-Malaba/Malakisi, Ewaso-Rongai Noigamaget and Sabwani. These rivers are the major tributaries of River Nzoia which drains into Lake Victoria. The water from the rivers is utilized for domestic consumption, small scale irrigation and also have potential for hydroelectric power generation to support rural electrification, industrialization and fisheries. These activities could be a mitigation towards floods in the county. River Nzoia catchments and its tributaries are however threatened by encroachment, agriculture and other human activities. In the Kitale Plain, the principal river is the Koitoboss which rises from the foot of the Koitoboss peak. The other major river in the area is River Suam which originates from the Mt. Elgon slopes. River Nzoia originates from the Mount Elgon area and flows southwards to Lake Victoria while River Sipi originates from the northeastern part of Mt. Elgon and flows towards the central Nile Basin (Rannveig and Bernardas, 2012). The mean monthly river discharge (m3/s) from 1947 to 2000 of 35 stations located on the Kenyan side (Fig. 3.5b) is displayed in Fig. 3.10. The mean discharge ranges from 3.4 to 8.9 m^3/s with an average value of 9.9 m^3/s.

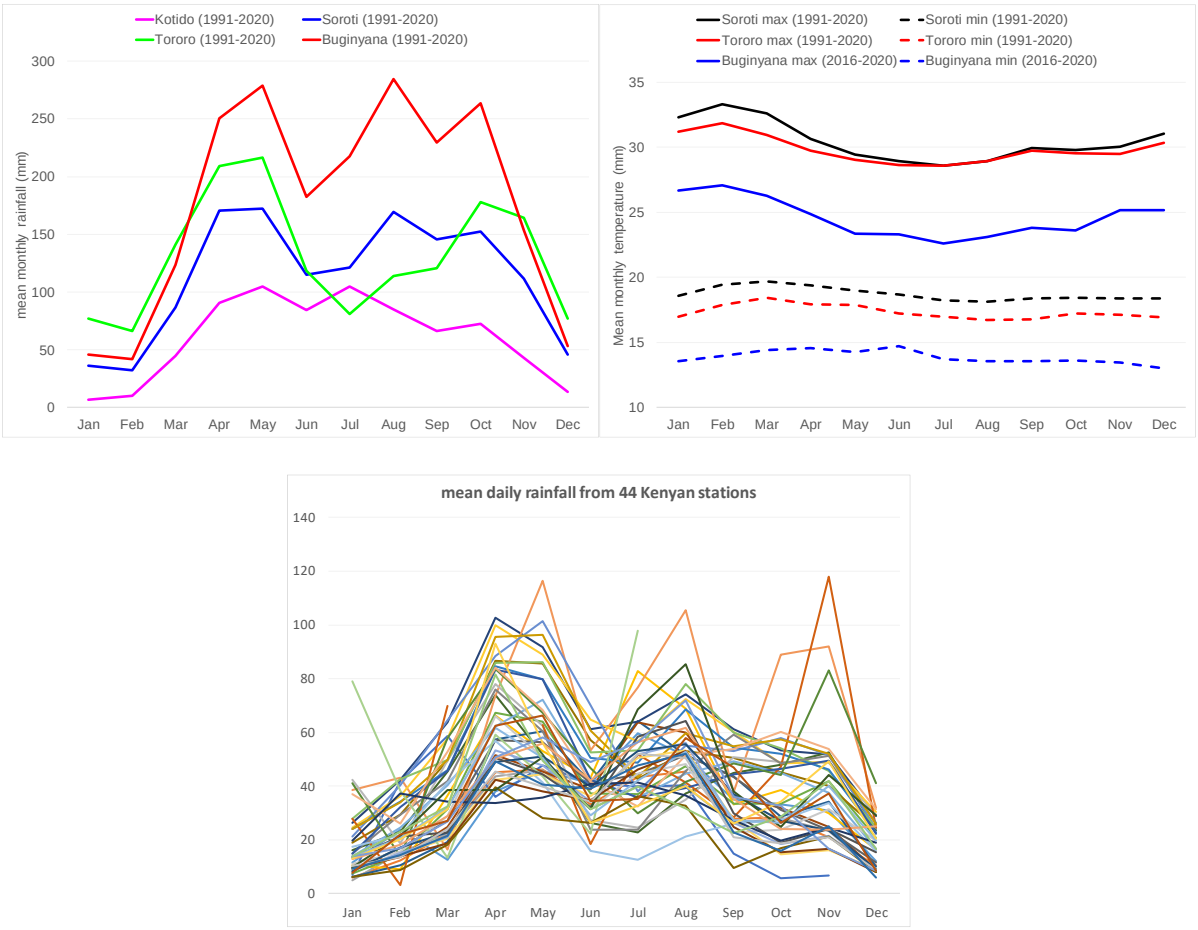


***Figure 3.4**: The mean monthly (1991-2020) rainfall (left)and temperature (right) and in stations of eastern Uganda and from Kenya 44 stations with daily rainfall (mm) records from 1931-2004 (bottom).*

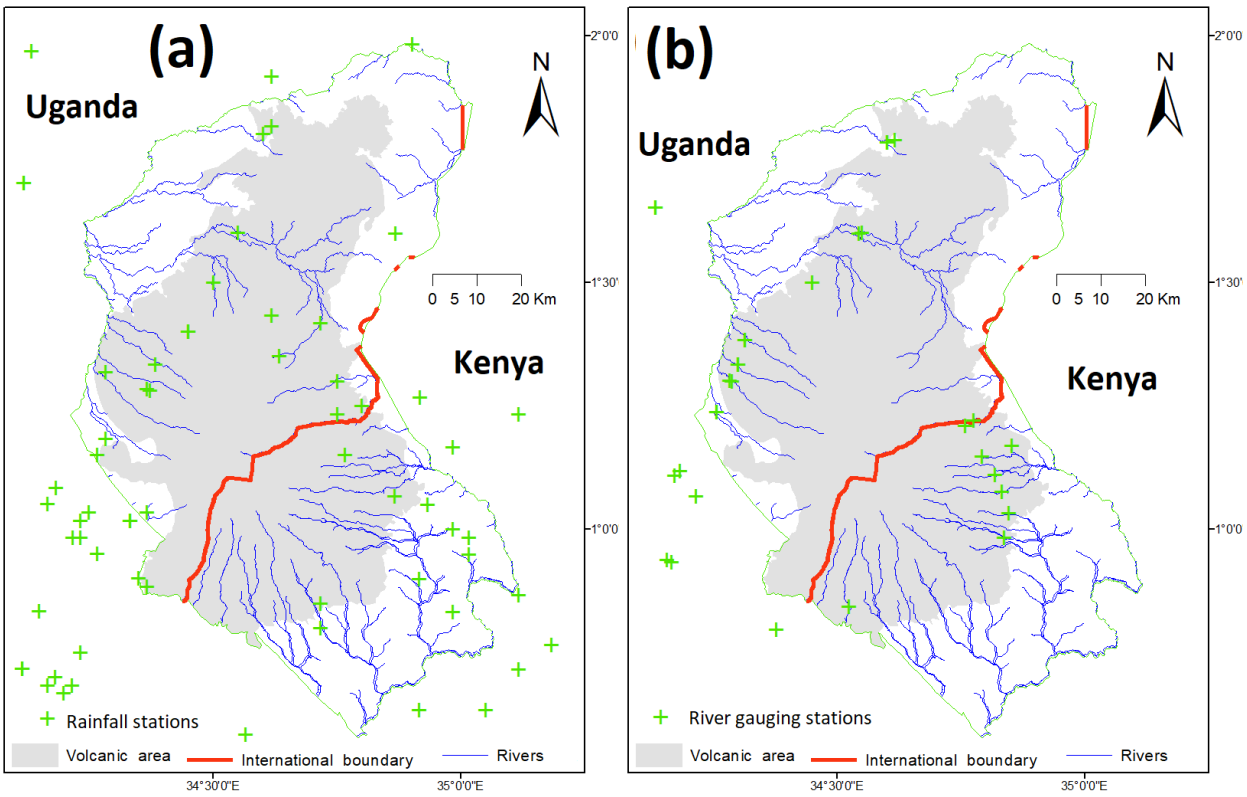


***Figure 3.5**: The location of (a) rainfall and (b) river discharge stations in the Mt. Elgon aquifer region.*

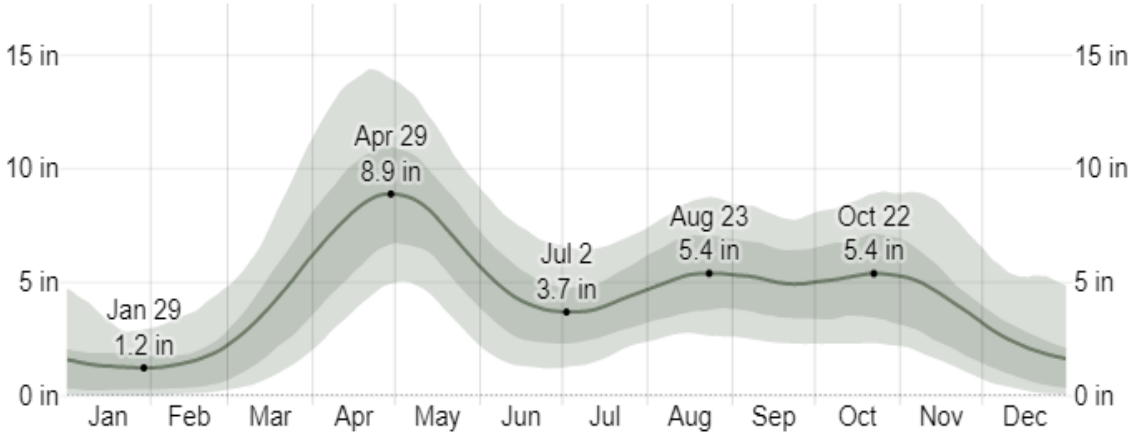


***Figure 3.6**: The average rainfall (solid line) accumulated over the course of a sliding 31-day period centered on the day in question, with 25th to 75th and 10th to 90th percentile bands at Bungoma, Kenya (Weather Spark, 2021).*

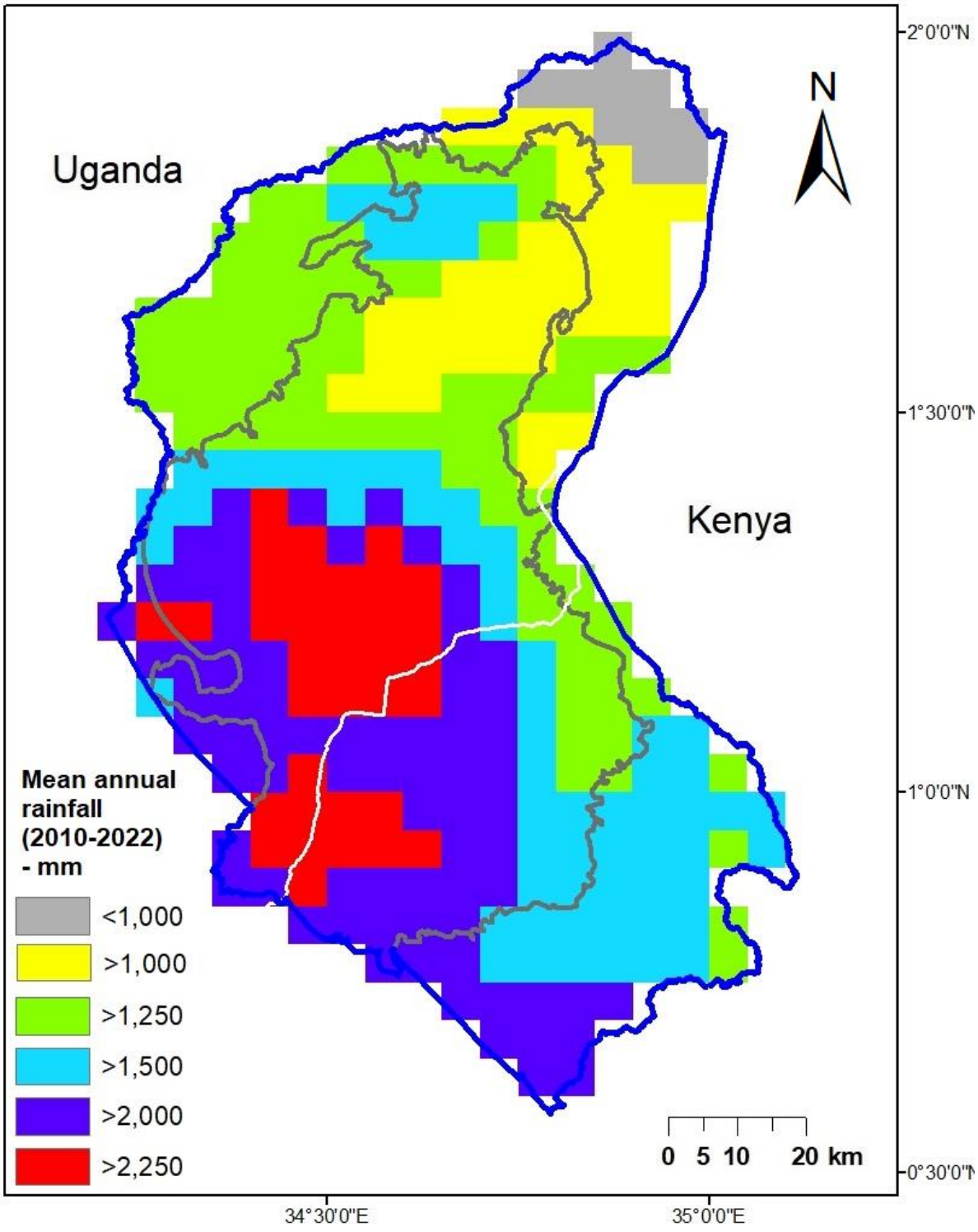


Figure 3.7*: Mean annual precipitation (2010 – 2020) using 0.05° resolution satellite imagery and rain gauge observations over the Mt. Elgon aquifer region shared between Uganda and Kenya (adapted from CHIRPS, 2022).*

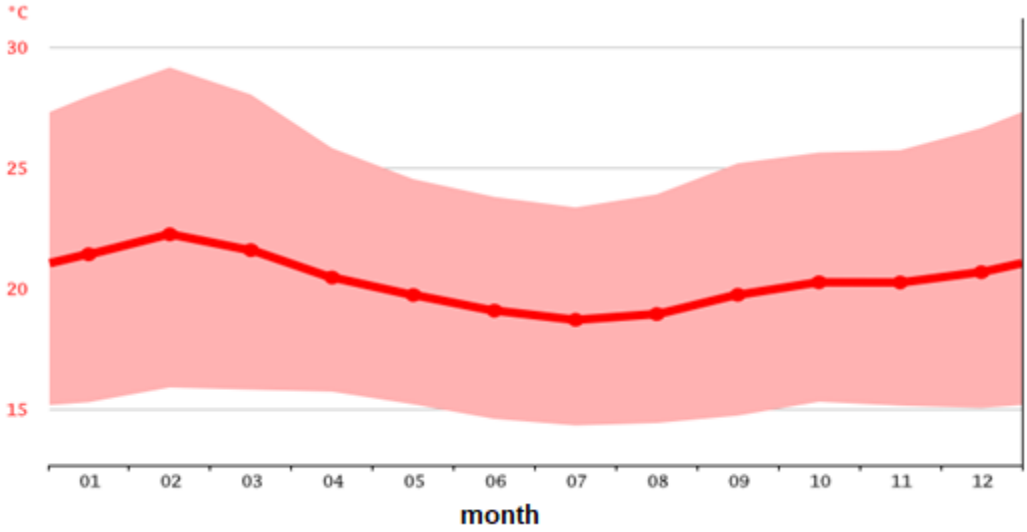


***Figure 3.8**: Mean monthly annual temperature variability for Bungoma, Kenya (Climate data, 2021).*

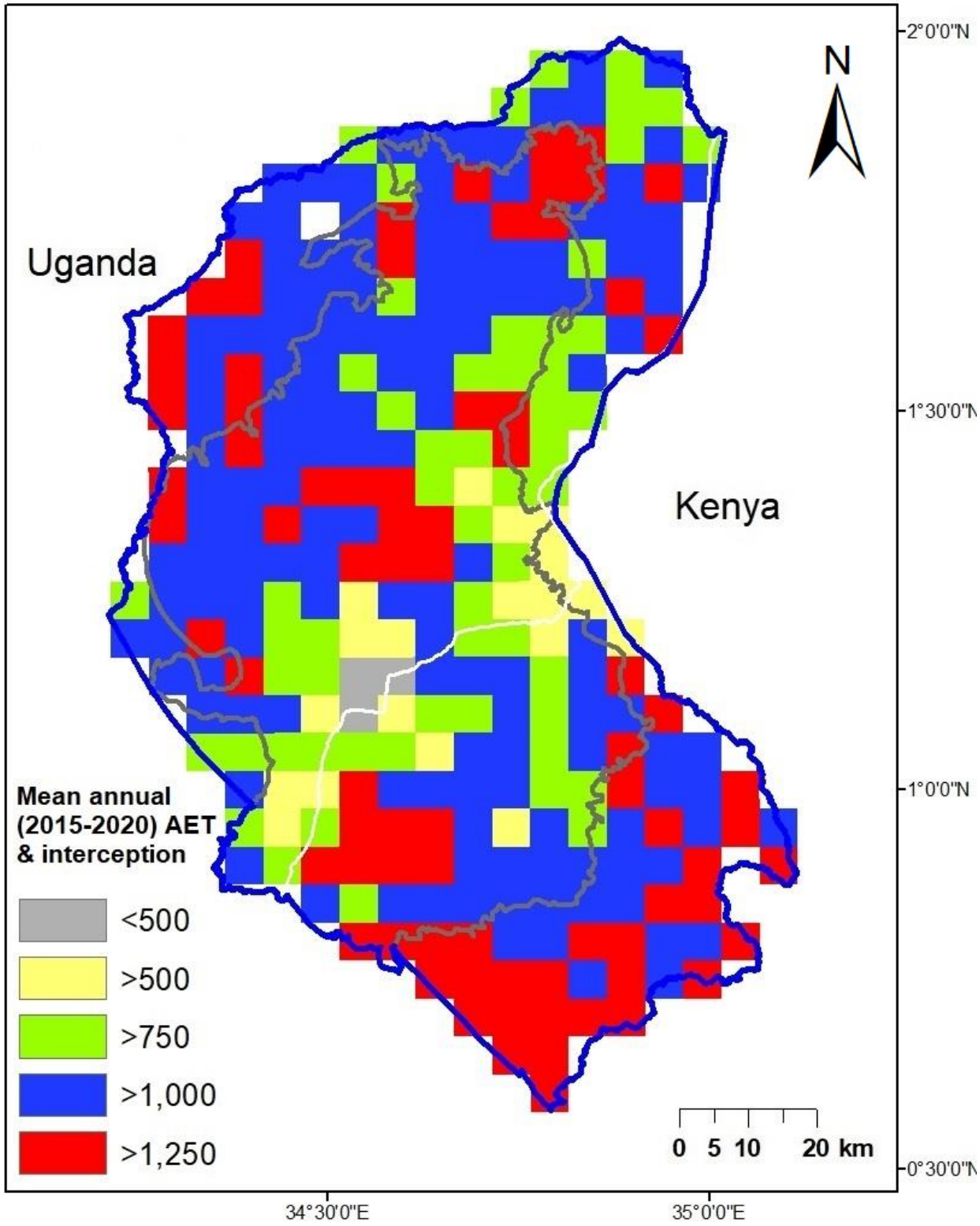


***Figure 3.9**: Mean annual (2015-2020) actual evapotranspiration and interception variability on a 100m resolution (adapted from WaPOR, 2021).*

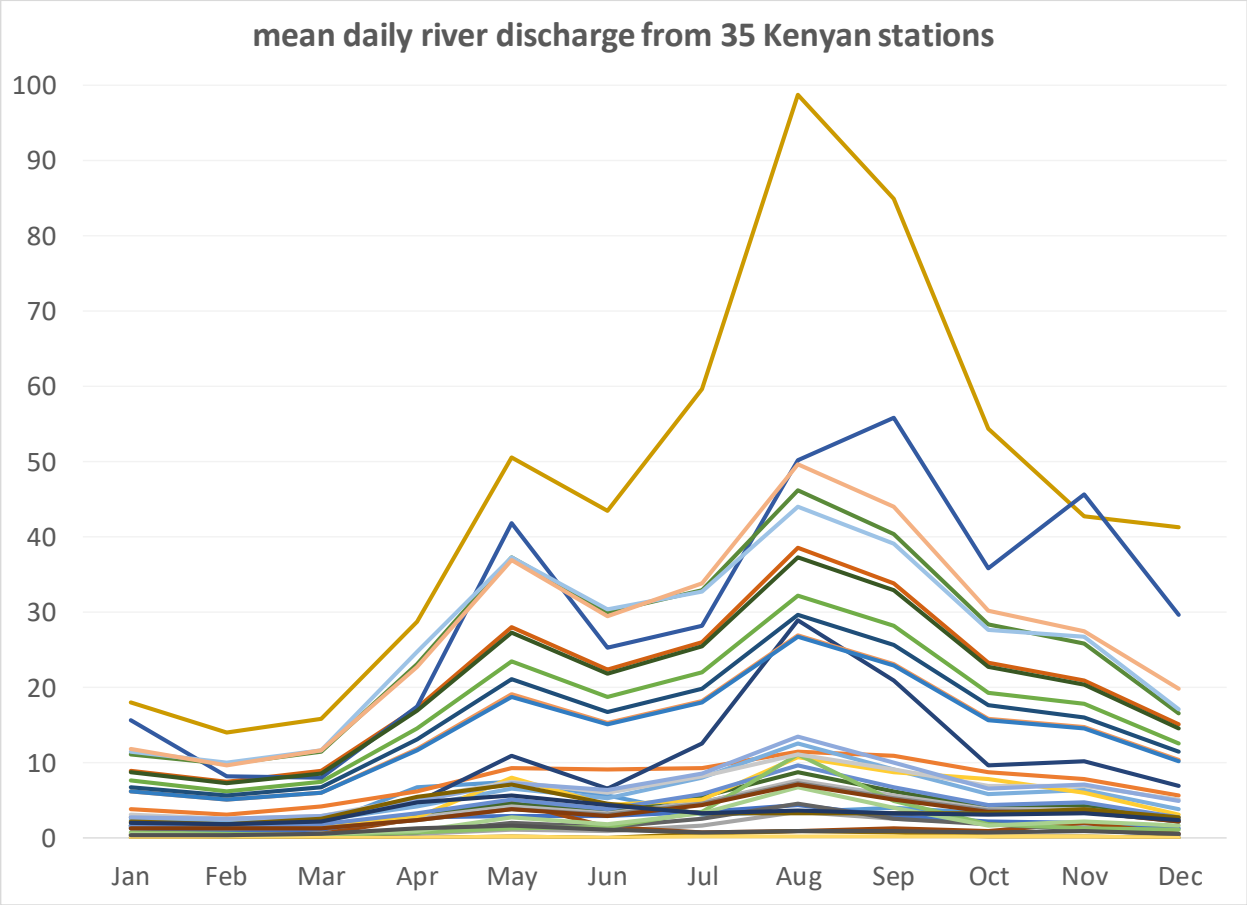


***Figure 3.10**: The mean monthly river discharge (m^3/s) from 1947 to 2000 of 35 stations on the Kenyan side of the Mt. Elgon aquifer region.*

3.2.3 Land use and land conver

Regionally, the land use and land cover of the Mt. Elgon aquifer region is mapped from the ESA Sentinel-2 imagery at 10m resolution. It is a composite of LULC predictions for 10 classes throughout the year in order to generate a representative snapshot of 2020. The classes broadly include water, trees, shrub, grass, flooded vegetation (wetlands and swamps), crops, built areas, bare land, snow/ice and cloud cover (Fig. 3.11). The southern parts of the Mt. Elgon aquifer region is highy cropped and built up. Around Mt. Elgon is a thick tree cover with shrubs towards its peak. The low-lying northern parts of the region is largely covered by shrub and grasslands.

The area on the Kenyan side has only one gazetted forest, the Mt. Elgon Forest Reserve, which covers an area of 618 km^2, and Mt. Elgon National Park, which occupies 51 km^2. Mt. Elgon area has variable vegetation ranging from grass savanna on the lowlands to montane forest and bamboo on Mt. Elgon slopes. Land use on the lower slopes of Mt. Elgon is intensive with cultivation of maize as the dominant crop. Adjacent to the Mt. Elgon forest are smallholder farmers who largely practice mixed farming but also depend on the forest for their livelihood. The practice of agro-forestry is common with trees like Sesbania (*Sesbania grandiflora*), Calliandra (*Caloundra calothyrsus*) and certain timber and fruit trees are planted together with crops or along the farm

borders. However, continued pressure from human activities significantly affects the forest cover. The forests are critical to the climatic conditions of the territorial boundaries of the region and beyond as they are the water catchments for Lakes Turkana and Victoria.

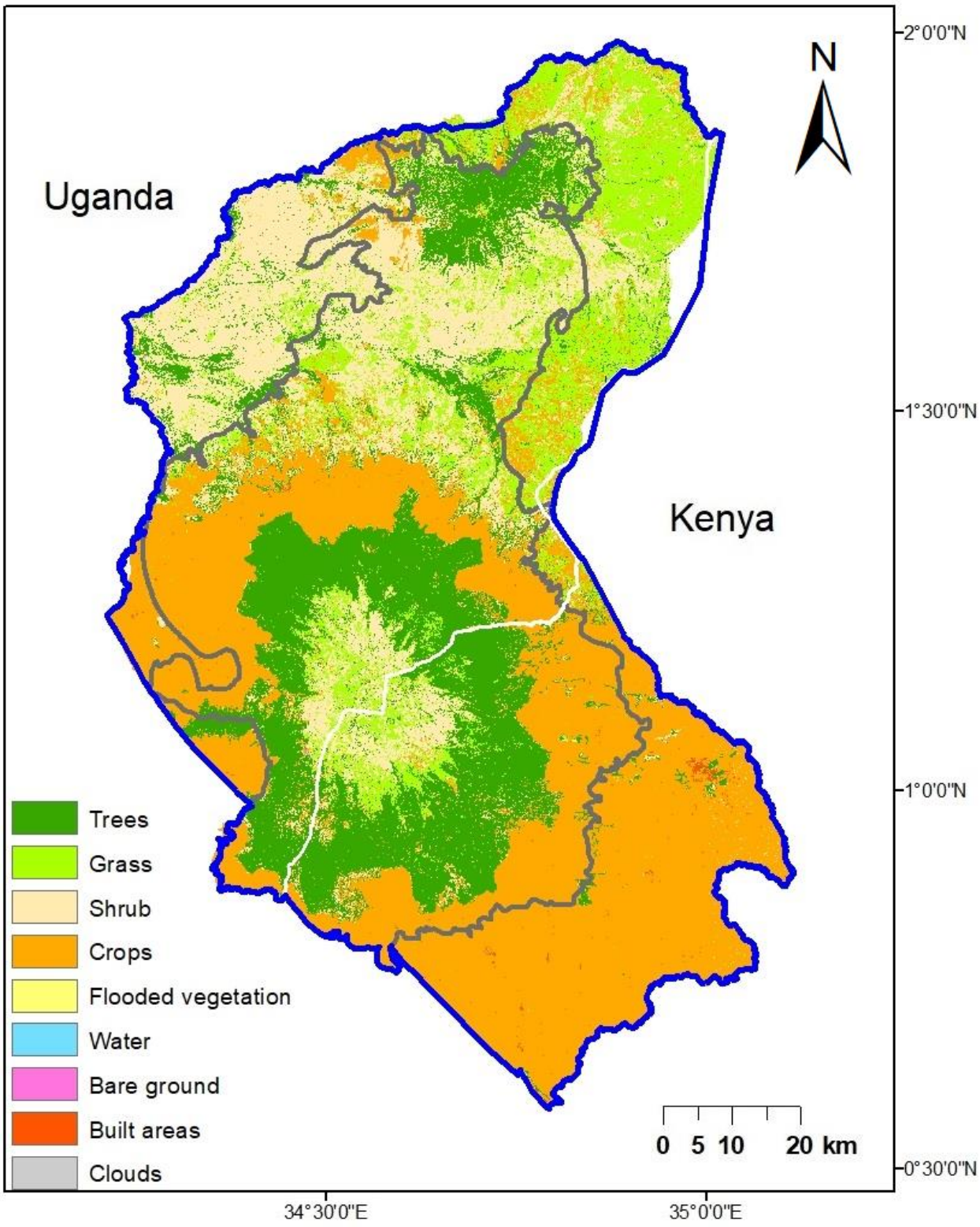


***Figure 3.11**: Land cover and land use around the Mt. Elgon aquifer region of Uganda and Kenya derived from Sentinel-2 of 10-m resolution (adapted from Karra et al., 2021).*

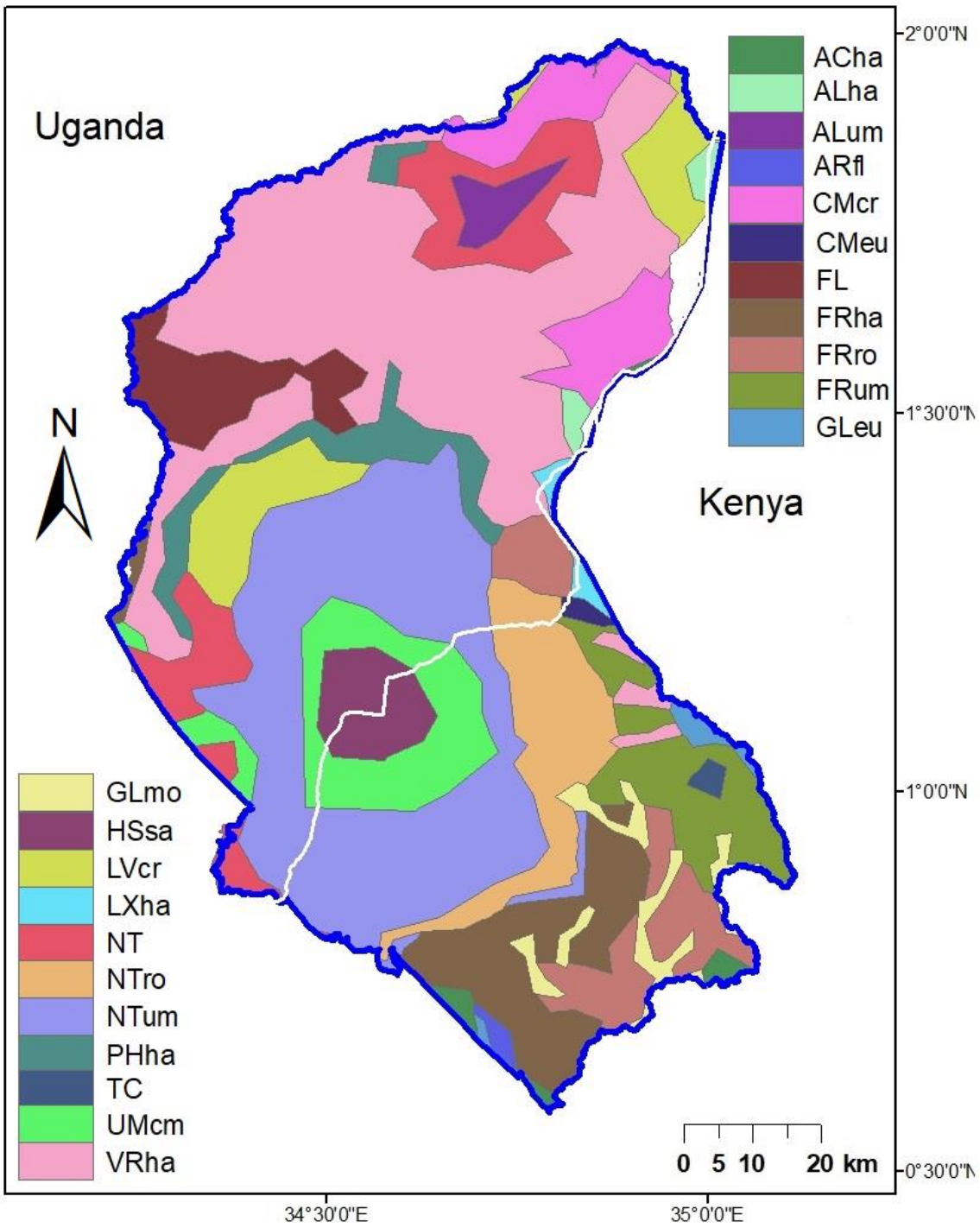
3.3 Geology of the aquifer system

3.3.1 Soils

The dominant soil type in the Kenyan side of the area is mainly clay. Generally, the soils are well drained, very deep, and red to dark red. This coverage describes both the soil physical and chemical properties of Kenyan soils. It was done by Kenya soil survey (KSS) in 1982 and revised in 1997. The soil cover is reddish brown to grey in colour and supports farming of maize and coffee and other natural and planted trees. There is a close relationship between ferralsols and cambisols which are formed from disintegration of granitic rocks. The granites give rise to coarse light brown, sandy, soils more subject to soil erosion than the more clayey varieties, while the diorites, syenodiorites and syenites, having a greater proportion of mafic minerals, give darker red brown, more clayey, type. The calcareous are moderately sodic and the deeper soils are saline. Nitosols are found at the transition between the MMB rocks and the volcanic. These soils are well drained, deep and dark red.

Most soils in Amudat and Nakapiripirit districts of Uganda are of moderate to high productivity whereas others are categorised to be moderate to low productivity. In this part of the aquifer area, the key issues in relation to land degradation are soil erosion and decreasing soil fertility. Bukwo, Kapchorwa and Kween have soils that can be categorised into three zones which include Mount Elgon high farmlands, farm-forest and short grass plains. The soils in the Mount Elgon high farmlands of Bukwo, Kapchorwa and Kween, are derived almost entirely from volcanic parent materials and are typically red-clay loams, well-drained, highly leached, often acidic, but high in nutrients thus making them highly productive. The forest zone of these districts is characterised by reddish-brown loam soils over deep clay loam subsoils. Clayey soils with often vertic properties characterise the short grass plains of these districts. The Sebei flat plains are in addition characterised by calcareous soils. This zone extends up to the lower steps or terraces of Mount Elgon where the clay loam soils are more often acidic. The rocks on the slopes are deeply weathered; the dominant soils are vertisols, regionally known as “black cotton soils”. The area is highly influenced by past volcanic activities and the soil is very variable. The impermeable nature of most of the rocks makes the adjacent areas of Mt. Elgon vulnerable to landslides during wet seasons. Topsoils are shallow especially around the Mt. Elgon National Park. Generally, the soils in the highlands are clays, while those in the midlands and the lowlands are clay loams or sandy.

Regionally soil data was derived from the European Soil Data Centre (ESDAC, 2014). More than 50% of the Mt. Elgon aquifer region is underlain by haplic vertisols (Fig. 3.12). Other key soil types include haplic ferralsols, eutric gleysols, albic plinthosols, rhodic ferralsols, haplic acrisols, plinthic acrisols, eutric fluvisols, chromic and cambisols.



ACha - Haplic Acrisols; ALha - Haplic Alisols; Alum - Umbric Alisols; ARfl - Ferralic Arenosols; CMcr - Chromic Cambisols; CMeu - Eutric Cambisols; FL - Undifferentiated Fluvisols; FRha - Haplic Ferralsols; FRro - Rhodic Ferralsols; FRum - Umbric Ferralsols; GLeu - Eutric Gleysols; GLmo - Mollic Gleysols; HSsa - Sapric Histosols; LVcr - Chromic Luvisols; LXha - Haplic Lixisols; NT - Undifferentiated Nitisols; NTro - Rhodic Nitisols; NTum - Umbric Nitisols; PHha - Haplic Phaeozems; TC - Undifferentiated Technosols; UMcm - Cambic Umbrisols; VRha - Haplic Vertisols;

***Figure 3.12**: Soil types around the Mt. Elgon aquifer region of Uganda and Kenya (adapted from ESDAC, 2014).*

3.3.2 Geology

Mount Elgon is located to the west of the Gregory Rift and with an Early Miocene age, is one of the oldest volcanoes in the region. The volcanism is related to the pre-rift stage of the East African Rift System (EARS) which included the initial development of the Kenya-Tanzanian Dome. Doming and volcanism related to a deep-seated magma plume spread southward from the Ethiopian segment of the EARS at approximately 30 Ma. The location of Mt. Elgon is significant because as rifting developed to the half-graben and full graben stages, volcanism in the Gregory Rift shifted both southward and eastward. An unusual feature of the Elgon Volcano is that it is built directly upon Basement terranes, as determined by the earliest mapping (Davies, 1952), (Fig. 3.13). In comparison, most volcanic cones associated with the Gregory Rift are constructed on earlier generations of rift-related volcanic rocks. The western sector of Elgon overlies granite-gneiss of the Central African Craton, part of a more-or-less contiguous Archaean terrane between western Kenya and the Albertine Rift in western Uganda. The eastern sector is located on the metasediments of the Mozambique Belt (Neoproterozoic). Magma may have been fed through a central conduit that exploited a structural weakness on the edge of the craton. The region around Mount Elgon includes a number of pre-Elgon intrusive bodies, including, for example, the Budeda Hill carbonatite (King et al., 1972; Woolley, 2001). There are also basins dominated by Miocene age sedimentary rocks. A unique cache of Miocene fossils, including mammals, aquatic reptiles, birds, and crabs, has been discovered in a basin near Butwa on the northeastern slopes of Mount Elgon (Bishop et al., 1969). The Mount Elgon volcanism is dominated by nephelinitic tephra and agglomerates (Davies, 1952), typical of a group of magmas defined by Baker (1987) as characterising the pre-rift activity of the Gregory Rift. Agglomerates, which can be readily observed on the higher slopes, include clasts which are typically10 cm in size. Locally blocks of nephelinite and phonolite up to 1 m in size occur. Well-bedded tuffs are a subordinate feature. Lavas (nephelinite and minor phonolite and trachyte) are estimated to contribute less than one per cent by volume of the volcanic pile. The dominance of tephra is consistent with a high explosive index, typical of much of the pre-rift volcanism of the Gregory Rift.

The region consists of Mozambique Belt (MMB) rocks as the oldest unconformably overlain by Neogene volcanics and Pleistocene to Recent soils as the youngest units (Gibson, 1950; Searle, 1952; Miller, 1956). The MMB rocks consist mainly of quartzite and schist derived from argillaceous and arenaceous sediments which were transformed by metamorphism and recrystallization into quartz and feldspar-rich rocks with much muscovite, biotite, and hornblende minerals. These rocks are fossiliferous and considered to be from the Pre-Cambrian. The main members of this unit are conglomerates, mudstone and grits while pebbly grits and sandy mudstones make up the subordinate with different sequence of deposition. The Mount Elgon Neogene lavas comprise a great mass of agglomerate, breccias and tuff with intercalated bands of lava, the hole having been ejected from a vent during Neogene period. The boulders of lava in the agglomerate are composed of nephelinites that contained minerals such as olivine, augite, magnetite, ilmenite and perovskite similar to the lava flows themselves. Surrounding the caldera produced round the vent are lavas and breccias of phonolitic-nephelenites in which aegirine-augite and orthoclase appear. The floor of the caldera, lying over 300 meters below the caldera rim and beyond, is composed of volcanic ash, the last eruptive material ejected from the volcano.

The detailed lithology of the main geological formations is summarised as follows;

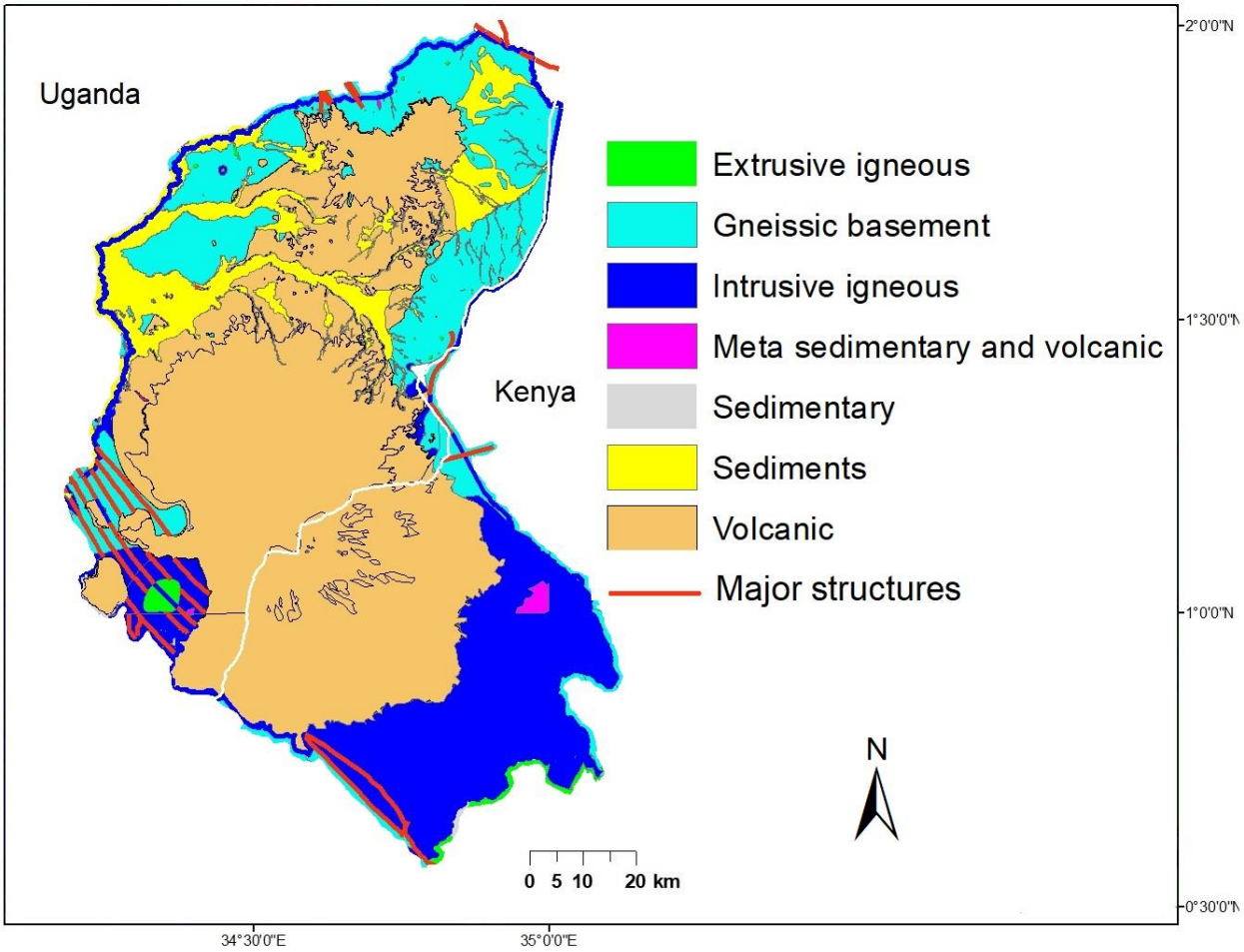
Mobile Mozambique Belt (MMB) rocks; the rocks in the study area consist of metamorphic rocks that resulted mainly as the effect of pressure, and consequent rise in temperature. These rocks are mainly pelitic schists and gneisses, metamorphosed semi pelitic sediments. Main minerals include quartz, feldspar, muscovite, biotite, and hornblende.

Pelitic schists and gneisses; These rocks include muscovite-quartzite, mica schist and hornblende schists. Biotite-schists were closely associated with the asbestos deposits in some areas forming an outer rim to the zoned bodies. The schists occur within the metamorphic succession, but showed considerable distortion. Inclusions within the muscovite include rutile, zircon and apatite. Chlorite-schists are rare in the area. The outcrops are fine grained, dense, glistening black rocks which outcropped only over narrow widths, suggesting dyke-like forms.

Metamorphosed semi-pelitic sediments; These gneisses are formed by the metamorphism of sandy shales and argillaceous sandstones and are represented in the area by biotite gneisses, feldspar-porphyroblast gneisses and the banded microcline augen gneisses. The semi-pelitic sediments are good indicators of groundwater occurrence and flow due to their porosity and permeability within their individual grains and foliation planes.

Neogene volcanic rocks of Mt Elgon; Huge boulders of agglomerates and phonolites occur around Mt. Elgon National Park. Neogene lavas of Mt Elgon are largely composed of the huge mass of agglomerates, breccia and tuffs with intercalated bands of lava, the hole having been ejected from a vent during Neogene times. The boulders of lava in the agglomerates are composed of nephelinites that contain mafic material such as olivine, augite and magnetite. Surrounding the caldera are lavas and breccias of phonolitic-nephelinites in which aegirine augite and orthoclase appear round the vent. The floor of the caldera, lying over 300 metres below the caldera rim, is volcanic ash that mark the last eruptive material ejected from the volcano. Isolated occurrences of nephelinite are found capping hills in the Suk plains. Though the vents through which these lavas were extruded have not been discovered, a volcano plug has been found at Sagat Hill containing agglomerates with associated nepheline-syenite-porphyry intrusions and dykes.

Most geological formations originate from the Precambrian supereon. Large sections of the aquifer are dominated by alkali volcanics including areas around Mount Elgon (one of the oldest volcanoes in East Africa) and Mount Kadam. The portion of Amudat District that lies within the aquifer boundaries is partially Aruan series and partly Quaternary sediments. The lithologies are dominated by volcanic rocks and associated sediments. In the portion of Amudat district within the aquifer boundary, alluvium (sand, silt and gravel) are observed while the central section of the aquifer is overlain by superficial alluvium with associated swamps. (Awoja Catchment Management Plan, 2017). The geology in the Mt. Elgon region comprises of mainly Pre-Cambrian and Cainozoic rock formations including volcanics, granites, and sediments. The top of the mountain is characterized by scarps of agglomerates in linear pattern.



Volcanic rocks (volcanic lava, tuff, agglomerates, mudflow and nephelinite); Sediments (alluvial and lacustrine sediments, outwash debris and laterite); Gneissic basement (gneiss, granulite, migmatite, charnokite and basement); Intrusive igneous rocks (granite, gabro, diorite, granodiorite, granitoid, pegmatite, fenite and ijolite); Extrusive igneous rocks (carbonatite, phonolite, nephelinite, basalt, rhyolite, marble and metasomatic rocks); Meta sedimentary and volcanic rocks (amphibolite, schist, quartzite and metavolcanic rocks); Sedimentary rocks (sandstone, mudstone, arkose, conglomerate and grit).

Figure 3.13: The main geological units of the Mt. Elgon aquifer region shared between Uganda and Kenya.

Stratigraphically, agglomerates lava overlies the basalt lava which in turn, overlies the banded granite gneiss and migmatites (Fig. 3.14). Key lithological units of Mt. Elgon aquifer on the Ugandan side is summarised in Table 3.1.

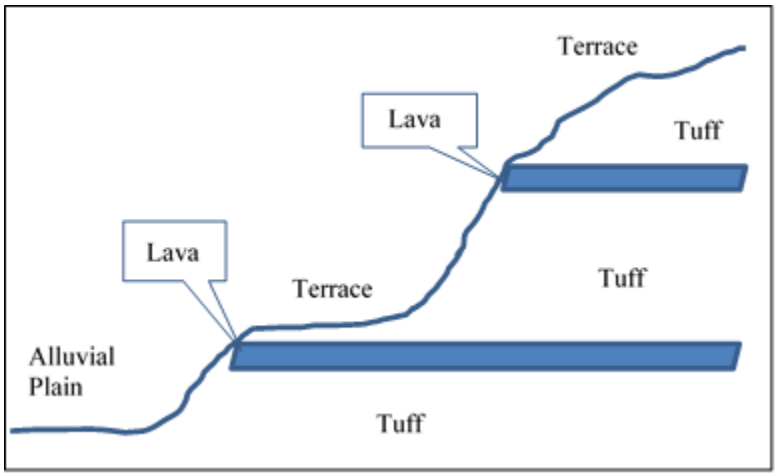


***Figure 3.14**: Schematic diagram of Mt Elgon stratigraphic units on the Ugandan side.*

***Table 3.1**: Key lithological units of Mt. Elgon aquifer on the Ugandan side.*

Era		Period	Epoch	Name	Age (Ma)	Lithology
Cenozoic		Quaternary	Pleistocene to Present	Quaternary Sediments	0-1.6	Sediments, alluvium, black soils and moraines
		Tertiary	Miocene	Volcanic	12.5 - 25	Volcanic rocks and associated sediments; nephelinite, phonolite
Precambrian	Archean		Aruan Techtonic		2,600	Banded gneiss
		Gneissic -Granulitic Complex			-3,400	Undifferentiated gneiss and granulite facies rock in the north: gneiss, granite, amphibolite, charnockite, enderbite, quartzite

3.4 Groundwater occurrence

The region around the volcanic massif is considered to form the recharge area which discharges to the outlying catchment areas. The aquifer occupies a solitary extinct Pliocene shield volcano with one of the largest craters in the world, measuring about 8 km in width, located in the western part of Kenya, in Trans Nzoia County and bisected by the Kenya-Uganda border. The Mount Elgon aquifer is considered a multi-layered hydraulically connected, largely confined aquifer whose lithology is predominantly basalt crystalline rocks.

The aquifer is a multiple-layered hydraulically connected system which is largely confined but some parts are unconfined. The average depth to the water table is 18 mbgl within Uganda. The average depth to the top of the aquifer is 30 mbgl while data is not available on the average thickness of the aquifer system (TWAP Groundwater, 2015). Previous studies on the Kenyan side indicated a shallow unconfined aquifer occurs from ca. 15 mbgl, while for the deeper confined aquifers, there are two layers up to 100 mbgl beneath which are either volcanic rock sequences at

higher altitudes, or metamorphic rocks at lower altitudes (e.g. Olago, 2018). The porosity of fractured consolidated rock materials within the aquifer system varies between 0.05 and 0.15 from an empirical list of variation in porosity for both consolidated (rocks) and unconsolidated formations.

The aquifer on the Ugandan side is dominated by the fractured crystalline basalt (Fig. 3.15) that unconformably overlies the banded granite gneiss and migmatites of the basement complex. In some sections of the aquifer especially in the highland areas, the agglomerate lava is an aquitard offering the aquifer, semi-confined/ leaky conditions.

Figure 3.15*: Left - Photograph of fractured basalt a dorminant lithology on the Ugandan side. Right - An example of protected spring discharging from a basaltic hydrogeological formation.*

3.4.1 Depth of water table

The depth to water table is inferred from the static/rest water level (SWL or RWL) on well completion ranging from ground level to 90 mbgl, with mean and median values of 9.4 and 7 mbgl, respectively (Fig. 3.16). It varies between 2 and 24 mbgl on the Kenyan side. The depth to water table decreases with the direction of decreasing surface elevation. For most of the areas across the aquifer, the water table depth varies between 2 and 28 mbgl with the exception of pockets of much lower groundwater levels of above 28 mbgl. There is a close correlation between the water table depth and the geological formation defining the hydrogeological properties of the aquifer. The direction of groundwater flow mimics the surface elevation and is thus in the direction of the surface drainage. Major potential recharge sources include the Mt. Elgon region and Cherenganyi hills.

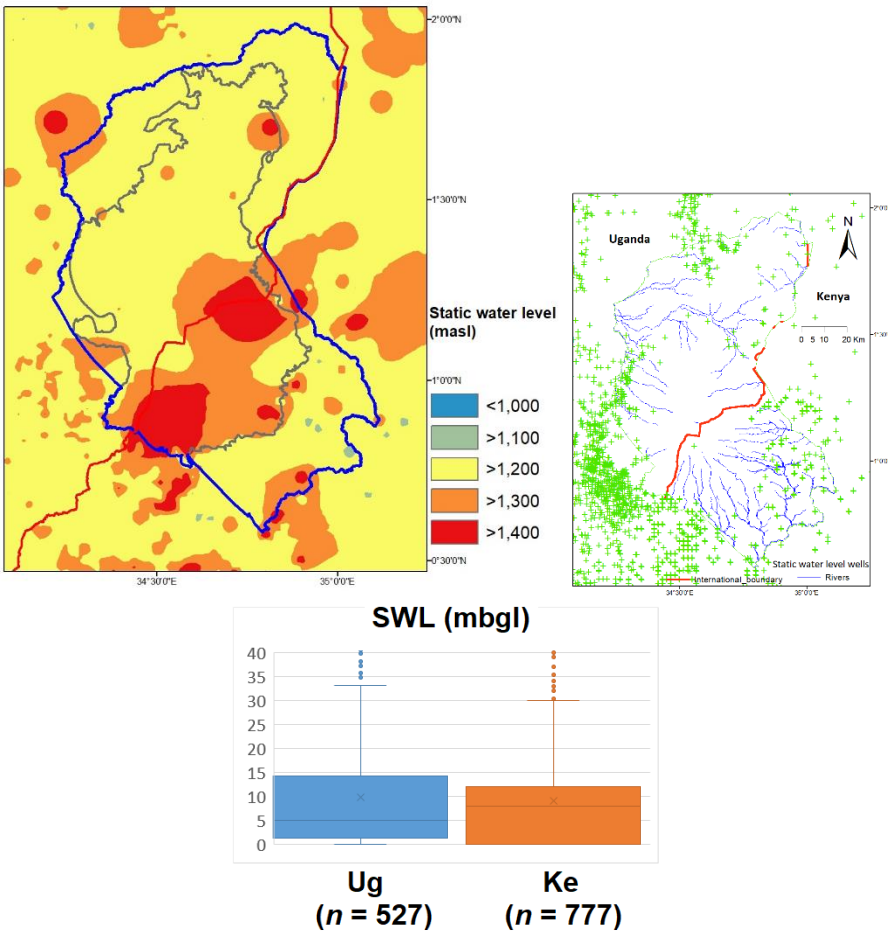


***Figure 3.16**: Spatial borehole coverage and box plots of static water level in the Mt. Elgon aquifer region.*

3.4.2 Depth of aquifer

The depth of the aquifer is inferred from the total drilled depth of the aquifer up to 300 mbgl, with mean and median values of 60.5 and 55.6 mbgl, respectively (Fig. 3.17). The depth of aquifer formation varies between 10 to 200 mbgl on the Kenyan side. However, for the large part of the aquifer the depth of the aquifer formation is below 100 mbgl derived from the maximum depth for a borehole of 100 mbgl except for the few exceptional areas.

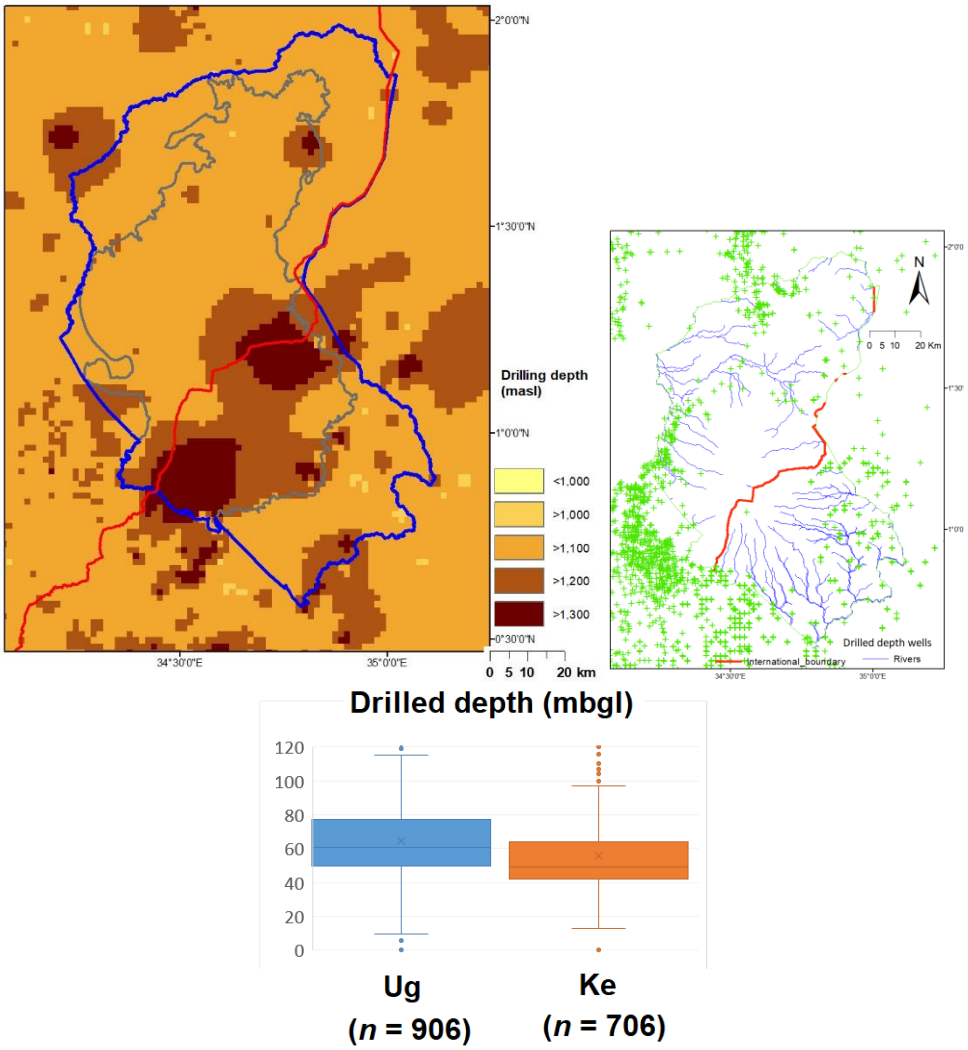


***Figure 3.17**: Spatial borehole coverage and box plots of the total drilled borehole depth in the Mt. Elgon aquifer region.*

The information on the depth of the aquifer also corroborated with the data of the newly proposed well construction sites on the Kenyan side. For all the sites, the recommended depth varies between 80 mbgl and 200 mbgl. However, for a majority of the surveyed sites, the depth recommended is below 150 mbgl. Note that the recommended depth from the geophysical surveys is always higher than the expected depth. For most of the investigations, geophysical approaches (Horizontal Electrical Profiling -HEP, and Vertical Electrical Sounding – VES) were adopted. Four survey locations in the three counties of Bungoma, Busia, Trans-Nzoia were selected covering the aquifer area. The areas included Kwanza Location, Kwanza Sub-Location, Koros Village (lat/long coordinates of 35 000’57.89” E, 01 008’ 34.75” N) with recommended depths of 150 mbgl; Kibabii Area, Bungoma County (lat/long coordinates of 36N 0672277, 6672600) with recommended depths of 80 – 120 mbgl; Angorom Location, Busia County (lat/long coordinates of 34 (lat/long coordinates of 07’30.74” E, 00 030’18.70”) with recommended depths of 200 mbgl; Chakol Division, Teso South Sub-County, Busia County (lat/long coordinates of 0.509763330, 34.197055000) with recommended depths of 120 mbgl.

3.4.3 Vertical thickness of aquifer

The vertical thickness of the aquifer was inferred from the difference between the water strike level and total drilled depth of the existing boreholes. Regionally, the difference between drilled depth and first water strike ranged from 144 m, with mean and median values of 29.9 and 28.0 m, respectively (Fig. 3.18). The aquifer thickness varies from <20 m to 133.2 m on the Kenyan side.

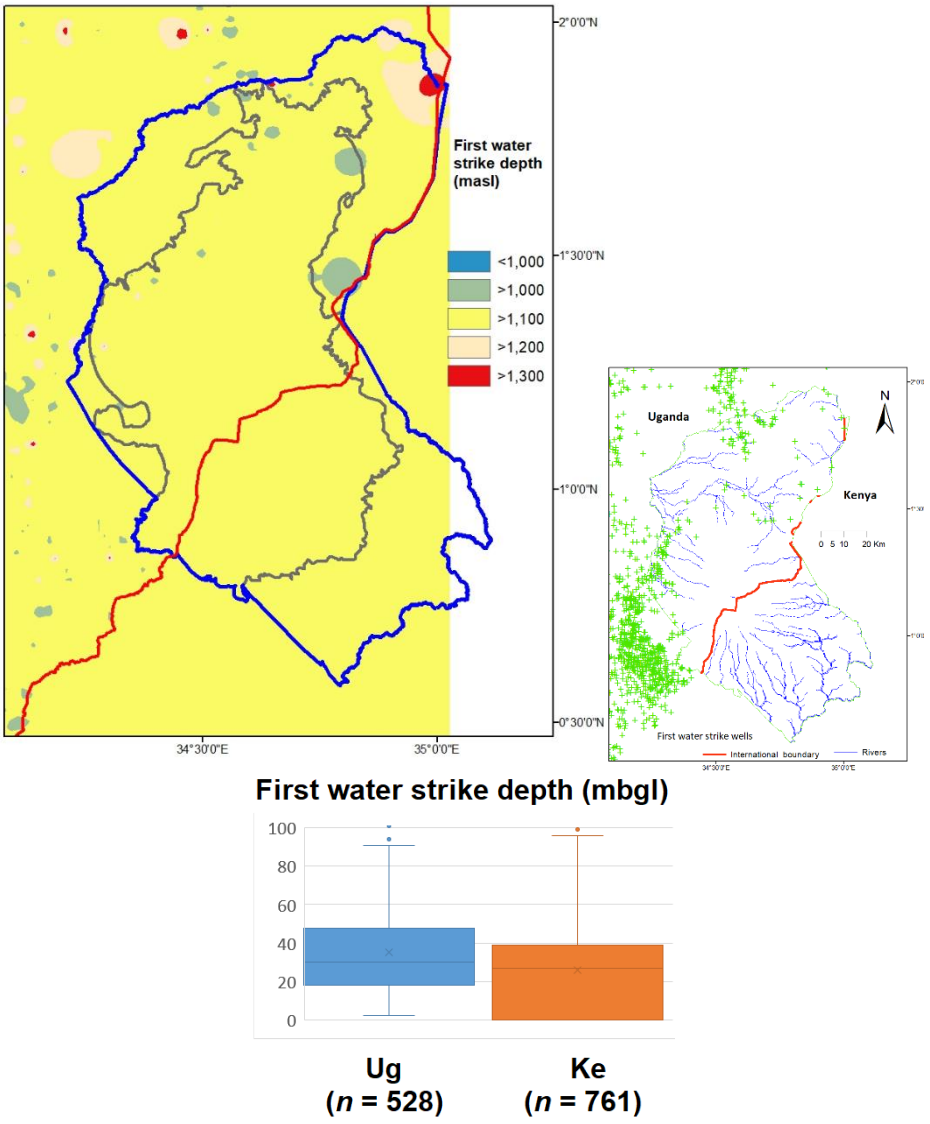


***Figure 3.18**: Spatial borehole coverage and box plots of the depth of first water strike in the Mt. Elgon region.*

3.4.4 Degree of aquifer confinement

The degree of aquifer confinement is inferred from the difference between the first water strike level and the static groundwater level. The difference ranged up to 65.8 m, with mean and median

values of 20.4 and 21.0 m, respectively. This information suggests that the regional aquifer system has largely varying degrees of confinement (semi-confinement/leakiness).

However, on the Kenyan side, the field visit indicated that there are also numerous shallow wells in the area whose water levels fluctuates seasonally indicating a phreatic aquifer system. Thus, the region can be considered as a multi-layered aquifer system with an aquitard separating the lower confined layer from the upper unconfined layer. The presence of springs whose discharge fluctuates seasonally is also an indication of a shallow unconfined aquifer system in the region. The extent of fracturing of the confining layer is not well known.

3.5 Recharge and discharge characteristics

3.5.1 Aquifer recharge

Groundwater recharge is mainly focussed or diffuse through one of three main mechanisms: rainfall percolating through the soil horizon to the aquifer, flooding of rivers/lakes/wetlands during the wet season, and regional/intermediate lateral/local movement along an aquifer from areas of higher ground with higher rainfall to lower-lying areas. Only the residual fraction will percolate through the root zone and start to flow vertically toward the aquifer. The relative proportions of surface runoff and groundwater recharge heavily depend on the nature of individual rainfall events and are less influenced by total annual rainfall. Intensive rainfall received in the area will have events that have a higher proportion of surface runoff. On the Kenyan side, the residual of rainfall and evaporation ranges from 100 to 567 mm yielding an average of approximately 300 mm. This is expected to occur across an area of 11,000 km^2. The total volume of water expected to infiltrate into the soil is approximately 3300 Mm^3. However, much of the water is also lost through soil evapotranspiration. Climate change models indicate that there is a likelihood of an increase in the number of high intensity storms. However, the impact of changing rainfall patterns on recharge also relates to the storage capacity of soils and aquifers. If the aquifer totally fills up during the wet season such that no more rain water can be stored and must become part of surface runoff, then there is no significant impact on water availability in the dry season. The change in depth to groundwater is more important in understanding the sustainability of groundwater exploitation. Table 3.2 shows water level fluctuations measured between Jan-2019 and Dec-2020 at Bungoma. The fluctuations indicate that recharge occurs in May/June/July and October/November/December. This coincides with the annual temporal variability of precipitation in the region. The change in water level in the borehole is on average approximately 3m between March when it is lowest and December when it is highest.

Table 3.2: Measured monthly depth to water level (mbgl) for Bungoma groundwater monitoring borehole.

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
9.85	9.86	10	9.7	7.5	8.25	8.03	7.8	8	7.8	7.3	7

The recent visit to the Kenyan side of the project area and discussion with the community indicated that recharge has decreased evident by the decreasing spring discharges. Anthropogenic actions at the land surface have directly affected groundwater recharge. Springs that were perennial are currently seasonal and the baseflow in some of the perennial streams has drastically decreased.

Destruction of vegetation has led to soil crusting and increased the velocity of runoff enhancing soil erosion and flash flooding, allowing more rainfall to reach rivers but making it less available for groundwater recharge.

Regionally across Africa, MacDonald et al. (2021) estimate for the period 1970–2019 from 134 ground-based estimates and upscaled statistically, long-term average distributed groundwater recharge rates. Recharge volume for Kenya and Uganda is 230 and 240 km^3/decade, respectively; depth for Kenya and Uganda is 400 and 960 mm/decade, respectively. Groundwater storage for Kenya and Uganda is 8,800 and 960 km^3, respectively. Groundwater annual recharge per capita for Kenya and Uganda is 430 and 530 m^3, respectively. Groundwater storage per capita for Kenya and Uganda is 160 and 7.4 x 1000 m^3, respectively.

3.5.2 Return flows from irrigation

Irrigation return flow is surface water that leaves the field following application of irrigation water. Irrigation return flow may be reused or it may discharge to a drainage channel or natural water body. With no significant irrigation being practiced in the area, recharge from irrigation return flows is almost negligible.

3.5.3 Managed aquifer recharge

Theoretically, aquifers can be artificially recharged by pumping downwards into specially designed wells, but this very energy intensive option is not economically viable for the study area. There has been no evidence of managed aquifer recharge in the study area.

3.5.4 Extent of recharge zones

Recharge zones are areas where water infiltrates through permeable rocks and sediments and the saturated zone is at depths where surface ecosystems (e.g., palustrine, lacustrine and riverine wetlands, riverine water bodies and terrestrial vegetation) are unable to access the groundwater. However, subterranean ecosystems (e.g., aquifer and cave ecosystems) underlying recharge areas may be groundwater dependent. Areas around Mt. Elgon has a higher recharge potential and is thus considered as higher recharge zones for the Mt. Elgon aquifer system.

3.5.5 Recharge and discharge characteristics

Locally, the recharge of the aquifer is generally very low to medium, estimated to vary between 0 to 100 mm/ annum. The main source of recharge is precipitation but the extent of the recharge zone is not well known. However, infiltration rates of up to 600 mm/ annum have been indicated in the area covered by Mount Elgon National Park. Discharge is mainly through natural spring and stream flows especially on the mountain slopes. In the flat plains the main mechanism of discharge is abstraction through boreholes and shallow wells. The direction of groundwater flow is considered to be generally from east to west following the surface water drainage (JICA Final report, 2010).

3.6 Groundwater infrastructure and development

Groundwater infrastructure in the Mt. Elgon aquifer region include gravity flow schemes and protected springs predominantly at higher altitudes on mountain slopes while boreholes and shallow wells are located in the flat plains. The majority of the deep boreholes and shallow wells are hand-pumped. Tables 3.3 summarise the population distribution by districts of Uganda served

by the different water source types including improved water sources and traditional unsafe water sources. Distribution of domestic water sources by districts of Uganda include protected springs, shallow wells, deep boreholes, rainwater harvesting, and public tap/ gravity flow scheme (Table 3.4). Water source management arrangements per districts of Uganda in the Mt. Elgon aquifer region include communal, private/ individual, private operator, institutional and other (Table 3.5).

***Table 3.3**: Population distribution by districts of Uganda served by the different water source types in Mt. Elgon aquifer area.*

District	Total Population	Population Served by improved water sources	Rural population Served by improved water source	Urban Population served by improved water sources	Population still dependent on traditional unsafe water sources
Amudat	126,479.	55,600	43,900	11,700	70,879
Bududa	238,501	157,271	153,093	4,178	81,230
Bukwo	101785	80,727	72,663	8,064	21,058
Bulambuli	202,171	141,163	133,265	7,898	61,008
Kapchorwa	112,932	97,170	84,505	12,665	15,762
Kween	103,502	85,955	82,352	3,603	17,547
Nakapiripiriti	194,424	114,514	110,533	3,981	79,910
*(Namisindwa) Manafwa	377,193	261,114	239,633	21,481	116,079
Sironko	262,951	194,243	171,498	22,745	68,708

*There is no readily available data on Namisindwa so data used was that of Manafwa district out of which it was recently curved.

***Table 3.4**: Distribution of domestic water sources by districts of Uganda within the Mt. Elgon aquifer area.*

District	No. Domestic water points	No. Piped Water Schemes	Percentage by Technology type				
			PS	SW	DBH	RWH	PT/GFS
Amudat	186	-	0.9	3.4	95.7	-	-
Bududa	980	3	64	0.5	2.4	0.1	32.9
Bukwo	590	1	26.5	4.8	1	0.1	67.5
Bulambuli	758	2	42.6	12.4	19.1	0.1	25.8
Kapchorwa	631	9	65.5	-	2.2	0.1	32.3
Kween	481	1	56.9	0.7	20.5	0.1	21.8
Nakapiripiriti	468	9	1.6	9	79	0.1	10.3
*(Namisindwa) Manafwa	1,371	2	58	1.7	31.3	0.1	8.9
Sironko	1,125	1					

*There is no readily available data on Namisindwa so data used was that of Manafwa district out of which it was recently curved.
PS: Protected Spring; SW: Shallow well; DBH: Deep Borehole; RWH: Rainwater Harvesting; PT/GFS: Public Tap/ Gravity Flow Scheme.

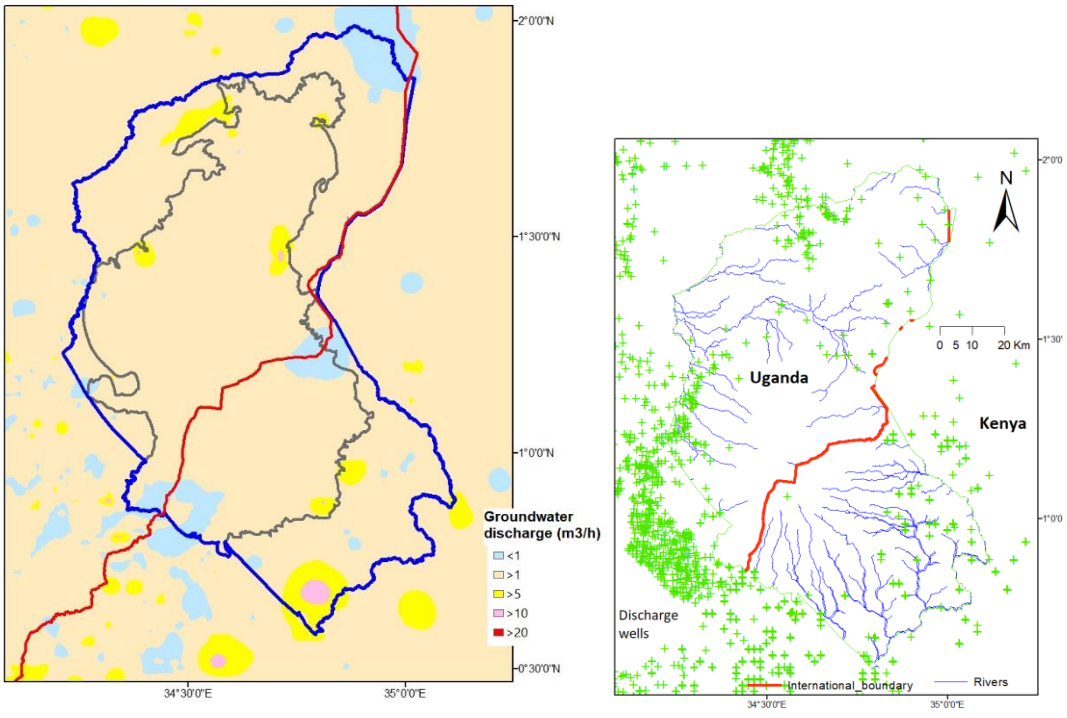
***Table 3.5**: Water source management arrangements per districts of Uganda in the Mt. Elgon aquifer region.*

District	Water Source/ Point Management arrangements (%)					Gender Mainstreaming in source management (%)
	Communal	Private/ individual	Private Operator	Institutional	Other	
Amudat	98.6	-	-	1.4		82
Bududa	92.9	0.7	0.1	6.2	-	94
Bukwo	81.3	10.9	0.6	7.2	-	97
Bulambuli	95.2	0.1	0.3	4.1	0.3	97
Kapchorwa	88.7	3.6	1.1	6.6	-	95
Kween	87.1	7	0.4	5.2	0.2	92
Nakapiripiriti	71.6	0.9	12.8	14.5	0.2	92
*(Namisindwa) Manafwa	94.5	0.7	0.2	4.5	0.1	92
Sironko	95.2	0.5	0.2	3.9	0.2	88

*There is no readily available data on Namisindwa so data used was that of Manafwa district out of which it was recently curved.

3.7 Groundwater well source properties

Regionally, the yield of groundwater boreholes ranged up to 43.3 m^3/hr, with mean and median values of 2.6 and 1.5 m^3/hr, respectively (Fig. 3.19).



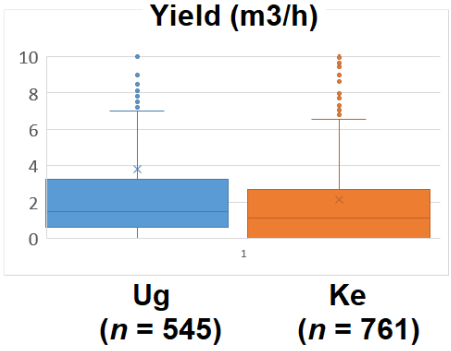


***Figure 3.19**: Spatial borehole coverage and box plots of the groundwater borehole yields in the Mt. Elgon aquifer region.*

On the Ugandan side, a summary of groundwater drilling depth, static water level, well yield and depth to bedrock of each geological unit (e.g. Quaternary, Alkali volcanics, Aruan Series and Gneiss-Granulite Complex) is presented in Table 3.6. A summary of groundwater drilling depth, static water level and well yield for main districts of Bududa, Kapchorwa, Manafwa, Nakapiripiriti, Sironko is presented in Table 3.7. Groundwater drilling depth in the two major catchments of Awoja and Mpologoma average 71.1 and 57.0 mbgl, respectively (Table 3.8). Drilling depths are shallow in the southern part and progressively increase northward. Static water level by the same two catchments average 11.9 and 10.7 mbgl, respectively (Table 3.9), Static water levels are generally shallow in the south and progressively deepen northwards into the Karamoja districts of Amudat and Nakapiripiriti, with the exception of the central part of the aquifer where the static water levels are found to be shallow. Well yields average 1.96 and 2.03 m^3/hr, respectively (Table 3.10). Well yield is basic data which is necessary for designing water supply facility. Hand-pumped well require at least 0.5m^3/hr to function. For motorised pump wells, yields should be more than 1.5 m^3/hr for effective use. The yields of boreholes are generally low within the aquifer area with the least yields experienced in the eastern district of Amudat (<0.6 – 1.5 m^3/hr) and in the southern districts of Bududa, Manafwa and Namisindwa (1.0 – 1.5 m^3/hr). The rest of the aquifer area has yields ranging from 1.5 to 5.0 m^3/hr.

***Table 3.6**: A summary of groundwater drilling depth, static water level, well yield and depth to bedrock of each geological unit on the Ugandan side of the Mt. Elgon aquifer region.*

S. No.	Formation name	Drilling Depth		Static Water Level		Well Yield		Depth to Bedrock	
		Data No.	Average (mbgl)	Data No.	Average (mbgl)	Data No.	Average (m^3/h)	Data No.	Average (mbgl)
1	Quaternary	190	66.1	166	16.2	178	1.9	151	26
2	Alkali volcanics	49	64.6	47	15.9	46	2.3	32	28
3	Aruan Series	77	85.2	64	23.3	71	2.0	62	24
4	Gneiss-Granulite Complex	3,551	62.5	3,127	13.9	3,345	1.9	2,946	28

***Table 3.7**: A summary of groundwater drilling depth, static water level and well yield by districts of Ugandan side of the Mt. Elgon aquifer region.*

S. No.	District	Drilling Depth		Static Water Level		Well Yield	
		Data No.	Average (mbgl)	Data No.	Average (mbgl)	Data No.	Average (m^3/h)
1	Bududa	3	43.3	3	17.3	3	1.6
2	Kapchorwa	13	92.4	13	28.5	13	1.8
3	Manafwa	74	62.2	74	14.8	72	1.5
4	Nakapiripiriti	49	83.2	45	19.3	41	2.2
5	Sironko	51	58.9	46	11.4	49	1.9

***Table 3.8**: Groundwater drilling depth by catchments of the Ugandan side of the Mt. Elgon aquifer region.*

		Drilling depth (mbgl)				
No.	Name	Number of Samples	Average	Maximum	Minimum	SD
1	Awoja	338	71.1	198.3	6.0	30.5
2	Mpologoma	1,163	57.0	194.0	5.6	21.3

Ave: Average, Max: Maximum, Min: Minimum, SD: Standard Deviation

***Table 3.9**: Static water level by catchments of the Ugandan side of the Mt. Elgon aquifer region.*

		Static water level				
No.	Name	Number of Samples	Average (mbgl)	Maximum (mbgl)	Minimum (mbgl)	SD
1	Awoja	318	11.9	91.5	0.3	11.1
2	Mpologoma	1,041	10.7	94.6	0.2	6.7

Ave: Average, Max: Maximum, Min: Minimum, SD: Standard Deviation

***Table 3.10**: Well yield by catchments of the Ugandan side of the Mt. Elgon aquifer region.*

		Well Yield (m^3/h)				
No.	Name	Number of Sample	Average	Maximum	Minimum	SD
1	Awoja	338	1.96	17.0	0.0	2.2
2	Mpologoma	1,163	2.03	20.7	0.0	2.5

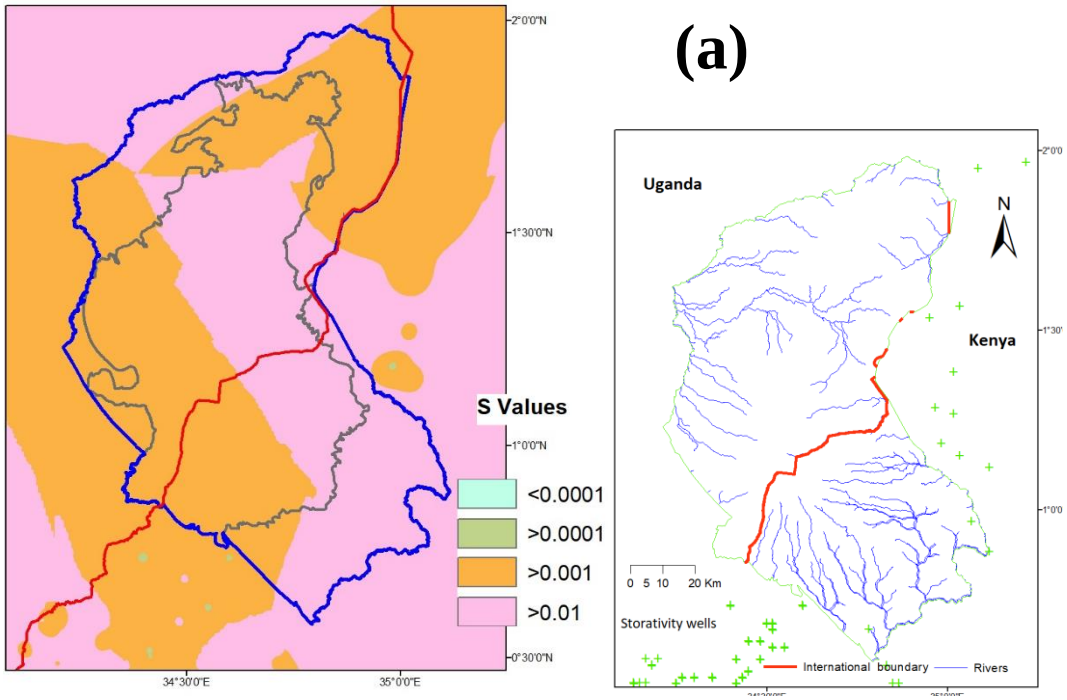
Ave: Average, Max: Maximum, Min: Minimum, SD: Standard Deviation

3.8 Hydraulic properties

Transmissivity describes the ability of the aquifer to transmit groundwater throughout its entire saturated thickness. A part of the secondary datasets included analysed transmissivity and storativity values. However, most of the primary datasets were obtained from test pumping after well completion of new groundwater sources. These records were scanned and transcribed to create a digital dataset. The pumping test duration was for at least two to three hours under constant

rate using a low yielding electric pump; recovery data was recorded for 60-180 minutes and was often incomplete; the pumping phase itself was also often less than 2 hours; and only manual dip measurements were made. The BGSPT^{TM} approach was used (Barker 1985; Barker and MacDonald, 2000). The method assumes the groundwater flow being modelled is through homogeneous and porous media. Despite this, the method is illustrated to be capable of analysing fractured aquifers to a sufficient degree of accuracy provided that the borehole penetrates a representative sample of the aquifer, flow is laminar and the travel time taken for water to move from the matrix to the borehole is short (Barker and Black 1983; Black 1985). BGSPT^{TM} is a code designed to simulate and analyse pumping test data accounting for well storage. Input data (time in days, drawdown in metres and discharge in m^3/d^{-1}) from the test pumping records is run by an executable file to produce an output file. The model used is relevant for the datasets derived from weathered hydrogeological formations, assumes a semi-confined aquifer of infinite extent, overlain by an unconfined aquitard, with horizontal flow in the aquifer and vertical flow in the aquitard through Darcy's Law allowing for well losses. Model parameters included transmissivity (T) (constrained by 0.1 - 100 m^2/d^{-1}), well radius (constrained by 0.03 – 0.08 m), aquifer (constrained by 0.002 - 0.01 m^{-2}/d^1) and well losses (constrained by 0.002 - 0.001 m^{-5}/d^2). The BGSPT model attempts to minimize R^2 (the sum of squares of residuals - differences between observed and calculated drawdowns). The BGSPT^{TM} was preferred as it provides a reliable transmissivity estimate.

Transmissivity of the Mt. Elgon aquifer system varies largely between 0.1 and 100 m^2/day. Regionally, the mean and median transmissivity values are 9.7 and 2.4 mbgl, respectively (Fig. 3.20). The secondary data for storativity derived from the Kenyan side averages 0.0027.



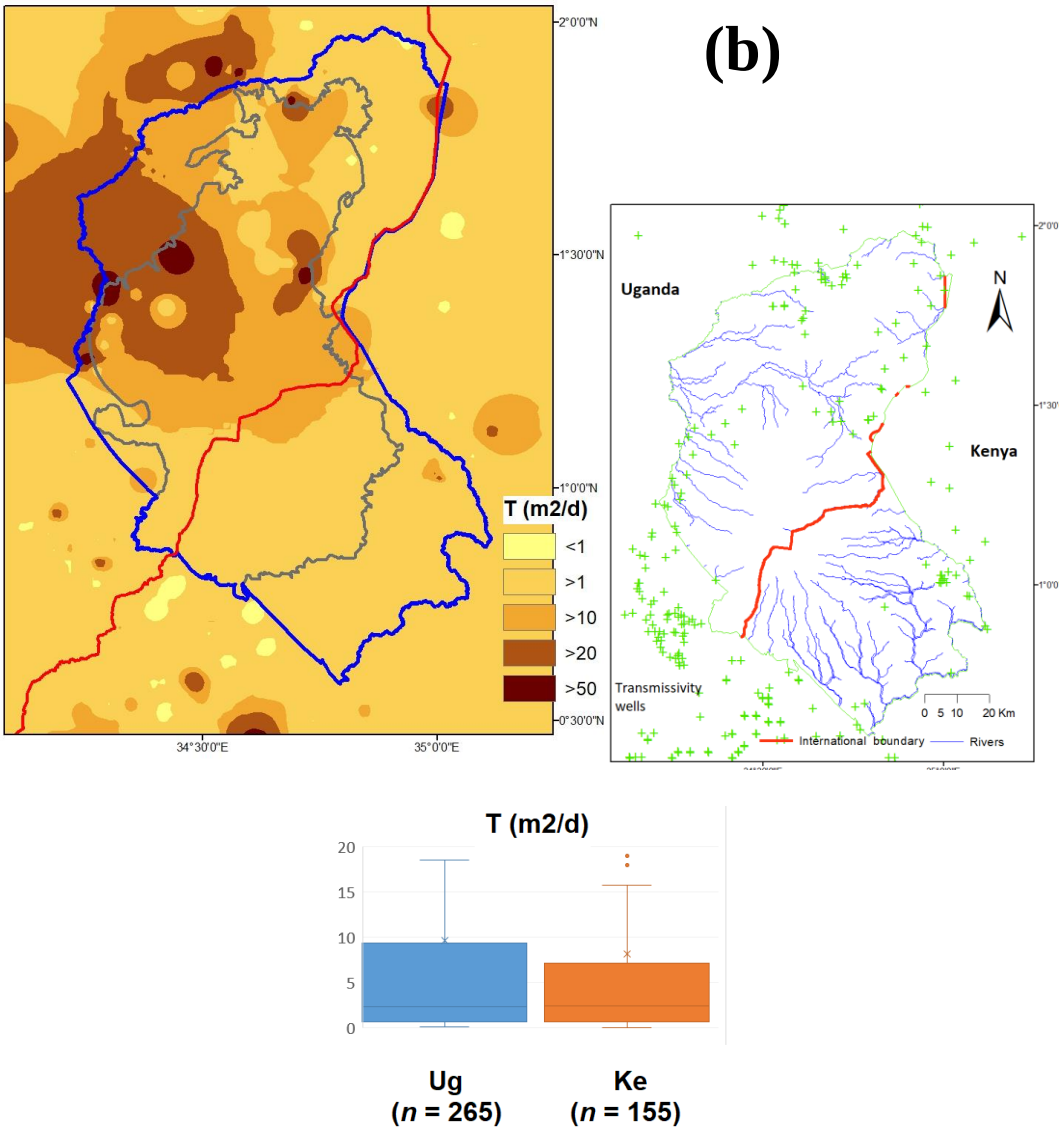


Figure 3.20: *Spatial borehole coverage and box plots of the (a) storativity and (b) transmissivity of the aquifer system across the Mt. Elgon aquifer region.*

On the Kenyan side the hydraulic conductivity varies from 0.001 to 6.8 m/day based on specified aquifer thickness. The total volume of pore water for the Mt. Elgon Aquifer system was determined by the saturated thickness of an aquifer multiplied by its average total porosity over an areal extent of the aquifer. Figures used include, spatial area of 11,000 km^2, saturated thickness of 25 m, and average total porosity of 0.1, yielding a total aquifer volume of 27,500 km^2. m. The amount of water available for confined aquifer release from storage for a specific storage of 0.001 is 7,975 km^2.m. On the Ugandan side the average of hydraulic properties (transmissivity, storage coefficient and pumping rate) categorized by the main geological units is summarised for Quaternary, Alkali volcanics, Aruan Series and the Gneiss-Granulite Complex (Table 3.11).

***Table 3.11**: Average of hydraulic properties categorized by the main geological units on the Ugandan side of the Mt. Elgon aquifer region.*

	Geological unit	Data number	Transmissivity (m^2/h)	Storage coefficient (%)	Pumping rate (m^3/h)
1	Quaternary	16	0.056	17.8	1.61
2	Alkali volcanics	1	0.122	26.5	1.53
3	Aruan Series	11	0.193	21.4	2.79
4	Gneiss-Granulite Complex	96	0.127	13.2	2.06
	Total/average	124	0.125	19.73	2.00

3.9 Safe recharge and sustainable yield

On the Ugandan side of the aquifer region potential sustainable groundwater yield in the main sub-catchments is estimated to average 0.044 MCM/km^2/yr (Table 3.12).

***Table 3.12**: Potential sustainable groundwater yield by catchments on the Ugandan side of the Mt. Elgon aquifer region.*

No.	Sub-catchment	Potential GW Yield (MCM/yr)	Area (km^2)	Potential GW Yield (MCM/km^2/yr)	Potential GW Yield ($m^3/km^2/d$)
1	Muchilmakat	44.3	949.9	0.047	127.7
2	Kelim	19.5	697.3	0.028	76.5
3	Taboki	15.0	386.6	0.039	106.5
4	Chebonet-Atari	13.5	345.3	0.039	107.4
5	Sipi	1.7	39.4	0.044	121.4
6	Muyembe	5.0	59.8	0.084	228.9
7	Simu-Sisi	3.1	75.1	0.041	111.9
8	Sironko	6.8	188.0	0.036	98.5
9	Lake Okolitorom	30.9	748.0	0.041	113.2
	Total	**139.8**	**3489.4**		
	Average			**0.044**	**121.33**

3.10 Conceptual hydrogeological model

The most dominant geological units underlying the Mt. Elgon aquifer region are summarised in Table 3.13. These lithological units are categorised into seven main hydrogeological formations including extrusive igneous rocks, gneissic basement, intrusive igneous rocks, meta sedimentary and volcanic rocks, sedimentary rocks, sediments and volcanic rocks (Fig. 3.19). The hydrogeological formations with the most borehole sites include extrusive igneous rocks, gneissic basement, intrusive igneous rocks, sediments and volcanic rocks. A comparison is made of three key parameters of transmissivity, TDS and yield of the groundwater sources. Mean (11.8 and 11.4 m^2/d) and median (2.1 m^2/d) *T* values is similar in the extrusive igneous rocks and gneissic basement, respectively; the intrusive igneous rocks have lower mean (8.5 m^2/d) and median (1.7 m^2/d) values, whereas slightly higher mean (14.4 and 17.6 m^2/d) and median (3.2 and 2.8 m^2/d)

values are in sediments and volcanic rocks, respectively. The mean (250, 290 and 296 mg/l) and median (279, 275 and 255 mg/l) TDS values are similar in extrusive igneous rocks, gneissic basement and sediments, respectively; intrusive igneous rocks have lower mean (135 mg/l) and median (98 mg/l) TDS, whereas volcanic rocks have higher mean (354 mg/l) and median (286 mg/l) TDS. The mean (2.8 and 3.1 m^3/hr) and median (2.9 and 1.8 m^3/hr) yields are highest in the sediments and extrusive igneous rocks, respectively; lower and similar mean (1.7, 2.3 and 2.3 m^3/hr) and median (1.0, 1.2 and 1.1 m^3/hr) yields are in gneissic basement, intrusive igneous rocks and volcanic rocks, respectively. The preliminary conceptual hydrogeological model of the Mt. Elgon aquifer system depicts recharge in the higher volcanic mountain areas, with slopes dominated by runoff and springs, that flow and infiltrate into the low-relief region underlain by deeply weathered and fractured crystalline rocks, and discharge through alluvial and lacustrine sediments, and wetlands (Fig. 3.21). The region underlain by deeply weathered extrusive igneous rocks and gneissic basement have fairly similar and slightly higher permeability compared to the intrusive igneous rocks which is the most dominant hydrogeological formation.

***Table 3.13**: Comparison of transmissivity, TDS and yields of groundwater boreholes across the main geological formations of the Mt. Elgon aquifer region.*

	Extrusive igneous rocks	Gneissic basement	Intrusive igneous rocks	Meta sedimentary and volcanic rocks	Sedimentary rocks	Sediments	Volcanic rocks
Area (km^2)	1,792	10,463	10,471	290	66	9,562	5,463
T **(m^2/d)**							
n	22	56	94	1	2	13	19
mean	11.8	11.4	8.5	1.8	20.6	14.4	17.6
median	2.1	2.1	1.7	1.8	20.6	3.2	2.8
TDS (mg/l)							
n	26	84	240	4	2	14	21
mean	250	290	135	171	244	296	354
median	279	275	98	147	244	255	286
Yield (m^3/hr)							
n	66	130	443	3	5	24	56
mean	3.1	1.7	2.3	1.8	1.8	2.8	2.3
median	1.8	1.0	1.2	2.6	1.8	2.9	1.1

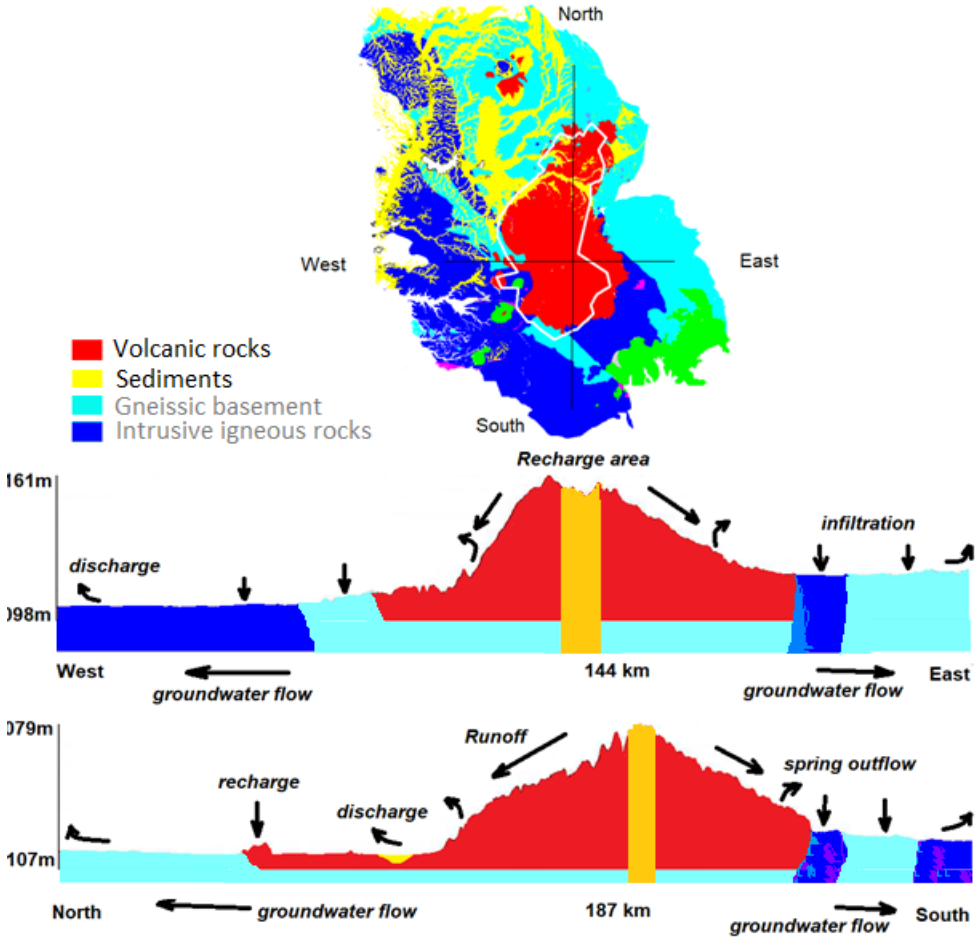


Figure 3.21: *Conceptual models of the main hydrogeological formations of the Mt. Elgon aquifer system.*

4. SOCIO-ECONOMIC CONSIDERATIONS FOR GROUNDWATER DEVELOPMENT

4.1 Socio-economic context

4.1.1 Population, literacy and poverty

The total population of Uganda as per the census 2014 report was 34.6 million people (UBOS, 2014). In comparison to the population of the 2002 census report the population had increased by approximately 10 million people (ibid). However, the 2019/2020 National Household Survey indicated Uganda's population at 41 million with 27% living in urban areas and the rest in rural areas (UBOS, 2020). The Elgon sub-region population was estimated by Uganda population Census analytical report 2014 at approximately 1.7 million people representing 5% of the total population in Uganda (UBOS, 2014). Given the growth in population in the country in general and as represented by the UBOS website, it is correct to assume that the population in the Elgon sub-region has increased over the past years. Table 4.1 represent the population of the sub-region of Uganda per district broken down to represent males and females.

***Table 4.1**: Population of the Elgon sub-region by districts of Uganda.*

S.I. No.	District	Males	Females	Total
1	Bukwo	44, 770	44,483	89,253
2.	Kapchorwa	51,169	53,441	104,610
3	Kween	48,579	47,044	95,623
4	Bududa	105,938	105,745	211,683
5	Bulambuli	85,837	91,485	177,322
6	Manafwa	171,745	181,119	352,864
7	Mbale	237,610	255,194	492,804
8	Sironko	121,989	124,547	246,536
	Total	**867,637**	**903,058**	**1,770,695**

***Source:** UBOS (2014) National Population and Housing Census*

Looking at the literacy levels in the region. The Uganda Bureau of statistics reported its findings in the National Household surveys in terms of secondary school enrolment and literacy levels. School enrolment by the UNHS 2019/2012 puts the net secondary school enrolment into education facilities at 29.9%. Literacy rate for persons between 2016/2017 – 2019/2020 at 80% (UBOS, 2020). The literacy rates of the people in the Elgon sub-region is not high, in fact one of the challenges noted by the Uganda investment authority while profiling the region is that the people are inadequately skilled. This was reported in comparison to their investment potential with the aid of ICT resources. Thus, more skills are required for the region to be able to compete favourably.

The poverty levels of the Mt. Elgon sub-region have reduced according to the Uganda National Household Survey 2017/2018 - 2019/2020. Statistics revealed the percentage number of poor people in Uganda and the poverty rates. In accordance to the study area, the proportion of poor living in the Elgon region 2019/2020 was 13.2%. In comparison to the 35% in 2016/17, there was a reduction of more than half noted in the proportion of the poor people living in the Elgon sub-region. Therefore, the Elgon sub-region was found to contribute 4.1% in 2019/2020 to national

poverty levels as opposed to 7.8% in 2016/17. This therefore, means that between 2016 and 2020, the people of the Elgon sub-region experienced a reduction in poverty rates as well as the sub-region's contribution to the national poverty levels. The Elgon sub-region is involved in four main activities and these include farming, tourism, mining and manufacturing.

Trans Nzoia is a cosmopolitan county in Kenya with cultural diversity and is among the top fifteen densely populated counties in the country. The population for the county in 2018 was projected to 1,111,686 persons of which 551,302 are male and 560,384 are female. The community groups in the Kenyan Mt. Elgon aquifer area include the Ogiek indigenous peoples with a population of approximately 18,000 people, some still living in the ancestral lands in Chepkitale on Mount Elgon; the indigenous Sabaot tribe, also known as the '*Elgon Maasai*' and other local communities who live in the catchment area including the Nandi, Pokot, Marakwet, and Sengwer.

4.1.2 Agriculture

Uganda has a number of natural resources including fertile soils, minerals and petroleum. Of all these resources, agriculture is the most important and contributes largest to Uganda's Gross Domestic Product (GDP). According to the Uganda country coffee profile, Agriculture contributes 42% of Uganda's GDP and coffee takes the biggest share at 15%. There are two types of coffee grown in Uganda including Robusta and Arabica coffee. The Mt. Elgon sub-region located in Eastern Uganda is known for growing Arabica coffee. Uganda Coffee development authority also reports the contribution of coffee to GDP by regions. Arabica coffee is grown in Bugisu on the slopes of Mt. Elgon and was first introduced in 1912. The Eastern region under which Mt. Elgon sub-region falls contributes 22% to the country's coffee production following the central and western regions. Thus the region is important in terms of its contribution to the country's income.

The population in the Elgon sub-region is predominantly an agricultural society. The region is involved in coffee farming where the coffee is grown together with banana in the same plantations. The people of the Elgon sub-region also grow wheat, maize, barley and Irish potatoes particularly in Sebei districts (UIA, 2019). There is also livestock raring, poultry keeping, apiary and piggery. Additionally, in Bugisu coffee, banana, Irish potatoes, peas, beans, fruits and are grown as well as groundnuts, maize, sorghum, millet, cotton, soya beans, sweet potatoes, sunflower, and rice. The area boasts of a good road network therefore, the produce is sold across the border to Kenya and people from neighbouring districts such as Teso sub-region.

In Kenya, the lower slopes of Mt. Elgon, is dominated by intensive maize cultivation. There are also a lot of smallholder farmers practicing mixed farming and are heavily dependent on the Mt. Elgon catchment for their livelihood. The practice of agro-foresty is also common in the region with trees including Sesbania, and Caliandra.

4.1.3 Tourism

The area also relies on tourism as a source of income. The region hosts the Mt. Elgon National Park which has a variety of species of animals to include antelopes. From the mountain also flows River Sipi which forms the famous Sipi falls that attract tourists to Kapchorwa. They also have over 299 birds' specie and also the hot springs in the crater, plus the *imbalu* dance tradition (UIA, 2019).

4.1.4 Mining

A number of minerals have been found in the Mt. Elgon sub-region to include, limestone in Kapchorwa, gold in Bukwo, vermiculite in Mbale, phosphate in Manafwa. Factories such as Tororo Cement are already getting raw materials form the region. There is also reports of the existence of rare minerals in the Sipi caves and Manafwa to include calcite, magnetite, flourapophyllite, natrolite and philipsite (UIA, 2019).

4.1.5 Manufacturing

The sub-region is known for growing coffee, particularly Arabica coffee. In the region are two unions to include the Bugisu cooperative union and the Sebei cooperative union. Elgon sub-region boasts of a number of manufacturing opportunities with an agricultural sector which is doing well. Its location has given it the advantage to sell its produce to Kenya and Sudan plus other surrounding regions. In addition, the Uganda National Household Survey 2019/2020 also revealed the proportion of the population involved in the subsistence economy in the Elgon sub-region to be 42.1% (UBOS, 2020). The subsistence economy did not only indicate agriculture but included wage earning that could not keep the population below the poverty line and doing business which could not make them move out of poverty.

4.1.6 Governance of groundwater resources

Water resources governance deals with the issues of management and determines the power, ownership, boundaries, decision making and course of actions regarding water resources. Once governance is challenged, management is ineffective thus compromising the groundwater quality and quantity, access, the cost of accessing water and potential may raise conflict over the resource. Groundwater governance is undertaken by various governmental and non-governmental stakeholders such as policy makers, public sector organisations and private sector organisations. In some communities one of the key components of groundwater management is shared dialogue workshops which bring together academics, technicians, educators, politicians, community leaders and the local community to discuss the challenges of management and supply of groundwater. These types of platforms are meant to highlight on the existing groundwater challenges and offer solutions that depending on the type of ecosystem. However, in the Mt. Elgon aquifer region, it is not clearly known as to what platforms apart from the assigned technical units and community based management of water resources.

4.2 Socioeconomic characteristics of the aquifer areas

4.2.1 Social economic characteristics of the Ugandan side of the aquifer area

This study took place on the Ugandan side in the districts of Kapchorwa, Kween, Bukwo, Bulambuli, Sironko, and Bududa. While Mbale, Nakaprirpirit, and Amudat were part of the study area, it was not practically possible to cover them due to time factor and bad weather (rain). For example, while in Bukwo, the road connecting to Amudat and Nakapiripirit was bad due to the heavy rains which made it difficult to access the two districts from Bukwo. The socio economic indicators of the study areas are described in the following sections.

Sironko is approximately 245 km by road northeast of Kampala, Uganda's capital city. Sironko town lies at the foothills of Mount Elgon. The area is prone to landslides and flooding. On more than one occasion, landslides have killed people and caused damage and loss of property (Echweru, 2019; Kitunzi, 2019; Naturinda, 2017) in the area of Sironko town and in other parts of

Sironko district. Like all the other districts in the region, the population of the district has been increasing rapidly.

Bulambuli district was created by Act of the Ugandan Parliament, in 2009, and became operational on 1 July 2010. Prior to that, the district was part of Sironko district. The terrain in the southern part of the district is mountainous and is prone to flash flooding (Edyegu, 2011). Bulambuli district is bordered by Nakapiripirit district to the north, Kapchorwa District to the east, Sironko District to the south and Bukedea district to the west (Uganda District Map). According to Google maps (2021), Bulambuli, the district headquarters, is located approximately 32 km by road, northeast of Mbale, which is the largest city in the sub-region. According to the *New Vision* (2014), the northern part of the district, closer to Nakapiripirit district, is drier and is prone to clean water shortages. The district is prone to natural disasters and has been hit by severe floods every after a heavy down pour of rains. The impact of the rains has caused floods that left many families homeless, displaced, food that were collected were socked and washed away and those in gardens were destroyed and rotting. The population of the district has been increasing over years. The major economic activities in the district are subsistence agriculture and animal husbandry are the two main economic activities in the district. Crops grown include: *matooke*, cassava, rice, groundnuts, sorghum, and millet.

On the other hand, Kween district is a district in Eastern Uganda. The district headquarters are located at Binyiny, one of the two town councils in the district. Kween district is bordered by Nakapiripirit district to the north, Amudat district to the northeast, Bukwo district to the east, the Republic of Kenya to the south, Kapchorwa district to the west and Bulambuli district to the northwest. Google maps show that the town of Binyiny, where the district headquarters are located is approximately 69 km by road northeast of Mbale, the nearest largest city. The district was created by act of parliament and started functioning on 1 July 2010. Prior to that, it was part of Kapchorwa district. Together with Kapchorwa district and Bukwo district, it forms the Sebei sub-region, formerly known as Sebei district. The district is located on the northern slopes of Mount Elgon, at an average altitude of about 1,900 m above sea level. The district has three town councils; namely: Binyiny, where the district headquarters are located, Kaproron and Chepsukunya (Chekwech, 2013).

Relatedly, Kapchorwa district is a district in the eastern region of Uganda. The town of Kapchorwa is the district's main municipal, administrative, and commercial centre, and is the site of the district headquarters. The district is bordered by Kween district to the northeast and east, Sironko district to the south, and Bulambuli district to the west and northeast. The district headquarters at Kapchorwa, is approximately 65 km, by road, northeast of Mbale, the nearest large city. The district is approximately 295 km northeast of Kampala. Under the colonial administration, Kapchorwa district was Sebei County, located in North Bugisu in the now defunct Bukedi district. Kapchorwa district is home mostly to Kalenjin peoples, including the sub-groups Sabiny, Pokot, and Nandi. They were mainly cattle keepers in the late 1960s, but that changed when their northern neighbours, the Karamojong, raided most of their cattle and displaced hundreds of people. The populations most affected lived along the Kapchorwa plains; particularly in Ngenge Sub-County of Kapchorwa district and in Bukwo district. This displacement of the population has resulted in abject poverty among the affected households. In 2005, Kongasis County was split off of the district to form Bukwo district. In 2010, more territory was peeled off to form Kween district.

Together, Kapchorwa district, Bukwo district, and Kween district comprise the Sebei sub-region, home to an estimated 200,000 according to the 2002 national census. In 1991, the national population census estimated the district population at 48,700. The 2002 national census estimated the population at 74,300, with an annual growth rate of 4.5 percent. In 2012, it was estimated that the population had grown to about 114,100. In August 2014, the national population census enumerated the population at 104,580. According to the district statistics, the population of Kapchorwa district stands currently at 126,938 composed of 61,965 (49%) males and 64,972 (51%) females, 2021 projection based on 2014 census results (https://kapchorwa.go.ug/lg/population-culture). The districts mainly rely on subsistence agriculture which is the main economic activity in Kapchorwa district. Some of the crops grown include: millet, potatoes, beans, simsim, sunflower, cotton, coffee, wheat, tomatoes, cabbage, passion fruit, and onions. Apart from the above crops, animal husbandry is practiced; and the livestock domesticated are mainly cattle, goats, and chickens (Alinyo, 2012).

According to Directorate of Water Development (2021), the access rates in Kapchorwa vary from 47 % in Western Division Sub-County to 95 % in Tegeres Sub-County. Kapchorwa has 661 domestic water points which serve a total of 105,469 people – 91,151 in rural areas. 59 water points have been non-functional for over 5 years and are considered abandoned. Kapchorwa has 8 piped schemes (http://wsdb.mwe.go.ug/index.php/reports/district/56). According to the Approved Five Year District Development Plan 2020/2021 to 2024/2025 for Kapchorwa, it was reported that during the period 2015/16-2019/2020 although safe water coverage stagnated at 75% in view of the high population growth rate, piped water supply systems were constructed in five Rural Growth centres namely; Kapkai-Chema, Ngangata-Tumboboi, Chebonet-Munarya. According to Directorate of Water Development (2021), the water access rates in Bulambuli vary from 18 % in Bulegeni Town council Sub-County to 95 % in Buginyanya Sub-County. Bulambuli has 883 domestic water points which serve a total of 164,145 people – 157,512 in rural areas. 46 water points have been non-functional for over 5 years and are considered abandoned. Bulambuli has 1 piped scheme. Access to water is 72%, the rural functionality is 97%, equity is 83%, while management is at 90%, and gender stands at 98%. According to Directorate of Water Development (2021), the water access rates in Kween vary from 57 % in Kwanyiy Sub-County to 95 % in Ngenge Sub-County. Kween has 514 domestic water points which serve a total of 89,955 people – 86,314 in rural areas. 38 water points have been non-functional for over 5 years and are considered abandoned. Kween has 4 piped schemes. Access is 83%, rural functionality is 93%, equity is 72, management is 85%, and gender is 91%.

4.2.2 Social economic characteristics of the Kenyan side of the aquifer area

The study was conducted in three (Trans-Nzoia, Bungoma and Busia) counties within which the Mt. Elgon aquifer is located in western Kenya.

Trans – Nzoia County

The County has a population of over 1 million people of which 554,992 are male and 557,034 are female. The majority of people within the county are under the age of 14 years who cover approximately 43% of the entire population. There are 5 sub-counties in the County, with Kiminini Sub-County having a population of 270,721 people, Saboti having 226,045 people, Kwanza having

226,102 people. Endebes having 123, 818 people and Cherangany having 265,000 people. The tribes that are found in the region includes Luhyas, Kalenjins, Sabaot and Kikuyu as the main tribes. Kitale is the capital town of the county which has become more cosmopolitan with 15% of the population being made up of other diverse Kenyan tribes. Majority of the people are Christians, with only a small fraction of the population, especially in major towns professing to Islam and Hindu. The land tenure systems for the county includes free hold land which has absolute ownership; lease hold – which people lease for periods ranging from 33, 66, 99 and 999 years; and temporary occupational licenses which are for a period of 9 months and in these types of land, no permanent structures can be put up.

The County is characterized by large pieces of farmland which belong to the Agricultural Development Corporation. The main land uses in the area includes rural areas covering 29%, Forests or natural vegetation covering 17%; roads for transport 1%; urban areas 2%; wetlands 1%; and agriculture 49%. The main economic activity in the County is farming. Other social infrastructures include schools which are over 1000 and they include ECDE centres, primary schools, secondary schools, colleges and vocational training centres. The county's main water supply is from protected springs, piped water, and rain water, dams, ponds, lake, rivers, and unprotected springs. Approximately 65% of the county uses improved water sources while the rest relies on unimproved sources.

In Trans-Nzoia County, water scarcity is as a result of inaccessibility by most people because of the long distances they have to travel to get water. The county hosts 2 water towers, Cheranganyi and Mt. Elgon. There are 2 drilling rigs for the county that serves the purpose of groundwater abstraction. There are up to 350 sanctioned boreholes for both institutions and individuals. The deepest one is 300 m but most of them are between 60-100 m. There are also many springs that have been protected by the county and civil society organizations. There are also a lot of shallow wells, especially ones which are done by individuals for their home use.

Some of the challenges experienced are when land owners who have given out their land for drilling of boreholes to serve the whole community come back and claim the resource as their own, and blocks the community from accessing it. There are boreholes that are very low yielding especially when going close to the Mt. Elgon region. In an area like Kiptogot the sources of water is from the Kiptogot River, and piped county water supply. However, because of the high population, this water source is not enough to cater for the whole community. There are springs that have been developed by the communities. The lower side of Kiptogot has serious water challenges and they fully depend on springs and boreholes. Whenever there are government projects on water resources development, the Kiptogot community is not usually involved in the decision making process. The people most affected by water issues in the area are women because they have to walk long distances to get the water. They have to wake up at 5:00 am to get water and prepare their children for school and therefore they are prone to catching diseases. Where there is piped water, vandalism is common as people cut the pipes so that they can get access to the water and illegally access the water for small scale irrigation.

Bungoma County

The county has a population of 1,809,310 people of which 883,475 are male and 925,835 are female. The county covers an area of 3032.4Km^2. The main economic activities in the county are

agriculture and micro, small and medium scale enterprises. Health services within the county are provided by health centres and level 2 and 3 hospitals. The number of schools is over 1,000 and these include Early Childhood Development (ECD) centres, primary schools, secondary schools, colleges, and vocational training centres. The main national resource is the Mt. Elgon forest and national park. The county has 45 wards and 256 village units. The county is inhabited by Bukusu, Tachoni, Batura, Sabaot, Iteso and other Kenyan communities who reside side by side in peace. The County is generally cosmopolitan. The County has 2,880.78 km^2 of arable land. Land uses include: agriculture, forestry, mining, human settlements, business, social and public amenities. Land is also used as collateral to obtain credit as well as for aesthetic purposes. Main crops produced include maize, beans, finger millet, sweet potatoes, bananas, sorghum, Irish potatoes and assorted vegetables. Sugarcane, cotton, palm oil, coffee, tea, sun flower and tobacco are grown as cash crops in the County.

In the county, water that is obtained from groundwater resources is not salty or turbid, it is clear water. People usually dig the shallow wells themselves and then use buckets to get the water. Accessibility of water is a big challenge within the county because of distance and congestion, or overdependence by the people. Many people gather at one water point, like springs to get water at the same time, and this usually results in conflicts.

The communities have gotten help in. abstracting water resources from organizations like Kefinco, but once the donors pull away, there is usually poor maintenance of the protected springs and borehole structures, which lead to their destruction and even vandalism.

The county has a lot of water during the rainy season but very little water during dry seasons because of poor reserves. There are surface waters like rivers within the county. However, people use donkeys and bicycles to fetch the water; there are people who take their animals to drink the water, and there are also people who do their household chores like washing there, therefore contributing to significant pollution of the water points. The rivers are also very far from each other, and some people have to walk 6 km back and forth to get access to the water. Piped water from the county can lack for a period of three months. During this time, the communities are forced to buy water from water vendors who get water from springs.

The social issues that are experienced within the county are teenage pregnancies because girls have to go very far in search of water and once, they are away from home for long, they get involved in sexual relationships. For instance, the water spring in Toroso in Cheptais, high schools (both boys and girls) are sent to the water point from school to get water for their use in the school. This mingling results into sexual relationships. Also, there is a lot of time that is wasted during the trips to the spring to get water. People also contract a lot of diseases from the surface water points because there is a problem with maintaining good hygiene.

The springs in the different sub-counties have been developed by the County Government, Water resources Management Authority, and the World Bank. There is poor water management in some areas within the county. For instance, in Chepkube, Chebombai WRUA is responsible for catchment protection, and they have been assisted by some organizations and government institutions to establish water development programmes. For instance, spring protection of 5 springs by WRA; River Bank protection by GIZ; capacity building on water management, and river bank protection by CIFOR. These activities helped the water situation in Chepkube a little but because of the population and high dependence on groundwater, there is still need for more.

The shared challenges experienced by the communities include poor water quality, poor access to water because of distance in accessing water. Women are the most affected because they have to travel long distances to get water. Water that is available without travelling long distances has to

be paid for, which is difficult for most people because of poverty. There are conflicts at the point of access of water. There are people who come to the water point with 40 jerricans and the other people will have to wait for all of them to be full before they get their turns. In some instances, girls have had to leave the waterpoint at 8:00 pm, and this is not safe.

In Kuywa there is a better management system for groundwater management. The Kuywa WRUA has a strong membership including good representation of women and persons with disability. There is a fee of 2,000 KES that are paid to the WRUA by people looking to abstract water which goes towards conservation efforts. They have different rates for membership where individuals pay 3,000 KES, institutions pay 20,000 KES for a membership that is renewable after every 5 years. The Kuywa springs serves a very wide community, including people of Sikulu, Terem Kibisi, Mukasa. There is a lot of vandalism in the area, as people destroyed the first spring called the Lukuna spring that is currently operational.

The most water stressed areas in Bungoma County are Sirisia and Bumala. Groundwater is used for domestic purposes. Groundwater in Sirisia is not suitable for consumption because it has a lot of iron. The county is planning to do a deionization programme as part of operations and maintenance of the groundwater resources in the area. The users of the water in the springs are so many that water has to be pumped every one hour or people will not have access to the water, if it is not pumped even for one hour. After the county government has done and upgraded a borehole, it is usually handed over to the community through committees that become responsible for collecting revenue on it and using the money to maintain the boreholes and protected springs. The people who pay for the water are the ones who have the water piped to their homes, and therefore the water is metered and they have to pay based on their rate of consumption.

Busia County

The aquifer covers the Teso North sub-county in Busia County that has a population of 54,928 people. The main challenges that the sub-county is facing include deforestation, encroachment of riparian and wetlands, water scarcity, water pollution, sand harvesting, soil erosion, and poor sanitation. There is a water challenge but it is not so dire. There are boreholes that have been done by the county government to serve the communities. These resources are then handed over to the community through water management committees. In the past, there was no women involvement in the committees but this is quickly changing, as there is a one third representation of women in the leadership of the committee.

There are 300 protected springs in the county but only a small fraction of these is found within the Teso North sub-county. There is a very high dependence on groundwater. The uses of water are for domestic purposes, kitchen gardens, dispensaries and in schools. The boreholes that have been developed for community use are solar powered and piped to people's homes, and they pay their water usage fees to the committees which are in charge of management and maintenance of the resource. Groundwater potential is poor in Teso North sub-county.

The main challenges experienced in the area are biases on selection of areas that need to receive boreholes. This is not done on needs basis but on nepotism. There is a lot of corruption and substandard work at the County because there have been several boreholes that have been sunk only to find no water, or water that cannot be used because of too much contamination by heavy metals. There are also a lot of political conflicts.

The Akbui water projects in Malakisi is an upgraded borehole that is solar powered. The borehole serves 105 households with approximately 5 – 8 people in each of the households. All the households have taps in their homes. The resource also serves 4 schools and 1 health facility. The

cost of the water is 45 KES per unit of water used. The water is purely for domestic use. It is limited in supply and cannot be used for agriculture as well.
The benefits that the community has realized from this project include the following: women find it easier to get their house chores done; children go to school on time and are therefore more focused on their education; and water borne diseases have reduced. The project challenges include: There are people who do not want to pay for the water because they believe it was done for free for their use, hence they do not understand the reason for paying for access to the water. The group is usually forced to disconnect water for such groups; and cases of illegal connection – people not going through the proper channels to get their water connected because they want to avoid the cost implications.

Indigenous peoples

The indigenous community within the Mt. Elgon aquifer are the Ogiek. Majority of them live in the moorland of Mt. Elgon forest in Kaptama Ward. Their members are represented by the Sirgoi WRUA since they use groundwater resources like springs and boreholes within the area. There is a water challenge in this area. There are 6 springs that have been protected. The springs and swamps are the largest sources of water for the people of this community. The water from the river sometimes floods and therefore cannot be used. When this happens, people are forced to walk up to 3 km in search of water. During dry seasons, the water in the springs sometimes dries up, and therefore people have to use water from the river, and the high dependency ends up polluting the water, making it unsafe for human consumption, there is a great need for more springs to be protected so as to serve a wide community of people. According to the WRUA network officials, 40% of the human activities in the forest contribute to declining water quantity and quality. Such activities include but not limited to overstocking of livestock, illegal logging, use of toxic herbicides and charcoal burning.

4.3 Socio-economic pathways (SEPs)

4.3.1 Population

Ugandan regional population

The population in the Mt. Elgon Aquifer has been increasing rapidly due to many factors like urbanization and the search for better opportunities and amenities in town (Table 4.2). Mbale is the most populated while Bukwo is the least populated, respectively.

***Table 4.2**: Population of the Elgon sub-region by districts of Uganda.*

District	Males	Females	Total
Bukwo	44, 770	44,483	89,253
Kapchorwa	51,169	53,441	104,610
Kween	48,579	47,044	95,623
Bududa	105,938	105,745	211,683
Bulambuli	85,837	91,485	177,322
Manafwa	171,745	181,119	352,864
Mbale	237,610	255,194	492,804

Sironko	121,989	124,547	246,536
Total	**867,637**	**903,058**	**1,770,695**

Source: *UBOS, 2014 National Population and Housing Census*

According to Uganda Bureau of Statistics (UBOS) (2018), Uganda's population was estimated at 37.7 million of which 52 percent were females. The proportion of the population aged below 15 years constituted slightly more than half of the total population and the dependency ratio declined from 107 in 2012/13 to 97 in 2016/17. Three in every ten households (31%) were headed by females. Only one in every ten Ugandans aged less than 18 years (11%) had a birth certificate. The highest percentage of Ugandans aged less than 18 years who had birth certificates were in the Central region (12%) and the lowest percentage were in the Eastern region (8%).

UBOS (2018) noted that the population distribution shows the spatial spread of people within a given geographical area. Concerns over spatial distribution of the population are virtual in planning at the national, regional and district levels. Uganda's population is still predominantly rural (76%). This compares well with the findings of the 2014 Uganda Population and Housing Census (79%). The proportion of the population living in urban areas largely remained the same between 2012/13 and 2016/17. Eastern and western regions had the larger share of the population (26% each, respectively) compared to other regions. Kampala's comprised about four percent of the population in 2016/17 and has remained the same since 2012/13. The increase in the proportion of the urban population is attributed to the creation of more urban centres.

According to UBOS (2018), children aged less than 13 years constitute 46 percent of Uganda's population while the age-group 14 – 64 years accounts for 51 percent of the population. Regardless of residence, the age-group 14 – 64 years constitutes the largest percentage of the population, i.e. rural areas (49%) and urban areas (58%). Compared to other sub-regions, Kampala had the highest percentage of the population aged 14 – 64 years (64%) while Karamoja had the lowest (42%). Overall, the household population aged 14 – 64 years slightly increased from 48 percent in 2012/13 to 51 percent in 2016/17. Age dependency ratio, is the ratio of the dependent population (0 to 13 years and 65+ years) to the proportion of economically productive population (15 to 64 years). Age dependency ratios are calculated and used as proxy estimates for actual dependency in the population because a large proportion of persons included in the non-dependent age-group (15 to 64 years) could also be dependent.

UBOS (2018) observed that the dependency ratio for Uganda in 2016/17 was 97, implying that there were more people in the working age group (14-64 years) than the dependent age-groups. A higher proportion of the working age population than the dependents provides the country with an opportunity to harness the demographic dividend. Accordingly, the demographic dividend is the economic growth potential that can result from shifts in a population's age structure, mainly where the share of the working age population 14 – 64 years is larger than the share of the population 13 years or younger or 65 years and above (Bloom, et al., 2003). The dependency ratio was higher in male-headed (103) compared to female-headed households (92), meaning that the burden of taking care of dependents was higher in male-headed than in female headed households. Dependency ratio was lower in urban areas (74) than rural areas (106), signifying a greater care taking burden on rural than urban households. Across sub-regions, Karamoja had the highest dependency ratio (141) while Kampala had the lowest (54). In the PRDP districts, the dependency ratio was higher

in the severely affected districts (113) than in the spill-over districts (105) and sporadically affected districts (102). The overall dependency ratio dropped from 107 in 2012/13 to 97 in 2016/17. The dependency ratios were generally lower in 2016/17 than in 2012/13 irrespective of the background characteristics apart from Elgon sub-region where the dependency ratio increased from 101 in 2012/13 to 105 in 2016/17.

According to UBOS (2018), Uganda's population is estimated to have increased by 3.6 million persons (from 34.1 million to 37.7 million). There were slightly more females (52%) than males (48%). The proportion of the population aged less than 15 years constituted slightly more than half of the total population. The proportion of urban population largely remained the same between 2012/13 and 2016/17 at about 24 percent. The dependency ratio declined from 107 in 2012/13 to 97 in 2016/17. The average household size remained the same at about 5 persons per household. Three in every ten households (31%) were headed by females with slightly more female- headed household in urban areas (33%) than in rural areas (30%).The practice of polygamy was most common among persons aged 40 – 59 years (18%). Polygamy was highest in the Karamoja sub-region (31%) but lowest in Kampala and Kigezi sub-regions (4%, respectively). Only one in every ten Ugandans (11%) below 18 years had a birth certificate. Central region had the highest percentage of the population possessing birth certificates (12%) while Eastern region had the lowest (8%). Furthermore, sixteen percent of the population had lived in another place before their current residence in the five years preceding the survey. Kampala had the highest percentage of persons who had lived in another place (31%) while Kigezi, Elgon and Bukedi had the lowest (5% each, respectively). Over four in every ten persons (45%) had moved from one rural area to another while 16 percent had moved from rural to urban areas (UBOS (2018).

Kenyan regional population

The population in the four counties of Kenya where the Mt. Elgon aquifer is located has been increasing rapidly since 1979 (Table 4.3). Bungoma County is the most populated among the counties while West Pokot is the least populated.

***Table 4.3**: County populations based on national censuses in Kenya (*after *National population census, 1979-2019).*

	1979	1989	1999	2009	2019
Trans Nzoia	259,503	393,682	575,662	818,757	990,341
West Pokot	158,652	225,449	308,086	512,690	621,241
Bungoma	503,935	679,146	1,011,524	1,375,063	1,670,570
Busia	297,841	401,658	552,099	743,946	893,681

The population trend is on sharp increase since 1979 (Fig. 4.1). Bungoma County has the sharpest increase in decadal population followed by Trans Nzoia while West Pokot has the lowest increase.

Trans Nzoia County is a cosmopolitan county with cultural diversity comprising majority of the 44 Kenyan tribes residing in the county. In addition, according to Kenya Red Cross and UNHCR, the county is home to 350 urban asylum seekers mainly of Southern Sudan origin as well as a transit point for refugees.

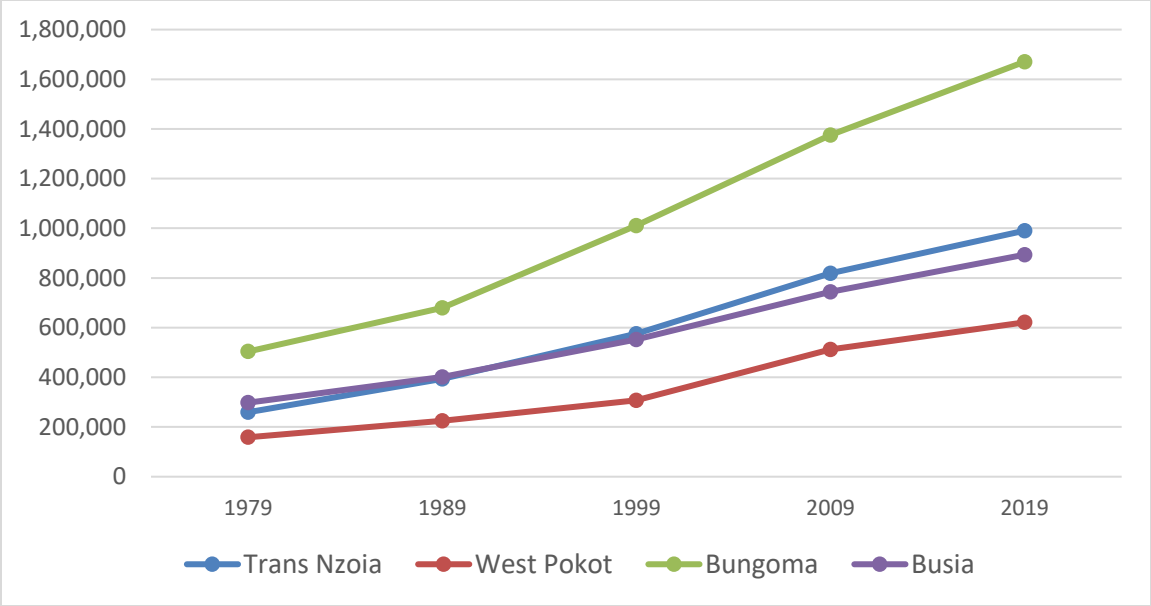


Figure 4.1*: Population trends of four counties based on the Kenya National Census data.*

According to the West Pokot County Integrated Development Plan (CIDP) 2018-2022, the population distribution in West Pokot County is influenced by climatic conditions and socio-economic development. Urban areas and high potential agricultural areas have high population distribution and density. The population density for the county is expected to increase from 85 in 2018 to 108 and 147 persons per square km in 2022 and 2030 due to the high population growth. With the sharp increase in population across the Counties within the Mt. Elgon Aquifer area, it suffices to say that the use of surface water has been on the increase since the population need the water to enhance their livelihood activities including agriculture and construction, hence increasing the potential to exploit the groundwater to bridge the gap of insufficient and inaccessible surface water in some areas.

4.3.2 Education

Ugandan region education

Based on statistics by UBOS (2018), the literacy rate for persons aged 10 years and above was estimated at 74 percent - a slight increase from 70 percent in the 2012/13. Literacy rate was higher for males than females. The overall Gross Enrolment ratio was estimated at 117 percent and was highest in the sub-regions of Teso (139%), Bukedi (133%) and West Nile (131%). Forty-three percent of persons aged 6 – 12 years had never attended school because their parents considered them too young for school. Furthermore, 12 percent of persons aged 15 years and above did not have formal education, while five percent of persons in the school-going-age (6 to 24 years) had never attended school. About half of persons aged 6 - 24 years in Karamoja had never attended school.

Kenyan region education

In Trans Nzoia County, currently there are 761 ECD centres, 483 primary schools, 169 secondary schools (151 public and 18 private), 14 youth polytechnics, 4 campuses of universities (University of Nairobi, Jomo Kenyatta University of Agriculture and Technology, Mt. Kenya University and Moi University) in Trans Nzoia county. In addition, there is one technical institute and one teachers' college. As at the end of 2012, the number of pupils in the Early Childhood Development Centres (ECD) was 36,185 with 956 teachers. At the start of 2014, the County had 813 ECD centres with 478 centres being public and 335 centres being private. The teacher pupil ratio was 1:38. The schools are both public and private. There are 525 primary schools in the County of which, 336 are public schools and189 are private schools. The County has 220,019 pupils enrolled in its primary schools. Out of these 109,477 constituting 49.7 percent are boys and 110,542 constituting 50.3 percent are girls with 4,559 teachers. The teacher to pupil ratio is 1:48 which is above the recommended ratio of 1:40. The dropout rate is 22 percent The County has 178 secondary schools of which 163 are public and 15 are private. The enrolment is 44,734 of which 23,753 are boys and 20,981are girls. Teachers are 999 and the teacher pupil ratio is 1:45 which is above the Ministry of Education recommended range of 1:40 and a transition rate of 52.7 percent. Under higher education, the country has witnessed an explosive expansion of university education in the last few years especially in the area of opening new campuses across the country. The county has benefited from this expansion and to date the Universities of Nairobi, Mt. Kenya, Jomo Kenyatta University of Agriculture and Technology and Moi University have opened campuses. In addition, there is Kitale Technical Training Institute and Nzoia Teachers Training College.

Busia County has 638 primary schools and 162 secondary schools with a population of over 252,057 pupils and 52,488 students respectively, 25 Vocational Training Centres and 3 university constituent colleges located in Amagoro, Nambale Market and Alupe Sub-County Hospital. According to the 2009 Kenya Population and Housing Census, 75.3% of the population, aged 15 years and above in Busia County have the ability to read and write which is 4.7 % below the national target. Adult learning and continuous education centres are being rejuvenated with at least five such facilities established in every sub-county. There are also privately owned educational institutions at all levels that complement the public ones. There are 919 Early Childhood Development Education (ECDE) centres in the county of which 440 are public and 479 private. In addition, a number of public primary schools in the county have, with the help of the County Government, integrated a pre-primary unit in their systems. Separately, the County Government, through the Department of Education and Vocational Training, has managed to build additional 210 Early Childhood Development (ECDE) centres.

In West Pokot County, there are 1,032 pre-primary schools centres in the county with 838 ECD teachers. ECDE enrolment currently stands at 77,679 giving teacher pupil ratio of 1:92. This enrolment represents approximately 51% of the total eligible number of ECD school age children under this age bracket. Low enrolment is contributed by nomadic lifestyle, long distances to schools and lack of enough feeding program. The county has 554 primary schools with total enrolment of 186,708 pupils in the county. The county has a gross primary school enrolment of 89% and a transition rate of 66 percent to secondary schools. Issues affecting primary school going school children in the county include lack of sanitary pads, inadequate teaching staff, early marriages, female genital mutilation, child labour, sexual abuse, inadequate learning and reading materials, inadequate access to water and healthcare, insecurity, high household poverty levels, inadequate parental care and lack of electricity connections in some schools. There are 120

secondary schools with total enrolment of 156,272 students in the county. There are a total of 987 teachers giving Teacher pupil ratio of 1:52. The county has a gross secondary school enrolment of 75 percent. Staffing and school infrastructure needs to be improved to enhance the learning environment and ensure quality education. There are six youth polytechnics in West Pokot County namely; Kapenguria, Chepareria, Ortum, Sigor, Sina and Kodich. Enrolment in county polytechnics is very low. Huge gender disparities also exist in enrolment in favour of males. There are eleven tertiary institutions in the county of which five are polytechnics, extra mural centre of Nairobi University, Kisii University, Elgon View Training Institute, Kitale technical branch, Kenya Institute of Professional Studies, Teachers training colleges (Chesta TTC and Murpus TTC), ECDE Teachers College, Kapenguria and Ortum Nursing Schools. These tertiary institutions remain insufficient and there is need to put up more institutions in the county. West Pokot County has low literacy level of 30% compared to the national literacy level of 62% .These people are limited in their operations due to illiteracy. According to the CIDP, Adult education literacy should be a part of many approaches to reducing poverty as multiple initiatives needed to lift people out of poverty.

The increasing number of schools and colleges, and the number of children and students attending the educational institutions thereof indicates the increasing need and usage of water, both surface and groundwater. Since surface water may not be accessible to all the institutions in relation to the desired quality and quantity, groundwater has become the better option for many institutions. As a result, most educational institutions access groundwater by sinking of boreholes within their compounds.

4.3.3 Infrastructure and Energy

Trans Nzoia County had a total of 4421.7 km of road network out of which bitumen surface is 163.3 km, gravel surface is 2,165.4 km and earth surface roads is 2093 km (Kenya National Bureau of Statistics, 2014). The County has the old colonial railway line of 23 km that terminates at Kitale town but is not functional. Additionally, the County has one functional airstrip at Kambimiwa which requires expansion and modernization. Currently major infrastructure works are being undertaken to modernise the bus terminus which also includes a Business Centre in Kitale town. The main sources of energy in the County are electricity, paraffin, liquid petroleum gas, firewood/charcoal, solar, and biogas.

Access to energy however varies between rural and urban areas. Wood fuel and paraffin are the most preferred source by a majority of the rural households for cooking and lighting while electricity and gas are most preferred in the urban centres (Kenya Population and Housing census, 2009). Electricity is the main source of lighting fuel in Trans Nzoia County, at 30.7 percent for 210,000 households surveyed and this can be attributed to the scale up in the rural electrification program. On the other hand, 29.1 percent of the households use paraffin tin lamps for lighting while 19.3 percent of the households use paraffin lanterns and 0.5 percent use pressure lamps. Similarly, other sources of lighting fuel used are generator, candle and battery lamp/torch at 0.1 percent, 0.2 percent and 1.1 percent respectively. 6 percent of the county households use other energy sources for lighting. (Source: 2009 Kenya Population and Housing census).

In Bungoma, the Mombasa – Nairobi – Eldoret – Webuye – Malaba highway (A104) traverses through the county. It is a major link road for trade and commerce. The Webuye - Kitale highway

has recently undergone improvement works, thereby positioning the county as the desired destination for attracting and retaining investment. The County has two underutilized airstrips in Webuye and Bungoma Towns. In 2016, the country had 2,325.8 MW. This was composed of; hydro (818.2 MW), thermol oil (803.5 MW), geothermal (652 MW), wind (26.1 MW) and cogeneration (26 MW). Since 2013, 46,520 additional households and 520 additional primary schools have been connected to electricity. As for lighting, only 4% of residents in Bungoma County use electricity as their main source of lighting. A further 27% use lanterns, 67% use tin lamps, and 1% use wood fuel. Going by KNBS statistics of 2013, in Bungoma County 1% of residents use liquefied petroleum gas (LPG), 2% use paraffin, 85% use firewood and 11% use charcoal as cooking fuel. Firewood is the most common cooking fuel by gender at 85% of male headed households and 86% of female headed households.

The total road network in Busia County is approx. 1,600 km and consists of 169.64 km of tarmacked roads, 591.91 km are of gravel surface and 838.55 km earth surface. Some of the roads are however impassable during rainy seasons because they lack appropriate drainage. The County is traversed by only 11 km of railway and served by one railway station in Malaba Town crossing into the Republic of Uganda. The Government of Kenya has identified two corridors for the development of modern, high capacity Standard Gauge Railway (SGR) transport system for both freight and passengers. Phase 1 (472 km) covering Mombasa to Nairobi was completed and Phase 2 (490 km) covering Nairobi to Kisumu to Malaba in Busia County is underway. The County has no functional airport or airstrip and has two ports at the Lake Victoria shores. The Sio Port in Samia Sub - County and Port Victoria in Bunyala Sub - County which mainly serve as fish landing ports. The main source of energy in Busia County is firewood with 95% of the households of rural population relying on it for cooking and heating. About 60% of the population in rural areas rely on kerosene as the main source of lighting. Only 49% of the county residents have access to main grid electricity. The county has not made sufficient attempts at exploiting the available renewable energy resources.

4.3.4 Land cover and Land use

Bungoma County has 2,880.78 km^2 of arable land mainly for crop farming and livestock production. County land uses include: agriculture, forestry, mining, construction of human settlements, business, social and public amenities. Land is also used as collateral to obtain credit as well as for aesthetic purposes. Spatial planning should be emphasized to enable sustainable utilization of land and air spaces. Land in the county is either privately owned (freehold) or held in trust by the government for the community. The average holding size in the County for small scale farm sizes is 1.5 acres, while for large scale farms is 10 acres. This implies that land sizes are declining due to fragmentation of land into uneconomical units/parcels. The County has some cases of landlessness and squatterdom. These cases are mainly in Mt. Elgon Sub-County where efforts to resettle families evicted from the Mt. Elgon forest reserve and Chepyuk settlement scheme are on-going. The same cases are common in urban areas and markets. Landless families are vulnerable to several socio-economic challenges such as abject poverty, malnutrition, food insecurity, diseases, social crime, rape, defilement, and HIV/AIDS. There is need for policy and legislation to address issues related to landlessness and homelessness. Settlement patterns in the county are influenced by productivity of agricultural land, transport and communication network and access to sources of employment, social and economic amenities and services.

Land is held both publicly and privately in Trans-Nzoia County. Public land is under ownership of public institutions while private land is owned by individuals or registered private groups, organization or companies. Majority of land in the County is under private ownership as either leasehold or freehold. In addition, some land in urban areas is also held on temporary basis under Temporary Occupation Licenses (ToLs). The average land holding in the County is 0.607 hectares for small farm holders and 12.15 hectares for large scale farm holders. The mean holding land size is however continuously reducing due to subdivision of land occasioned by population pressure. Landlessness in the County is characterized by squatter and informal settlers who have settled on public land. Incidences of landlessness is attributed to the displacement of some population during the 1992 clashes and 2007 post-election violence as well as evictions from forest reserves such as Kiboroa, Saboti and Kapolet forests. The population and settlement pattern in the County is predominantly rural in character. Most of the population in the County have settled sparsely in the rural areas with concentration of population in the existing urban areas. Kitale town accommodates the largest share of urban population with other people settled in the remaining sub-county headquarters including Kiminini, Kwanza, Endebess, Saboti and Kachibora.

In Busia County, the major land use in the county is for crop production and livestock farming. Other land uses include brick making, urban settlements, sand harvesting and quarrying. The sandy soil near the lake shores, beaches and sand from the rivers are harvested for use in construction. With the increasing population in the county, the land currently being used for forestry and agriculture is being converted into human settlement. It is expected that as the demand for food and shelter increases the land under forestry will be under more pressure. This is resulting into deforestation and destruction of water catchment thus drying up of streams leading to water shortages. Land is held on leasehold and freehold tenures. Leasehold tenures are available mostly in Busia Town within the original town boundaries. Small pockets also exist in Nambale Township. All the other lands are held under the freehold system with reservations available for public user purposes. Due to high population growth, most of the original large scale farms have been sub-divided beyond economically sustainable production capacities (2.7 hectares) with a large proportion of the population owning less than 0.6 hectares.

According to the West Pokot CIDP 2018-2022, land ownership in the county is under public, private and community. Public land consists among others of schools, hospitals, forests, cattle dips, holding grounds for livestock. Private land category is classified into registered land to individuals (absolute ownership), land leased to individuals and companies by county and national governments, while community land category consists of all the unregistered land which is held in trust by the county government. They are in form of group ranches and community shrines. The average farm sizes in the county stands at 20 acres. The population is predominantly rural depending on pastoralism as their main source of livelihood. Subsistence crop production is also undertaken in the arable areas. Land in West Pokot County is largely communally owned. As a result, cases of landlessness are minimal. The county government will work towards land reforms that address the needs of specific groups including women, widows, orphans, and persons with disabilities. Land reforms are geared towards holistic management and participatory governance of this critical resource to create a foundation for the implementation of projects identified in the integrated plan.

4.3.5 Agriculture, irrigation infrastructure and industries

Main crops produced in Bungoma include maize, beans, finger millet, sweet potatoes, bananas, sorghum, Irish potatoes and assorted vegetables. Sugarcane, cotton, palm oil, coffee, tea, sun flower and tobacco are grown as cash crops in the County. The area under food crops is 201,654.6 ha, while that under cash crops is 86,423.4 ha. Nzoia Sugar Company has about 50,000 hectares of land under sugarcane. Most of the agricultural activities are rain-fed, meaning that farmers only plant during the rainy seasons. Dependency on rain-fed agriculture exposes families to instances of food insecurity because of unpredictable weather patterns. Bungoma County is home to Mt. Elgon, which is one of the 5 water towers in the country. Irrigation potential in the County can be realized by harnessing the waters of river Nzoia and all rivers that originate from Mt. Elgon including Terem/ Kuywa, Kibisi and Lwakhakha/ Malakisi. The potential for harnessing groundwater for irrigation is also very high. The County has 4 irrigation schemes which are operational at Kamusinga, Chebukui, Kuywa and Stabicha.

The main factories and industries in Bungoma County include; Nzoia Sugar Company, Rai paper, Malakisi Tobacco Leaf Centre, Webuye Heavy Chemicals Industry, Kitinda Dairy, Musese and Chesikaki coffee factories. They rely on raw materials produced locally. Efforts will be made to sustain production of raw materials to enable industries operate optimally. Malakisi ginnery will be revived to cater for the cotton farming communities to improve their livelihoods. Some of the resources which can support the industrial sector in the County include; human resource, fertile land, rivers, forests, sun light, wind, conducive weather, rainfall, biomass, sand, rocks, dams, fish ponds, livestock, mountains and hills, energy, fair road and communication network. The Micro, Small and Medium Enterprises (MSMEs) are considered as sources of employment generation, economic growth, and social transformation. A significant proportion of the MSMEs are formal, while majority fall within the informal economy based on their size, location, ownership, status of formality and economic activity. The sub-sector produces a significant share of total value added, and provides a large segment of the poor and middle-income populations with affordable goods and services.

Trans-Nzoia County is endowed with natural conditions that favour growing of a variety of crops including food crops (maize, beans, potatoes, millet, bananas and wheat), industrial crops (coffee, tea) and a variety of horticultural crops such as tomatoes, cabbages, kales, avocadoes, oranges, mangoes including export crops such as French beans, sugar snaps, snow peas chillies and cut flowers. The County has high irrigation potential based on three (3) rivers of Ewaso-Rongai, Noigamet, and Sabwani, 65 dams, 2 water pans (Kobos and Twiga), over 300 shallow wells, over 132 potential springs, and over 150 boreholes out of which 34 were drilled, developed and rehabilitated by the County Government. Out of the 14 potential irrigation schemes across the County, only one (Koibei) is in operation covering 200 hectares and serving 450 households. The rest (13) are under planned rehabilitation which when completed will cover an average of 2,129 hectares and support food security and farm income initiatives to an average of 3,410 households. The most commonly used irrigation system are river-pump fed and river-gravity fed. Small scale farmers also carry out bucket, furrow and river-pump fed irrigation farming for some crops such as tomatoes, vegetables, fruits including export crops like French beans and snow peas. The major seed companies in the County such as Kenya Seed at Endebess Elgon Downs Farm as well as Western Seed Company and Agri Seed Company (SEEDCO) at Kiminini farms do sprinkle irrigation on their off season seed maize and horticultural crops. Some of the above irrigated crops particularly tomatoes, vegetables and flowers are under greenhouse drip irrigation system. There

are 18 County Government supported greenhouses; 72 individual farmer greenhouses and 540 commercial greenhouses under management of Mt. Elgon flowers and Panacol International mostly for export market.

In Busia County, some of the crops that are grown within the county in small scale include maize, beans, sweat potatoes, millet, cassava, tobacco, cotton and sugarcane. The broad agricultural production systems in the county include crop cultivation, livestock rearing and fisheries. Agriculture is the most important sector in the County as it provides for over 65% of the total earnings. Most people in the County are employed either directly or indirectly in this sector. Part of the available farmland is taken up by sugarcane farming as a cash crop. The total farming acreage is 155,990 acres of food crops while 29,525 acres is under cash crops. Small scale irrigation schemes range between 70 ha to 200 ha. National irrigation schemes have a total of 8000 Ha. Majorly, the crops under irrigation include; vegetables, melons, tomatoes, maize, sorghum and rice. The County Government of Busia has funded the ongoing Kabosokipi Ong'aroi Irrigation Scheme in Teso North/Teso South sub-counties.

In West Pokot County, the main food crops produced include maize, beans, sorghum, finger millet, green grams, Irish potatoes, sweet potatoes and bananas. The farmers also grow horticultural crops, which include fruits (mangoes, pawpaw, oranges, tree tomato and passion fruit) and vegetables both exotic and local (onions, cabbages, kales, pumpkins, sucha, cowpeas, saga, peas and carrots). The fruits and vegetables contribute immensely to food security as farmers use it for food as well as generate income to the households. Cash crops grown in the county include coffee, pyrethrum, sunflower and tea, which still has small acreage. There is high potential to expand area under cash crops when market is streamlined. Maize is the staple food in the county and is mainly grown in the high rainfall areas of the county especially in West Pokot sub-county. Coffee is grown in West Pokot and Pokot South sub- counties while pyrethrum is grown in Pokot South sub-county. The food crops grown do not meet food requirements for the county. The farmers get low yields for food crops as they grow them on subsistence basis and some farmers do not use fertilizers and certified seeds. According to the CIDP 2018-2022 the total irrigation potential is estimated at 10,000 ha of which 1,800 ha is currently under irrigation. The importance of irrigation in the county cannot be over emphasized. The people living in the lowlands virtually survive on it. It is therefore a crucial activity. Irrigation is mainly carried out by groups of farmers using irrigation canals and furrows abstracting water from rivers and streams. There are a total of 120 canals/ furrows concentrated mainly in Pokot Central and the lower parts of Pokot South sub-counties. There are several irrigation schemes which are complete while others are still under construction. The completed irrigation schemes are Ngorkal in West Pokot sub-county (20 ha), Kariamangole (60 ha) and Mokuwo (90 ha) in Pokot South sub-county. The irrigation schemes under construction include the following Mrel (200 ha) and Orwa (150 ha) in Pokot central, Tamough (20 ha), Tombul (40 ha) and Kochar (30 ha) in West Pokot sub-county and Kolotubei (? ha) in Pokot South.

4.3.6 Food Consumption and Food Security

UBOS (2018) report observed that Uganda's mean Dietary Energy Consumption (DEC) stands at 2,226 kcal/person/day with female-headed households consuming slightly more calories than the male-headed households (2,241 and 2,220 kcal/person/day, respectively). Considering the source of food, overall, food purchases (57%) contribute the largest share to the DEC followed by own-produced food (37%) with food received in-kind and food consumed away-from-home constituting

the remaining 8 percent. The share of the DEC from food purchases was much higher in urban areas (77%) while rural areas had a larger share of the DEC from own-produced food (42%). Across sub-regions, households in Kampala (88%) had the highest share of their DEC from food purchases, those in Kigezi (53%) had the highest share of their DEC from own-produced food while those in Karamoja (11%) had a significant share of their DEC from food received in-kind. Overall, 37 percent of households in Ugandans were food poor with the highest cases recorded in Karamoja (70%) and Bukedi sub-regions (58%) while Ankole (14%) had the fewest. Rural households were nearly twice as likely to be food poor compared with their urban counterparts (40% and 26% respectively).

4.3.7 Water supply and access

There are four urban and six rural water supply schemes in Bungoma County. Urban schemes are mainly piped and are operated by Lake Victoria North Water Services Board through the water service provider - Nzoia Water and Sanitation Company. Rural water schemes are operated by the County Water Department through its field water officers. According to MIC, 2015, 87% of the population in the county uses an improved source of drinking water – 96 percent in urban areas and 79 percent in rural areas. The average distance to the nearest water source is 0.2km down from 1.5 km in the year 2013 in rural areas and 0.2km down from 0.5 km in 2013 in urban areas. Most households in rural areas depend on individual piped, roof catchment and communal water points such as boreholes, springs and wells.

In Busia County, there are two main existing water supply schemes in Busia County. The Sio River Water Supply that serves Busia Town and its environs and the Bunyala Supply Scheme that serves Port Victoria Town. The National Government has recently launched two more schemes in the county. Kocholia Irrigation Scheme on River Malakisi, which aims to supply water to 10,000 people and Ang'ololo Scheme on River Malaba that will serve residents of Kenya and part of Uganda. Accessibility of water by citizens in the county currently standards at 42% of which 81.6% is improved water sources. The main water sources in Busia are surface water, groundwater, and runoff water. There are three main rivers in the county namely; Malakisi, Nzoia and Sio. Other sources include protected springs, dug well or rural piped schemes. Lake Victoria is an important resource for the people of Busia. The main source of drinking water in Busia County is borehole (46%) while other sources include: rivers (19.1%), springs (22.3%) and piped water (12.5%). Most of the water is not clean, therefore most people treat their water with chlorination being the most preferred method. Other methods for treating water includes boiling and decanting.

Water sources in West Pokot County according to the CIDP include streams, wells, boreholes, dams, roof catchments and piped water. An estimated 59% of households in the county use rivers/streams as their source of water. The number of households with access to borehole/spring/well water stands at 26,259 representing 28 percent of the population. There are also 8,563 households with access to piped water, and 1,210 households have access to piped water into their dwellings. The average distance to the nearest water point is 5 km. The main water supplies in the county are Makutano-Kapenguria, Tartar–Keringet, Karas, Kabichbich- Chepareria Water supply systems and are largely gravity propelled. These schemes are inadequate to serve the general population of the county. It is worth noting that the county does not have a water treatment plant to ensure that the county's population access clean drinking water. The number of households with latrines stands at 30,449 representing 33 percent of the population. There are 156 households

connected with septic tanks, 1,922 households with VIP latrines, and 62,901 households (67%) of the population using bushes (open defecation) especially in the rural areas.

4.3.8 Industry and Trade

Bungoma County has 350 market centres of different sizes spread all over the county. The development of the market infrastructure in these centres will be given priority in the plan period. To this end, the County has more than 10,000 licenced businesses in operation and it is envisaged that the number will double by the end of the plan period. The main factories and industries in the County include; Nzoia Sugar Company, Rai paper, Malakisi Tobacco Leaf Centre, Webuye Heavy Chemicals Industry, Kitinda Dairy, Musese and Chesikaki coffee factories. They rely on raw materials produced locally. Efforts will be made to sustain production of raw materials to enable industries operate optimally. Malakisi ginnery will be revived to cater for the cotton farming communities to improve their livelihoods. Some of the resources which can support the industrial sector in the County include; human resource, fertile land, rivers, forests, sun light, wind, conducive weather, rainfall, biomass, sand, rocks, dams, fish ponds, livestock, mountains and hills, energy, fair road and communication network. The focus of the county will be to promote agri-business and value addition with emphasis on establishing the Chwele agribusiness zone. The Micro, Small and Medium Enterprises (MSMEs) are considered as sources of employment generation, economic growth, and social transformation. A significant proportion of the MSMEs are formal, while majority fall within the informal economy based on their size, location, ownership, status of formality and economic activity. The sub-sector produces a significant share of total value added, and provides a large segment of the poor and middle-income populations with affordable goods and services. The county will provide an improved business environment for the sector to thrive.

Markets play an important role in the development of Trans Nzoia County. Records from the department of Finance and weights and measures indicate that there are approximately one hundred and sixty-nine (169) markets within the County. Out of these there are only 23 with built market infrastructure, including six big markets at Endebess, Kwanza, Sibanga, Kachibora, Sikhendu, and Gitwamba; two medium markets at Mitume and Kapkoi; and fifteen small markets at Tuigoin, Makutano, Kesogon, Chepchoina, Lukhome, Big Tree, Toll Station, Zea, Kologei, Motosiet, Bikeke, Wamuini, Sitatunga, Kinyoro, and Kimila. There is one wholesale market with inadequate capacity in the entire County and there is no wholesale hub. Trans Nzoia County has small and medium size mostly Agro-Based industries and the commonly referred to "*Jua Kali*" cottage industries. However, there exists great potential for large scale industrialization. The *Jua Kali* activities dominate small scale and informal industrial sector and their activities include metal fabrication, welding, bicycle repairs, motor cycle repairs, furniture making, tailoring and cloth making. It is estimated that the informal industries in the County has created employment to over 30,000 persons. According to the Micro, Small and Medium Enterprise (MSME) survey basic report of 2016, there are 16,300 MSMEs in the County employing 168,000 persons. Out of these enterprises only 30.9% are licensed while 69.1% are not licensed.

There are several markets in West Pokot County. The main ones are Kapenguria in West Pokot sub-county and Chepareria in Pokot South sub-county. Other Market Centres include: Ortum, Kabichbich, Sigor, Lomut, Chesegon, Kacheliba, Orolwo, Sarmach, Cheptuya, Kanyarkwat, Serewo, Kiwawa, Kamelei, Kasei, Tamkal, Nyangaita, Orwa, Sina, Tapach, Kamketo,

Kachemogen, Kapsangar, Chepkono, Kaptabuk, kapsait, Chepkondol, Sebit, Kodich, Konyao, and Alale. There are no industrial parks in the county. There are also no major industries processing finished products. The main economic activities in the county urban areas include: retail and wholesale trading, fresh produce and cereals businesses, entertainment and hospitality businesses, service industries including motor garages, cyber cafes, law firms, livestock auctions, private education businesses, honey processing, banking and financial services, real estate enterprises and road transport services. Most of these investments fall under the micro, small and medium scale enterprises category.

4.3.9 Household Expenditure and Welfare

UBOS (2018) report stressed that Uganda's average household monthly expenditure slightly dropped from UGX 328,200 in 2012/13 to UGX 325,800 in 2016/17, representing a marginal decline in monthly consumption expenditure between the two periods. The proportion of the population living in poverty increased from 19.7 percent in 2012/13 to 21.4 percent in 2016/17 an equivalent of about 10 million people living below the poverty line. The increase in poverty was most prominent in the Eastern region than in Northern region which had consistently been the poorest region in the country. Specifically, poverty was highest in the sub-regions of Karamoja (60.2%), Busoga (37.5%) and Bukedi (43.7%) and lowest in Kampala (2.6%), Wakiso district (2.7%) and Ankole (6.8%). The proportion of people living in poverty significantly increased in absolute terms. The Northern region registered the most significant decline in poverty from about 44 percent in 2012/13 to 33 percent in 2016/17. The income inequality increased in all regions between 2012/13 and 2016/17.

4.3.10 Household Assets, Income Sources and Financial Services

The UBOS (2018) report found out that the majority of owner occupied houses (41%) were jointly owned by male and female household members. Ownership of bicycles, radios, motorcycles and cars was mostly dominated by males. Overall, 43 percent of households reported subsistence farming as their major source of income while one in every four households (25%) reported wage employment as the main source of income. Forty-one percent of respondents perceived savings as "putting money in a special place or account for the money to be safe" while about a third (30%) perceived savings as "putting money in an activity or somewhere so that it can yield returns". Keeping money at home/secret place (33%) was the most commonly used mechanism for saving followed by saving with VSLAs (16%). Overall, nearly one in every four persons aged 18 years and above (23%) had ever borrowed/got money to be paid back later in the 12 months preceding the survey. The common types of loans/credit obtained were personal loans (33%), goods obtained on credit (25%) and credit from friends (22%). One in every four persons aged 18 years and above (25%) who sought a loan/credit did so to buy consumption goods and services while 23 percent borrowed to pay education expenses. Seventy-five percent of the household population aged 16 years and above are knowledgeable about mobile money although only 59 percent of them are registered mobile money users. MTN money (75%) followed by Airtel (42%) was the most commonly used mobile money service by persons aged 16 years and above.

4.3.11 Financial services

Bungoma County has an increasing number of financial institutions, namely, Kenya Commercial Bank (KCB), Equity, Family, Cooperative, National, Diamond, Bank of Africa and Barclays bank. It is also served by various micro-finance institutions such as Sidian bank, Kenya Women Finance

Trust (KWFT), and Faulu. Insurance services in the county include Geminia, NHIF, British American Insurance, Pan African Insurance, Blue Shield, African Merchants Assurance Company (AMACO) and Cooperative Insurance Company of Kenya.

Trans Nzoia County enjoys significant access to financial services. There are twenty-six (26) SACCOs in the County out of which twenty-two (22) are active while four (4) are inactive. Besides there are two SACCOs with Front Office Services Activities (FOSA). The SACCOS with FOSAS in the County are Trans County SACCO which has two (2) branches and the Trans National Times SACCO which has four (4) branches at Endebess, Sibanga, Kiminini and Kitale. The FOSA operations have assisted in mobilizing savings for small traders in the rural areas. This has enhanced uptake of short term and long term loans for social and economic development. The two SACCO societies with FOSA operations are licensed by Sacco Society Regulatory Authority (SASRA). There are also an estimated one hundred and eighty-three (183) M-Pesa agents in the County spread across the entire County. Trans Nzoia County is home to the major commercial banks out of the 44 commercial banks in Kenya. The main commercial banks have opened branches in the county. These are namely: Kenya Commercial Bank, Equity Bank, Cooperative Bank, Post Bank, Family Bank, Sidian Bank, Standard Chartered Bank, Diamond Trust Bank, M-Oriental Bank, Trans National Bank, National Bank, I&M Bank, NIC Bank and Barclays Bank. There are also 4 micro-finance institutions namely; Rafiki Bank, Kenya Women Finance Trust, Faulu Bank and 6 registered bank agents of commercial banks in the County spread across the 5 sub-counties in the County.

In Busia County, there are ten major commercial banks in the county and several microfinance institutions. These are Cooperative Bank of Kenya, Kenya Commercial Bank, Equity Bank, Barclays Bank of Kenya, National Bank of Kenya, Diamond Bank, Sidian Bank and Family Bank. Microfinance institutions operating in the county include Kenya Women Finance Trust and Faulu Kenya. There are also a few informal microfinance lenders complementing formal financial institutions. Insurance companies in the county include British American Insurance, African Merchants Assurance Company (AMACO) and Cooperative Insurance Company of Kenya and Madison Insurance Company. Mobile money services are currently offered by Safaricom (MPESA) and Airtel (Airtel Money).

West Pokot County has 3 commercial banks (KCB, Equity and Barclays), 4 Micro Finance Institutions and 6 SACCOs. Most of these financial institutions have their services concentrated in Makutano Town. Pokot Central and Pokot North sub-counties do not have banks or micro finance institutions thus limiting access to financial services. According to the West Poko CIDP 2018-2022, the percentage of citizens owning bank accounts remains low in the county. Loan uptake and repayment is also low and more effort is needed to reverse this trend. Agency banking is expected to play a key role in enhancing financial services penetration into rural areas and in mobilising savings for investment.

4.3.12 Health

Ugandan region health

According to UBOS (2018), overall, there was a reduction in the proportion of the population who were ill or injured by 12 percentage points; from 40 percent in 2012/13 (40%) to 28 percent in

2016/17. The female population (30%) was more likely have suffered from illness or injury compared with their male counterparts (26%). Malaria/fever (26%), and respiratory infections (18%), followed by severe headache (7%) were the most prevalent symptoms suffered. The prevalence of malaria was highest in the Teso sub-region (49%) and Kigezi (38%) while in Bukedi sub-region (5%) registered the lowest. Overall, about four percent of persons aged 10 years and above reported that they suffer from high blood pressure, two percent from heart disease while about one percent indicated that they suffer from diabetes. The prevalence of NCDs increases with age – for instance 26 percent of the elderly suffered from any one of the NCDs compared to those in the youthful ages i.e. one percent for those age 10 – 24 years and 5 percent for those 25 – 39 years.

Regarding substance abuse, UBOS (2018) report noted that overall, about five percent of persons aged 10 years and above were using or had used tobacco in the past; 17 percent of Ugandans consume(d) alcohol; while one percent of Ugandans currently use or used other drugs and narcotics. Health care seeking behavior was highest in sub-regions of Central (90%), Busoga (93%), Kigezi (88%) and lowest in Karamoja (74%), Elgon (65%) and Bukedi (60%). In addition, close to a half (48%) of the persons that had suffered illness/injury and had sought healthcare went to private hospitals/clinics followed by Government health facilities – hospital and health centres (34%). Furthermore, access to healthcare varied across sub-regions with over 34 percent of the persons in Acholi travelling a distance of at least 5 kilometers to access health care when they fell sick. In Uganda, only 11 percent of the population age 15 years and above are aware of health insurance service while only five percent were covered under health insurance. As regards households' expenditure on health, in real terms, there was a reduction in the average monthly household expenditure on health care services from UGX 27,600 in 2012/13 to UGX 22,800 in 2016/17.

Kenyan region health

According to the Bungoma CIDP 2018-2022, the County has a total of 184 health facilities. These include 17 hospitals, 14 Health Centres, 102 dispensaries, 20 FBO facilities and 52 private clinics. The most common diseases in the County are malaria, anaemia, pneumonia, diarrhoea and pepetic ulcers. The Trans Nzoia CIDP 2018-2022 indicates that the County has eight functional tier-3 public hospitals. The number of tier-2 and tier-1 public health facilities are 73 and 87, respectively. The average distance to the nearest health facility within urban centres is 1 km; while for rural areas it is 5 km. There is a general need for additional wards, beds and hospital equipment across all the County facilities. The Trans Nzoia County has a total of 43 registered private facilities distributed across the sub counties as follows: Kiminini (20), Cherang'any (6), Endebess (1), Kwanza (4) and Saboti (12). Based on tiers, there are 38 and 5 tier-2 and tier-3 private facilities, respectively. The health referral system in the County is supported by 15 ambulances, 9 of which are owned by the County government.

Busia County has a total of 81 health facilities according to the Busia CIDP 2018-2022. Malaria and road, traffic and accidents (RTAs) are among the top causes of morbidity and mortality in Busia County. Other common diseases include respiratory infections and skin diseases. Most of the diseases are caused by poor hygiene. 31% of the children below five years are malnourished while 26.5% are stunted. There has been concerted efforts to improve the situation by both the government and NGOs including provision of food supplements and promoting income-generating

activities to vulnerable groups. National Government policy objective is to achieve good nutrition for optimal health of all Kenyans. Enhancing food access, provision of special nutrition interventions for specific vulnerable groups and creating awareness to provision of nutritious food to all family members and especially children are among other major County government objectives.

The West Pokot County, according to the CIDP 2018-2022 has numerous gaps in most of the health system notably in Human Resources for Health. In terms of levels of care under community health services there have 60 community units spread across the sub-counties. Under dispensaries and health centres there are 105 health facilities, 10 being health centres. There are also five County hospitals. In addition, the County has 6 private clinics and one mobile clinic under the Beyond Zero initiative. The health worker (doctor, nurses and midwives) population ratio to patients stands at 1:1563 as compared to the 1:400 ratio recommended by the World Health Organization. This coupled with the average distance of 25 km to the nearest health facility makes access to quality health services a challenge in the County.

4.3.13 Labour force characteristics

According to UBOS (2018), the working age population increased to 19.1 million in 2016/17 from 16.5 million in 2012/13. The size of the working population was 15.1 million persons, an increase from 14.0 million in 2012/13. Overall, the working population constituted 79 percent of the working age population. The total population in employment was estimated at 9.1 million people of whom 46 percent were females. Overall, the employed population constituted 48 percent of the working age population. Overall, both LFPR and EPR declined from 62 percent to 52 percent and from 53 percent to 48 percent in 2012/13 to 2016/17, respectively. In regard to sub-regions, LFPR and EPR were highest in Kampala at 78 percent and 62 percent, but lowest in Bukedi at 25 percent and 24 percent, respectively. Overall unemployment rate was estimated at 9 percent. Kampala had the highest unemployment rates (21%) while West Nile sub-region had the least (3%). Unemployment was highest amongst persons aged 15 – 24 years (17%) while the age group 31 – 64 years had the lowest (5%). Overall, close to four in every ten persons (38%) was in employment (working for pay or profit), considered as paid employment – i.e. 30 percent were paid employees (not casual labourers in agriculture) and another 8 percent were paid employees (casual labourers in agriculture).

UBOS (2018) concluded that overall, elementary occupation workers (34%) had the highest proportion of employed population followed by skilled service and sales workers (24%) while agricultural, forestry and fishery workers (18%). The agriculture sector accounted for the largest share of employment (36%) while other services other than trade sector ranked second with 29 percent of people reportedly employed in the sector. Overall, the median wage of an employee was UGX 168,000 per month. The median wages of the working population in urban areas (UGX 220,000) was almost double that of their rural counterparts (UGX 120,000). Persons in paid employment in the Western region received the lowest median monthly earnings (UGX 110,000) while those in Kampala earned the highest (UGX 300,000).

4.3.14 Housing and Household Conditions

Overall, according to the UBOS (2018) report, 72 percent of households in Uganda live in owner occupied dwellings. The majority of households in rural areas were living in owner occupied

dwellings (83%) while in urban areas it was 44 percent. Dwellings with iron sheet roofs accounted for 75 percent while those with thatched roofs were 24 percent. Two thirds of the households (67%) lived in dwellings with brick walls while 59 percent lived in structures with floors made of earth. The use of 'tadooba' (canister wick lamp) for lighting declined from 66 percent in 2012/13 to 28 percent in 2016/17 while the use of grid electricity, solar and dry cells/batteries increased. Firewood and charcoal combined constituted the main source of fuel for cooking for 94 percent of the households. In addition, 83 percent of households used pit latrines, only three percent used flush toilets while about seven percent still use the bush (open defacation) because they do not have toilets. Also, 80 percent of households had access to improved sources of drinking water with 97 percent of the main drinking water sources within 3 km. The burden of fetching water mostly rests on female adults and the girl child.

4.3.15 Vulnerable Groups and Social Protection

UBOS (2018) report reveals that one in every ten (11%) children aged less than 18 years were orphaned, i.e. they have lost either one or both parents which translates to approximately 2.4 million orphaned children in Uganda. Orphanhood increases with the increase in age of the child i.e. it ranges from four percent for those 0 - 4 years to 23 percent for 15 - 17 years. Karamoja (17%), Acholi (19%) and Lango (16%) sub-regions had the highest incidence of orphanhood. Out of 8.5 million households in Uganda, 1.3 million had an orphan, constituting about 15 percent of all households. Overall, about 14 percent of the children aged 5 - 17 years were in child labour. The number of older persons increased from about 1.6 million in 2012/13 to 1.7 million in 2016/17. Older persons constitute about five percent of the population of Uganda. Close to half of the older persons (42%) had never been to school and these were predominantly females (57%) compared to their male counterparts (23%). Overall, two in every ten persons (19%) aged 60 years and above was living below the poverty line with the majority in the Eastern region (29%). Overall, there were about 1.09 million widows in Uganda constituting 12 percent of the total population of women aged 15 years and above. The Northern region has consistently had the highest percentage of widows since 2009/10 – i.e. it increased from 13 percent in 2009/10 to 15 percent in 2016/17. On the other hand, the proportion of widows in Kampala dropped from seven percent in 2009/10 to six percent in 2016/17 which could imply that widows in Kampala were more likely to remarry.

4.3.16 Information and Communication Technology

Overall, 73 percent of the households owned a mobile phone with 68 percent of the households reporting that the phones were owned individually while five percent indicated that the mobile phones were jointly owned. Ten percent of households reported that the television was owned individually while seven percent stated that it was owned jointly. Three percent of households reported that the computer/laptop was individually owned. Overall, four percent of the population had used a computer in the last 3 months - 56 percent of whom had used desktops, 36 percent had used laptop (portable) computers and eight percent had used tablets or any similar hand held devices. Forty percent of communities indicated that internet access points was available in their area. Forty-four percent of communities reported that the internet access point was less than 3 km from the village center. In addition, 52 percent of the communities rated that the service as average, 45 percent as good while 4 percent were of the view that the services were poor. Overall, only six percent of household members utilized the internet for any purpose. Of the persons that used the internet, 52 percent used it for social networking while 16 percent used it for academic work. Overall, four in every ten persons (43%) cited the lack of confidence, knowledge or skills as the

major reason for not using internet, followed by those that stated that they did not need the internet (18%). Close to six in every ten communities (56%) reported the availability of post offices. Less than one percent of households had used postal services (0.3%) in the last 30 days. Of the households that used postal services in the 30 days preceding the survey, 32 percent indicated that the postal office/outlet was non–existent and was the big challenge faced.

4.3.17 Community Characteristics

UBOS (2018) report stated that overall, only 18 percent of the communities reported having access to markets that sell agricultural produce and markets that sell non-agricultural produce within the Local Council (LC) I, respectively. The availability of a police station/post within the LC I, increased from 12 percent of communities that reported existence of the facility in 2012/13 to 17 percent in 2016/17. There was an increase in the proportion of communities that indicated the availability of paved national roads, from 52 percent in 2012/13 to 73 percent in 2016/17. Availability of unpaved national roads increased from 60 percent to 67 percent while that of feeder/district roads increased from 81 percent to 89 percent, respectively. Only five percent of communities indicated that they had access to agricultural extension workers within their LC I, dropped from 21 percent in 2012/13.

4.3.18 Household Enterprises

In terms of absolute numbers, there were about 3.1 million households that operated household enterprises in 2016/17 (UBOS, 2018). Close to four in every ten households (37%) operated household enterprises; with more male-headed households (38%) compared to the female-headed households (35%). There were more female proprietors in activities in trade (57%); manufacturing (51%) and hotels; restaurants and eating places (78%); while males dominated in agriculture, forestry and fishing (88%); transport and storage (98%); mining and quarrying (65%); and other service activities (61%). Nine in every ten (92%) of the household enterprises were started by a sole proprietor.

The majority (31%) of the household enterprises are located at home either inside or outside the premises of the proprietor. Fifty-five percent of the workers in household enterprises were working proprietor followed by hired labour (32%) and contributing family members (13%). In addition, 78 percent of the enterprises were started using their own savings, 13 percent of the enterprise owners revealed that they did not need any funds to start up while only five percent had taken a loan from financial credit facilities such as SACCOs, MDI, commercial banks and local groups. Over half of the enterprises (54%) relied on own savings to expand their household enterprises, followed by borrowing from local groups (16%) while 11 percent took loans from micro deposit taking institutions (MDIs) and formal banks altogether. Overall, lack of finances (26%), lack of demand for their goods and services (22%) and lack of inputs (12%) are the leading constraints of household enterprises accounting for 60 percent of all possible constraints faced (UBOS, 2018).

4.4 Key threats to sustainability of shared groundwater aquifers

Among the key threats to sustainability of the regional aquifer include:

- Over abstraction due to increasing demand as a result of the rapidly increasing population in the area of study;

- Decreased recharge of groundwater due to land degradation as a result of search for more farmland;
- Climate change leading to erratic rainfall which is the main source of recharge in the area;
- Increasing levels of pollution due to anthropogenic activities and increase in rural industry.
- Poor land use practices and land use/cover change:
    - Soil erosion and degradation due to poor farming practices, and sand harvesting;
    - Deforestation for fuel (charcoal burning), timber for construction, and land clearance for settlement;
    - Widespread planting of eucalyptus trees which are believed to be water intensive hence consuming large volumes of water;
    - Open hand-dug wells fatal to kids;
    - Pollution negatively impacting water quality, e.g. discharge of wastes into rivers, polythene materials clogging water sources, factories discharging effluents into water bodies, car washing in or next to water sources, open defecation into or next to water resources and wetlands, and some boreholes have high salt content;
    - Encroachment/construction on river banks/ riparian zones and drainage of wetlands;
    - Land fragmentation due to sub-division;
    - Poor sanitation, e.g. no latrines in some homesteads, no public toilets in some markets;
    - Diversion of water for horticulture reduces water flows in rivers;
  - Rapid population growth:
    - Improper catchment use has led to drying up of some springs;
    - Increasing demand for trees to provide energy, e.g. women cut down indigenous trees, and men/youth use trees for charcoal;
- Inadequate management capacity:
    - Limited funding to support conservation and management activities;
    - Political interference including diversion of funding at the county levels;
    - Inadequate involvement of local institutions particularly WRUAs in county government programmes on water resources in some counties;
    - Lack of cooperation from community members, e.g. resistance from riparian farmers encroaching on river banks;
    - Shallow wells go dry during dry seasons putting pressure on deep boreholes;
    - Illegal water abstraction;
- Inadequate financial support to manage proposed water use committe (e.g. WRUA) activities e.g. some SCMPs have not been funded for implementation while others have not been updated/reviewed due to lack of funds.

4.4.1 Land Use

Land use on the lower slopes of Mt. Elgon is intensive with cultivation of maize as the dominant crop. Adjacent to the Mt Elgon forest are smallholder farmers who largely practice mixed farming but also depend on the forest for their livelihood. In Kenya, some large-scale farms are owned and cultivated by Agricultural Development Corporation (ADC), Kenya Seed Company, East African Seed Company and several large-scale farmers. Common crops grown are maize (*Zea mays*), beans (*Phaseolus vulgaris*), potatoes (*Solanum tuberosum*), sweet potatoes (*Ipomoea batatas*), sorghum (*Sorghum bicolor*), cassava (*Manihot esculenta*) and finger millet (*Eleusine coracana*). Trans

Nzoia County is one of the most important maize production areas in Kenya. The practice of agro-forestry is common with trees like Sesbania (*Sesbania grandiflora*), Calliandra (*Calliandra calothyrsus*) and certain timber and fruit trees are planted together with crops or along the farm borders.

Groundwater-fed agricultural land

There is limited evidence on the existence of groundwater-fed agricultural land. Although wetland encroachment is rampant in the region with the main crops being vegetables. Wetlands are usually groundwater discharge areas and thus if farmed becomes a groundwater-fed agricultural land.

Groundwater-irrigated land

Mt. Elgon region is endowed with numerous natural perennial water courses whose sources can be traced back to the springs on the slopes of Mt. Elgon. Although not explicit for groundwater, there some large-scale irrigated flower farms and greenhouses. Horticultural products like vegetables, fruits, nuts, and flowers produced for both local market and for export are also cultivated along the river banks throughout the year. Cultivation in the dry seasons is based on baseflow which provide water for perennial rivers.

Groundwater supported wetlands and ecosystems

Groundwater Dependent Ecosystems (GDEs) are ecosystems that are partially or completely dependent on groundwater for their existence or health. When groundwater is close to the surface, plant roots can access it as a steady water supply so they can thrive in times of low rainfall. The plants then support the animal communities. When groundwater discharges to the surface it supports wetland and stream ecosystems. Underwater springs at the coast and in estuaries can provide nutrients for sea grasses and aquatic species. There are even some animal species that only live underground in the groundwater system aquifers. In addition to the intrinsic importance of maintaining the biodiversity of GDEs, they provide important resources for rural lifestyle. GDEs support fishing, bird watching, and other recreation. The locations of GDEs provide valuable insight to the hydrologic system within catchments and understanding GDEs is important to water resource, environmental, and agricultural management. One way of classifying groundwater-related ecosystems in the Mt. Elgon Aquifer is by their geomorphological setting (e.g. aquatic, terrestrial, coastal) and associated groundwater flow mechanism (deep or shallow). On this basis a number of different classes are recognized specific for the Mt. Elgon region and identified:

- Natural discharge from relatively deep groundwater flow systems rising to form distinctive springs (Fig. 4.2) with associated (often unique) aquatic ecosystems;
- Wetland ecosystems related to the discharge of shallow (and sometimes perched) groundwater flow systems as seepages in land surface depressions;
- Groundwater discharge from extensive aquifers providing (in part perennial and elsewhere ephemeral) dry-weather flow in the upper reaches of river systems which represent aquatic ecosystems;
- Discharge of groundwater flow systems to coastal lagoons, which is critical in diluting salinity from marine influences and providing unique habitats;
- Some extensive semi-arid and humid terrestrial ecosystems without standing water, but with very deep-rooted phreatophyte vegetation extracting moisture directly from the water-table.

Figure 4.2**:** *A typical example of groundwater dependent ecosystem, springs which is the main source of water for both domestic and livestock.*

Field observations indicate that Mount Elgon ecosystem support critical terrestrial and wetland habitats in addition the much-needed ecosystem functions, e.g., Nzoia River drains to Lake Victoria through a system of swampy valleys in Bungoma, Uasin Gishu and Trans- Nzoia. The different habitats support important biodiversity ranging from birds, mammals, reptiles and amphibians, plants among other biodiversity. The wetlands in the area are mainly characterized by rivers, springs, swamps and dams. The wetlands range from various sizes and are also under different management systems. The management ranged from communal, private and government to open access wetlands consequently exhibiting varying levels of threats and biodiversity importance.

4.4.2 Increased/unsustainable withdrawals

One of the main challenges that are faced by the shared aquifer is unsustainable withdrawals. As a result of climate change, over population, and increased needs of water for both household and commercial purposes, surface water has proven to not be enough within the aquifer areas. Groundwater is used as the main water source in many parts of the three counties studied. Most of the community and institutional boreholes have been developed by the county government, but there have not been any measures put in place by the environment and water offices of the county towards recharging of the aquifer. The level of abstraction of water through the County Government, individually developed groundwater resources, and institutions and commercial businesses is significantly higher than the level of efforts that are being put towards conservation and recharge. According to the National Environment Management Authority Offices in both Bungoma and Trans-Nzoia counties, there is a big gap with regard to conservation measures. This is one of the major threats to the sustainability of the aquifer. Other threats include deforestation

and land use pressure resulting from increased demand for resources to support livelihoods due to the increasing human population in the region.

4.4.3 Climate change scenarios

Projected climate change scenarios for the region is likely to increase the number of high intensity storms. This is expected to impact on rainfall patterns and modify the resulting recharge and storage capacity of soils and aquifers. Prolonged periods of intensive drought would put more pressure on existing surface water sources, and shallow groundwater wells and boreholes could dry up.

4.5 Current and projected groundwater abstraction

Annexes 10.11 and 10.12 show the list of groundwater abstractors on the Kenyan side based on the permitting records. The daily groundwater abstraction based on the provided records is 4,884 Mm^3/day which translate to approximately 1.8 Mm^3/year. There many other undocumented groundwater abstractors which implies the actual volume of groundwater abstracted is higher. The average yield in the area is approximately 2.74 m^3/hr. which translates to approximately 20 m^3/day. Much of the groundwater abstraction is mainly for domestic and institutional use. There is limited dependency of industry and agriculture on groundwater. Surface water is abundant in the aquifer region as most of the rivers and streams are perennial. Based on the available permits, surface water abstraction is estimated at 11,500 m^3/day which translates to approximately 4 Mm^3. The volume of water abstracted from surface water might be higher given the many illegal abstractions that are often not documented.

The Mt. Elgon aquifer system is an important catchment area providing water for both domestic and industrial use, as well as feeding into Lake Kyoga in Uganda via River Mpologoma and Lake Turkana in Kenya via Rivers Suam and Bukwa while River Nzoia flows southwards to Lake Victoria (GOK and UNESCO, 2012). The uses of groundwater in the Mt. Elgon region includes agriculture, clean water for domestic use and health purposes, rural water supply, different commercial industry uses, and ecosystem support. The continued depletion of surface water, coupled with the increased demand needs shows the dire need for groundwater in the region. Many people who are served by the Mt. Elgon aquifer in Kenya rely on groundwater directly from communal or privately owned boreholes, while some areas also use the groundwater through piped supply from wellfields. The rural population is mostly served through hand-dug wells or communal boreholes. The exploitation of groundwater is limited by poor water quality, poor groundwater management structures, and inadequate resourced to exploit the resource, especially in the rural areas. Local communities are usually under high water stress because of their needs for cultivation, livestock, domestic use, and social events such as cultural events and funerals. The routine sharing of surface water points in the region has put significant strain on surface waters, thereby increasing the exploitation of groundwater to fill the demand and supply gap. Community water supply is affected by long periods of drought, when shallow wells dry up. Shallow wells are usually dug for domestic water use, as opposed to commercial use. There are tensions between financial sustainability and universal access to rural water supply services. In rural areas, the use of pit latrines and waste dumps increases the risk of contaminating the groundwater resources that are being used to supply water. Due to this high risk of contamination, most of the people using shallow wells, do not use the water for drinking, but rather, for domestic chores, and personal hygiene. There are many people in the Mt. Elgon region who are affected by water scarcity, and

who could benefit greatly from the groundwater resources. Resource user groups like small holder farmers, livestock keepers, bee keepers, and traders are among the vulnerable groups in the region. Women are more at risk of water scarcity because of gender roles and gender task allocations. Affordability of the equipment and labour for exploiting groundwater resources is a critical factor to consider in the use of groundwater resources in the Mt. Elgon region. The economic and cost factor in exploitation of the groundwater resources has limited usage in poor and underserved communities, and also provided access to communities and people who have been able to afford it. This includes government, private sector, and donor supported initiative towards exploitation and use of groundwater resources. Groundwater offers a number of socio-economic advantages in the Mt. Elgon aquifer region of Kenya. These benefits include;

a) Increased food production and income
b) Reduced water shortage
c) Reduced risk of crop failure because of improved access to water resources
d) Increasing the area of land that is used productively
e) Increased water supply for domestic use
f) Increased employment activities directly in the water supply business for communally shared groundwater resources; and indirectly through increased productivity and water use for commercial activities
g) Increased resilience against drought.

Exploitation of groundwater resources for obtaining these benefits also comes at a cost in both economic and social aspects. For instance, increased exploitation of the resources continually depletes groundwater storage in the aquifer, especially if it is coupled with poor management and sustainable use practices. There is also the potential of abstraction costs increasing salinization of groundwater and increased pollution. Increase in area of lands that is used for production, can mean encroachment and destruction of groundwater dependent ecosystems. There are also issues of land subsidence, and water use conflicts which can arise through increased exploitation and use of groundwater resources especially with a poor management and governance structure, from the local to the national, and regional levels.

The Government of Uganda when carrying out rural water supply engages technical support units which assist the local governments to carry out governance and supply of water and these include experts such as water and sanitation specialist, community develop specialist, and public health specialists. At district level, district water officers, physical planners, environment officers, chief administrative officers, politicians and community development officers are responsible to ensure proper management and access to water. Communities as well have their own ways of managing water resources. Management committees of water users exist however, these are not given the platform to grow and perform their intended role, as a result they remain inactive (Twinomujuni et. al., 2020).

Some of the governance challenges raised from previous works for example the joint management projects include;

a) In spite of the existing institutional and legal framework governance challenges still exist where human activities around the mountain such as agriculture, pastoralism and others continue to affect the water quality and quantity.

b) Lack of political support leading to inadequate financing of activities and programs that may greatly enhance the quality of groundwater and also keep the management committees active.
c) Inadequate skilling of the community members in terms of maintain groundwater sources.
d) Lack of involvement in governance processes of all stakeholders especially community users that may fall in the vulnerable category (females, children, old people and indigenous groups).
e) Lack of interest by local communities to get involved in community monitoring.

Water resource management is a central issue for communities and countries with shared resources. In Uganda, communities are routinely under high water stress due to social pressures (e.g. funerals, cultural events) and environmental pressures (e.g. dry periods). These pressures cascade with routine sharing of water points. Women are more at risk of water scarcity due to gender roles and gender task allocation. New methods for defining and measuring water point functionality are required to adequately monitor progress towards SDG6 for safely managed water services. Affordable maintenance and repair are one of the main predictors of borehole functionality. This highlights the need for effective management models to address poor functionality.

Prolonged drought has been experienced in Trans Nzoia County over the past few years affecting agricultural activities, livestock and water sources. Some of the contributing factors include deforestation and changing weather patterns. This has necessitated the use of groundwater by the people living in the Mt. Elgon region.

A summary of water demand and usage on the Ugandan side of the Mt. Elgon aquifer region is presented. Table 4.3 presents water demand by sub-catchments of Awoja covered by the Mt. Elgon aquifer estimated for 2013, and this water demand is projected to 2040 (Table 4.4). Groundwater consumed and/or discharged per year in the Mpologoma catchment part is summarised in Table 4.5. Potential areas for irrigation in the region by 2010 (Table 4.6) and livestock production (Table 4.7) are also presented.

***Table 4.4**: Water demand by sub-catchments of Awoja covered by the Mt. Elgon aquifer in Uganda estimated for 2013.*

	Sub-catchment	Total Area (Km^2	EWR at 15% of Runoff MCM/yr	Domestic Demand MCM/yr	Livestock Demand MCM/yr	Rain-fed Agric Demand MCM/yr	Total Demand MCM/yr	Demand per Km2 MCM/yr/km^2
1	Muchilmakat	1497	21.45	0.4	2.3	1.0	25.2	0.02
2	Kelim	1277	26.55	0.7	1.6	2.8	31.7	0.02
3	Taboki	587	18.00	0.8	0.8	3.9	23.4	0.04
4	Chebonet-Atari	617	18.00	1.1	0.9	3.1	23.0	0.04
5	Sipi	89	6.00	0.1	0.1	0.3	6.5	0.07
6	Muyembe	137	9.45	0.2	0.1	0.5	10.3	0.07
7	Simu-Sisi	178	11.70	0.3	0.2	0.7	13.0	0.07
8	Sironko	276	18.15	0.9	0.5	3.1	22.6	0.08
9	Lake Okolitorom	1035	23.55	1.9	1.6	3.8	30.8	0.03

***Table 4.5**: Water demand by sub-catchments of Awoja covered by the Mt. Aquifer in Uganda projected for 2040.*

	Sub-catchment	Total Area (km^2)	EWR at 15% of Runoff MCM/yr	Domestic Demand MCM/yr	Livestock Demand MCM/yr	Rainfed Agric Demand MCM/yr	Total Demand MCM/yr	Demand per km^2 MCM/yr/km^2
1	Muchilmakat	1497	21.45	3.1	2.3	4.6	31.4	0.02
2	Kelim	1277	26.55	4.2	1.6	6.8	39.2	0.03
3	Taboki	587	18.00	3.8	0.8	5.7	28.2	0.05
4	Chebonet-Atari	617	18.00	4.2	0.9	2.8	25.9	0.04
5	Sipi	89	6.00	0.5	0.1	0.5	7.0	0.08
6	Muyembe	137	9.45	0.8	0.1	0.4	10.8	0.08
7	Simu-Sisi	178	11.70	1.0	0.2	0.5	13.4	0.08
8	Sironko	276	18.15	2.8	0.5	1.8	23.2	0.08
9	Lake Okolitorom	1035	23.55	8.7	1.6	3.6	37.5	0.04

***Table 4.6**: Groundwater consumed and/or discharged per year in the Mpologoma catchment part of Mt. Elgon aquifer area in Uganda.*

	Rural groundwater abstraction								Urban groundwater abstraction	Total groundwater abstraction
Sub-catchments	No. of deep boreholes	Total abstraction / day (1)	No. of protected springs)	Total abstraction / day (2)	No. of shallow wells	Total abstraction / day (3)	m^3 consumed and/or discharged		Total abstraction / year from production wells (m^3)	Total groundwater abstraction / year - Rural and urban combined (m^3)
							Per day	Per Year		
Namatala	469	2,345	537	12,888	52	130	15,363	5,607,495	-	5,552,380
Upper Manafwa	109	545	967	23,208	15	38	23,791	8,683,533	-	8,683,533
Middle Manafwa	475	2,375	201	4,824	16	40	7,239	2,642,235	-	2,604,640
Lwakhahka	97	485	172	4,128	12	30	4,643	1,694,695	-	1,684,110

Assumptions: 1 hand-pump equipped borehole abstracts $5m^3$/day; 1 Shallow well abstracts $2.5m^3$/day; 1 Protected spring discharges $24m^3$/day

***Table 4.7**: Potential areas for irrigation in the Mt. Elgon aquifer area in Uganda (as of 2010).*

Sub-basin	Area A (ha)	Area B (ha)	Total (ha)
Awoja	26,192	139,847	166,039
Mpologoma	59,091	309,774	368,865
Total	85,283	449,621	534,904

***Table 4.8**: Livestock production in and around Mt. Elgon aquifer area in Uganda.*

District	Exotic Crossbreed Cattle (no.)	Indigenous Cattle (no.)	Goats (no.)	Sheep (no.)	Pigs (no.)	Poultry (no.)
Bududa	3,304	23,731	21,391	1,548	4,973	142,943
Bukwo	2,035	12,439	9,737	991	638	36,920
Kapchorwa	4,747	29,023	22,721	2,313	1,488	86,148
Manafwa	3,304	23,731	21,391	1,548	4,973	142,943
Nakapiripirit	2,817	326,468	178,473	108,421	978	56,289

Sironko	8,154	42,295	30,625	3,932	6,381	205,561

4.6 Groundwater monitoring and trends in water level and quality

4.6.1 Water level monitoring

Figure 4.3 displays the locations of groundwater level with rainfall monitoring stations beyond the Mt. Elgon aquifer region. On the Ugandan side, the following water level monitoring stations are functional or have historical/archived datasets, including Pallisa, Soroti, Serere, Kangole, and Moroto Prisons.

At Serere daily groundwater level variations is monitored from 24 September 2009 to 30 January 2018; groundwater levels fluctuate from 0.7 to 9.9 mbgl with mean and median values of 6.5 and 6.7 mbgl, respectively (Fig. 4.4). At Soroti, daily monitoring is from 24 October 1998 to 27 January 2018; groundwater levels fluctuate between 4.8 and 8.6 mbgl, with mean and median of 6.9 and 7.0 mbgl, respectively. At Moroto Prisons groundwater level variations is monitored from 16 November 2010 to 30 January 2018; groundwater levels fluctuate from 8.0 to 13.5 mbgl with mean and median values of 10.4 mbgl. At Pallisa daily groundwater level variations is monitored from 22 October 1998 to 10 January 2018; groundwater levels fluctuate from 8.9 to 13.9 mbgl with mean and median values of 11.5 and 11.4 mbgl, respectively. Kangole monitoring station has daily groundwater records from 17 September 2010 to 30 January 2018; groundwater level fluctuates from 6.1 to 12.4 mbgl, mean and median values are 8.9 and 9.1 mbgl, respectively. At Bugoma, there is monthly groundwater monitoring in a borehole influenced by pumping from January 2008 to November 2018; values vary from 7.2 to 33.6 mbgl, with mean and median of 18.1 and 17.4 mbgl, respectively.

Rainfall records is available at Karenga – Moroto (31 December 1951 to 29 November 1977); Kangole – Moroto (31 December 1951 to 30 May 1988); Katakwi (31 December 1926 to 30 December 2007); Serere (1 November 2010 to 1 May 2017); Soroti (25 March 1999 to 15 March 2018); Pallisa (1 May 1999 to 26 June 2017); and Moroto Prisons (1 June 2014 to 31 January 2018).

River discharge and level records include; River Omunyal Upper water level records is from 19 August 1965 to 31 May 2002l the water level fluctuates between 6.0 and 8.6 m, mean and median of 7.3 m (Fig. 4.5). River Manafwa discharge and water level records is from 16 May 1997 to 28 February 2015; water level and discharge fluctuate from 7.3 m and 0.0 m^3/s to 12.2 m and 102.9 m^3/s, respectively; mean water level and discharge is 9.7 m and 8.9 m^3/s, with median of 9.7 m and 6.7 m^3/s, respectively. River Namalu discharge and water level records is from 16 May 1997 to 28 February 2015; water level and discharge fluctuate from 2.2 m and 0.0 m^3/s to 3.9 m and 17.8 m^3/s, respectively; mean water level and discharge is 2.4 m and 0.5 m^3/s, with median of 2.3 m and 0.2 m^3/s, respectively. River Namatala discharge and water level records is from 1 January 1990 to 30 November 2020; water level and discharge fluctuate from 7.0 m and 0.6 m^3/s to 11.1 m and 43.1 m^3/s, respectively; mean water level and discharge is 7.5 m and 2.4 m^3/s, with median of 7.4 m and 1.5 m^3/s, respectively. River Simu discharge and water level records is from 1 April 1993 to 30 November 2020; water level and discharge fluctuate from 0.5 m and 0 m^3/s to 3.7 m and 22.2 m^3/s, respectively; mean water level and discharge is 1.4 m and 3.2 m^3/s, with median of 1.4 m and 2.2 m^3/s, respectively. River Sipi discharge and water level records is from 13 June 1997 to 30 November 2020; water level and discharge fluctuate from 0.9 m and 0.1 m^3/s to 3.3 m and 7.0 m^3/s, respectively; mean water level and discharge is 1.7 m and 1.8 m^3/s, with median of 1.6 m and 1.3 m^3/s, respectively. River Sironko discharge and water level records is from 1 January 1994 to 30 November 2020; water level and discharge fluctuate from 1.1 m and 0 m^3/s to 5.7 m and 63.0 m^3/s, respectively; mean water level and discharge is 1.8 m and 5.7 m^3/s, with median of 1.5 m and 3.0 m^3/s, respectively.

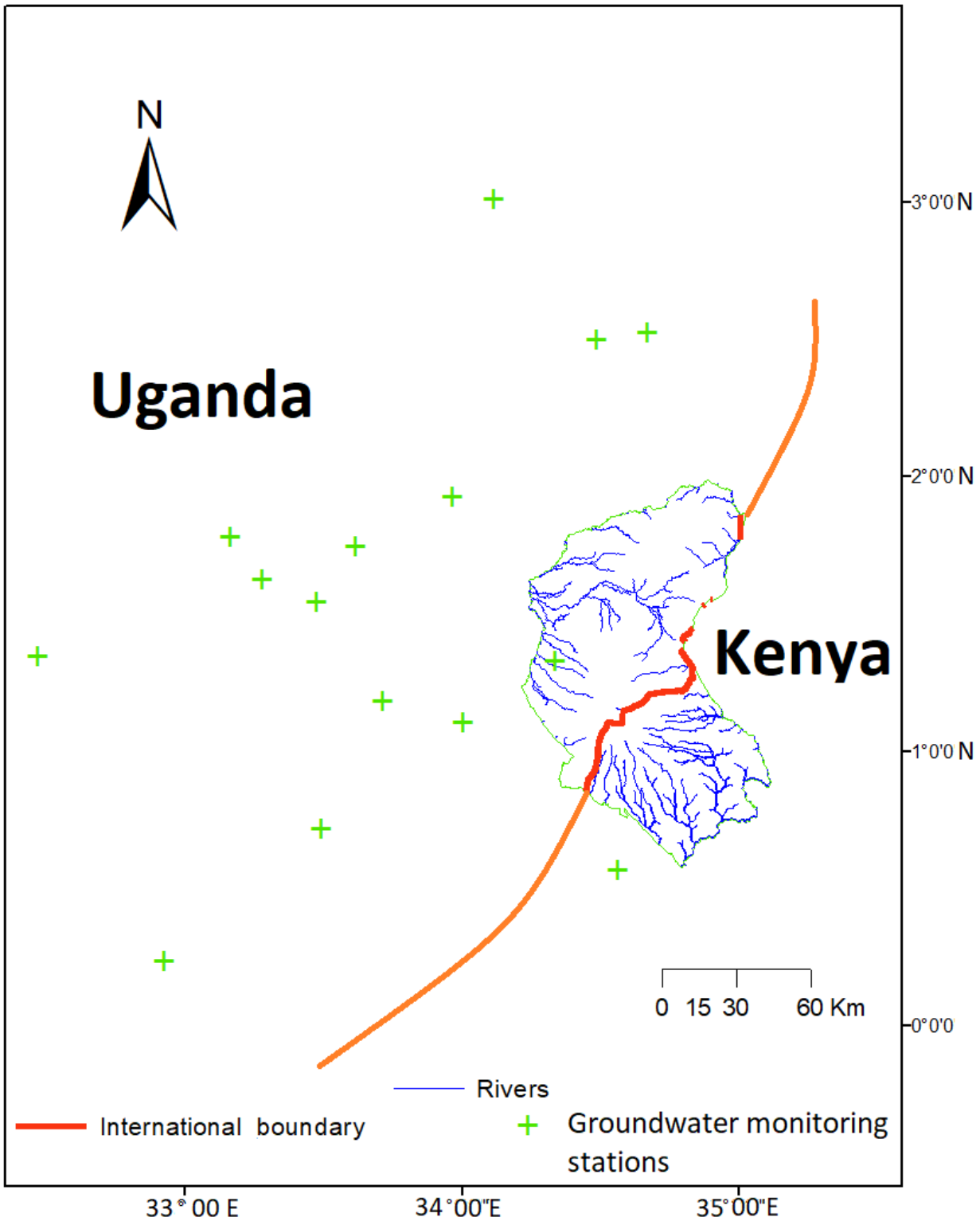
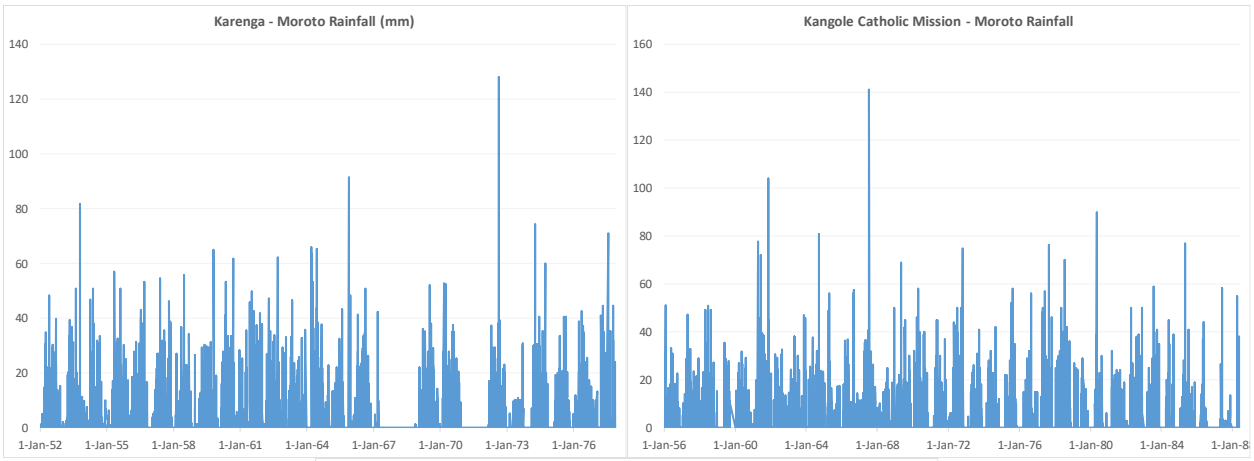
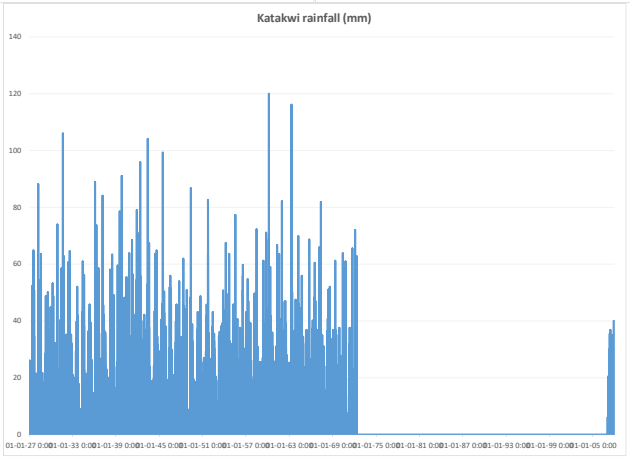


Figure 4.3: *Location of the groundwater level with rainfall monitoring stations beyond the Mt. Elgon aquifer region.*


Karenga - Moroto Rainfall (mm)
140
120
100
80
60
40
20
0
1-Jan-52
1-Jan-55
1-Jan-58
1-Jan-61
1-Jan-64
1-Jan-67
1-Jan-70
1-Jan-73
1-Jan-76
Kangole Catholic Mission - Moroto Rainfall
160
140
120
100
80
60
40
20
0
1-Jan-56
1-Jan-60
1-Jan-64
1-Jan-68
1-Jan-72
1-Jan-76
1-Jan-80
1-Jan-84


Katakwi rainfall (mm)
140
120
100
80
60
40
20
0

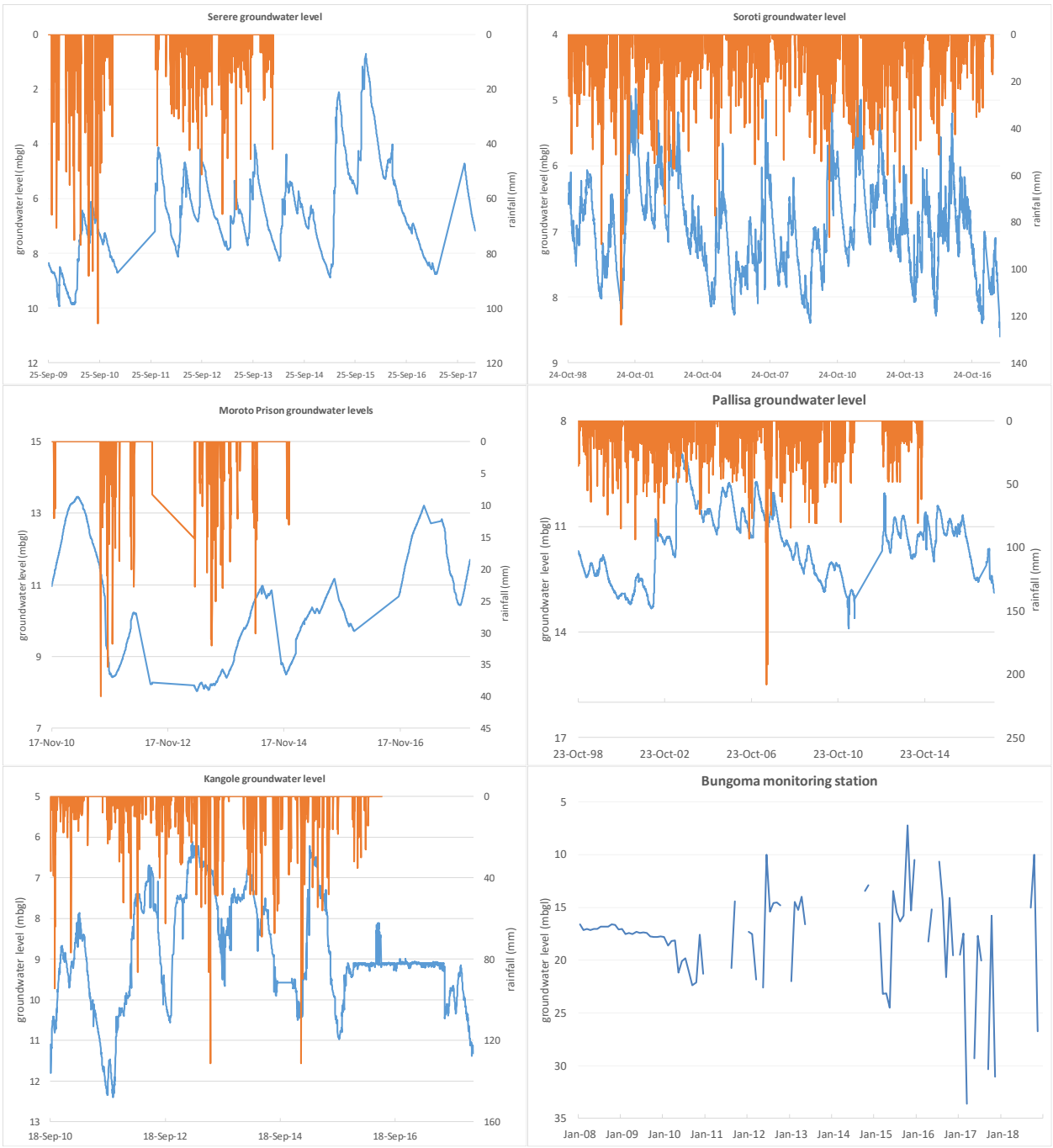
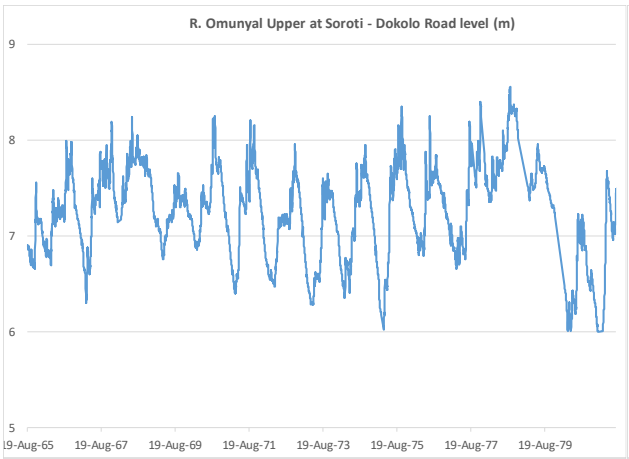
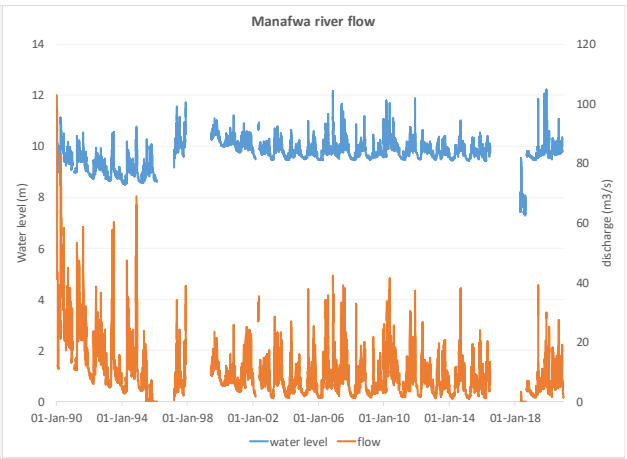
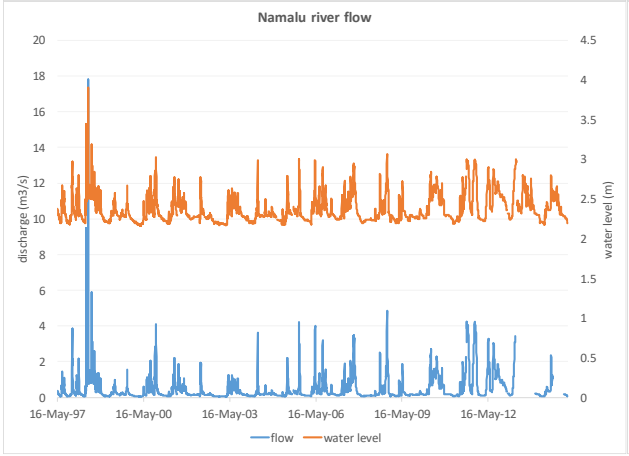
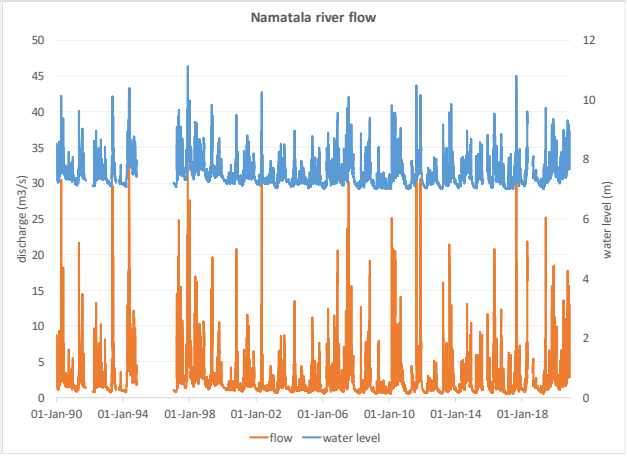


Figure 4.4: *Time series of the groundwater level and rainfall monitored in stations of the Mt. Elgon aquifer region.*


R. Omunyal Upper at Soroti - Dokolo Road level (m)
9
8
7
6
5
19-Aug-65
19-Aug-67
19-Aug-69
19-Aug-71
19-Aug-73
19-Aug-75
19-Aug-77
19-Aug-79


Manafwa river flow
Water level (m)
discharge (m3/s)
14
12
10
8
6
4
2
0
120
100
80
60
40
20
0
01-Jan-90
01-Jan-94
01-Jan-98
01-Jan-02
01-Jan-06
01-Jan-10
01-Jan-14
01-Jan-18
water level
flow


Namalu river flow
discharge (m3/s)
water level (m)
20
18
16
14
12
10
8
6
4
2
0
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
16-May-97
16-May-00
16-May-03
16-May-06
16-May-09
16-May-12
flow
water level


Namatala river flow
discharge (m3/s)
water level (m)
50
45
40
35
30
25
20
15
10
5
0
12
10
8
6
4
2
0
01-Jan-90
01-Jan-94
01-Jan-98
01-Jan-02
01-Jan-06
01-Jan-10
01-Jan-14
01-Jan-18
flow
water level

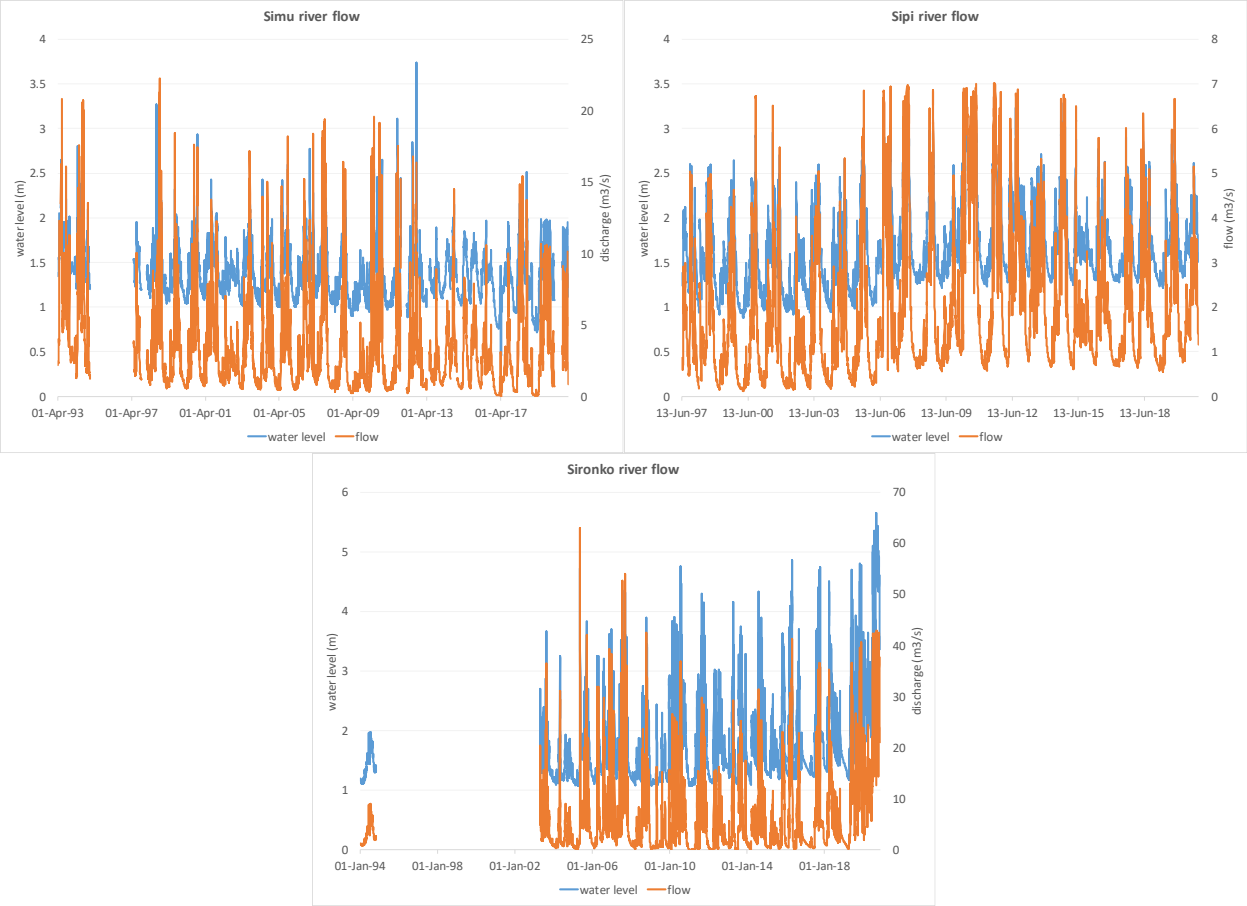


Figure 4.5: *Time series of the river discharge and level monitored in stations of the Mt. Elgon aquifer region.*

4.6.2 Baseline water quality

At well completion a set of physico-chemical (e.g. pH, EC) and chemical constituents of interest (e.g. NO_3, F, As) is analysed from water samples collected from new groundwater sources. Spatial groundwater borehole coverage of physico-chemical (alkalinity, pH, hardness, EC, TDS) and chemical (total Fe and F), and box plots of physico-chemical (pH, EC and TDS) and chemical (F and NO_3) constituents in groundwater at well completion is presented in Fig. 4.6.

Total dissolved solid (TDS) is an index of salinity in groundwater: high TDS water is felt saline by human. Generally, the suitable value of TDS is from 30 to 300 mg/l for potable water. The water quality based on Total Dissolved Solids (TDS) is a good indicator of the comprehensive water quality including salinity and iron content. Additionally, TDS is an important index as water quality standard, and is related to potable water and productivity of livestock or agricultural commodity. If TDS is very high value, the water must be treated or blended to be useful for mos uses. Since the average value of TDS in the study area is approximately 300 mg/l, most of the groundwater is suitable for drinking by humans. Based on TDS, the aquifer exhibits generally good water quality whose values range between 200 and 500 mg/l (Table 4.8).

In general, on the Kenyan side, groundwater is considered safe for human consumption. Electrical conductivity is generally (<1000 µS/cm) and thus groundwater in the confined aquifer systems can be considered as fresh. However, there are pockets of high EC, an indication of some extent of salinity which is a factor of the composition of the host rocks. Iron concentration is also below the maximum WHO (year?) permissible concentration of 0.3 mg/l expect for the few boreholes that have indicated high concentration values. This was also observed during the field visit especially in the areas around Sirisia Sub-County. Fluoride concentration is below the recommended 1.5 mg/l. A number of boreholes indicated manganese concentrations higher than the 0.1 mg/l permissible value. There is no evidence of anthropogenic pollutants in the groundwater.

There is limited information on the extent of solid waste and waste water control. Sanitation in rural areas is mainly by use of pit latrines and to a lesser extent septic tanks especially in rural growth centres. In informal settlements, the situation is critical as there is insufficient coverage of pit latrines. Most of the towns lack sewerage systems, and where they exist, they are currently functioning poorly. For example, the Alupe complex lagoons in Teso North are clogged and the system is practically useless. The only towns with basic effluent treatment facilities are Kitale, Bungoma, Webuye, and Busia - Kenya. The sewage plants at Bungoma and Webuye have been cited to be operating at only 25 per cent capacity. These sewerage works were constructed and commissioned in 1983 and are now old and adversely affected by limited connections due to low coverage of piped water.

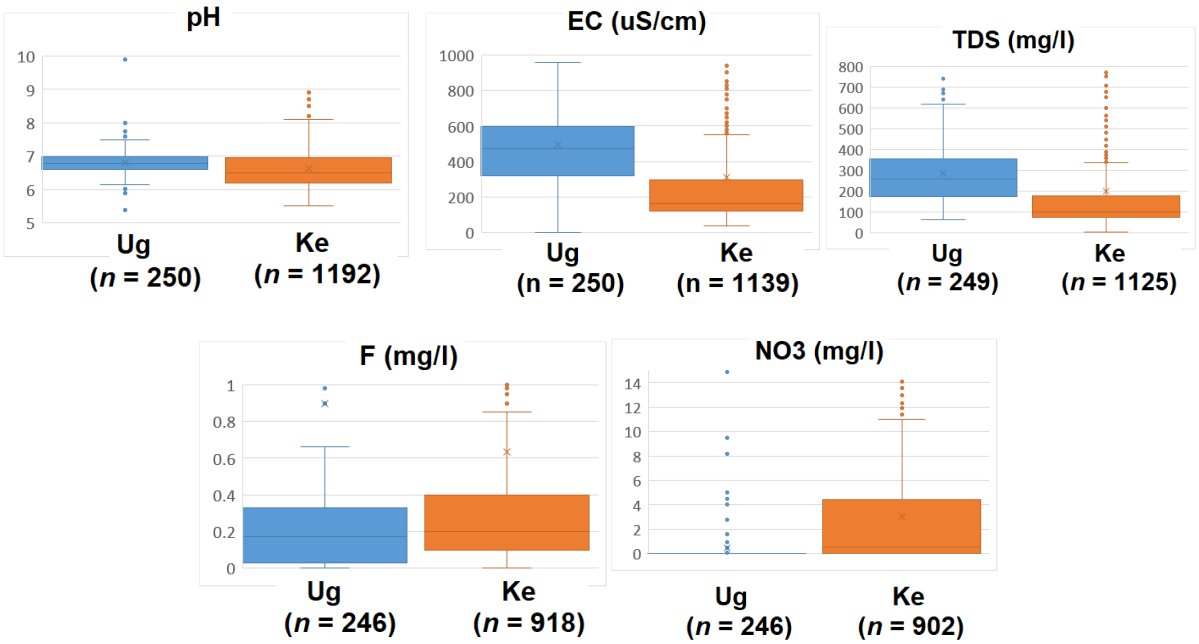


***Figure 4.6**: Spatial groundwater borehole coverage and box plots of physico-chemical and chemical constituents in groundwater at well completion in the Mt. Elgon aquifer region.*

***Table 4.9**: TDS by districts and catchments on the Ugandan side of the Mt. Elgon aquifer region.*

S. No.	District	Water Quality (TDS)

		Data No.	Average (mg/l)
1	Bududa	1	185.0
2	Kapchorwa	1	451.0
3	Manafwa	21	238.1
4	Nakapiripiriti	20	463.2
	Sironko	12	402.4

		Water Quality (Total Dissolved Solids, mg/l)				
No.	**Name**	**Number of Sample**	**Average**	**Maximum**	**Minimum**	**SD**
1	Awoja	87	315.3	1110.0	60.0	185.8
2	Mpologoma	258	289.0	2230.0	1.1	252.1

Ave: Average, Max: Maximum, Min: Minimum, SD: Standard Deviation

4.6.3 Projected water quality

A summary of the current and projected quality of surface and ground waters on the Ugandan side is presented. Table 4.9 shows selected surface water quality parameters for rivers and lakes in Awoja and Mpologoma catchments. The quality of selected groundwater quality parameters in boreholes, protected springs and shallow wells of Awoja and Mpologoma is presented in Table 4.10. Local rural and urban, and WHO (year?) drinking water standards against which the selected water quality parameters is compared is summarised in Table 4.11. Current and projected levels of selected pollutant parameters for the 2 catchments of Awoja and Mpologoma is presented in Tables 4.12 and 4.13.

***Table 4.10**: Surface water quality in the Mt. Elgon aquifer region of Uganda.*

SOURCE TYPE	Sub-catchment	Samples (No.)	pH	Turb (NTU)	TDS (mg/l)	Hardness (CaCO3) (mg/l)	Mn (mg/l)	As (*1) (mg/l)	F (mg/l)	Fe (mg/l)	E.C. (µS/cm)	Coliform Group (group/100ml	BOD5 (mg/l)	NH4 (mg/l)
Lake	Awoja	2	7.3	1.1	247	156	0.11	< 0.001	0.49	0.060	464	TNTC	1.5	0.11
River	Mpologoma	2	7.4	17.6	186	110	0.00	< 0.001	0.28	2.140	261	TNTC	3.3	0.17
	Total	4	14.7	18.7	433	266	0.11	< 0.001	0.77	2.2	725	TNTC	4.8	0.28

Turb.: Turbidity; *1 TNTC means, 'Too Numerous to Count

***Table 4.11**: Groundwater quality in the Mt. Elgon aquifer region of Uganda.*

SOURCE TYPE	Sub-catchment	Samples (No.)	pH	Turb (NTU)	TDS (mg/l)	Hardness (CaCO3) (mg/l)	Mn (mg/l)	As (*1) (mg/l)	F (mg/l)	Fe (mg/l)	E.C. (µS/cm)	Coliform Group (group/100ml
Borehole	Awoja	13	6.6	13.0	300	187	0.02	< 0.001	0.48	0.660	538	31
	Mpologoma	35	6.4	4.9	316	183	0.01	0.001	0.43	0.441	469	< 1
Protected Spring	Awoja	13	6.4	6.9	113	68	0.00	< 0.001	0.27	0.362	224	< 1
	Mpologoma	10	6.4	13.9	133	76	0.01	< 0.001	0.27	0.507	237	< 1
Shallow well	Awoja	2	6.6	22.5	212	148	0.01	< 0.001	0.38	0.890	359	< 1
	Mpologoma	5	6.4	26.5	305	197	0.02	< 0.001	0.29	0.787	516	< 1
	Total	78	38.8	87.7	1379	859	0.07	< 0.001	2.12	3.647	2343	< 1

Turb.: Turbidity; *1 TNTC means, 'Too Numerous to Count

***Table 4.12**: Drinking Water Standards from Ugandan and WHO (year?) guidelines.*

Standards	Basic Items				Harmful Items				Pollution Items			
	pH	Turb (NTU)	TDS (mg/l)	Hardness (CaCO3) (mg/l)	Mn (mg/l)	As (*1) (mg/l)	F (mg/l)	Fe (mg/l)	E.C. (µS/cm)	Coliform Group (group/100ml	BOD5 (mg/l)	NH4 (mg/l)

Standards for urban treated drinking water	6.5- 8 .5	10	500	500	0.1	0.05	1.0	0.3		0 /100ml		
Rural drinking water Standards	5.5 - 8.5	10	1000	600	1.0		2.0	1.0		0 /100ml		
Rural Drinking water Maximum Allowable Concentration (MAC)	5.0 - 9.5	30	1500	800	2.0	0.5	4.0	2.0		50/100 ml		
WHO (year?) criteria (drinking water)		5	1000	0.1	0.01	1.5	0.3	1.5		0/100 ml	4.8	0.28

*1 As for Arsenic, the values in the table shows the test results obtained in Japan. *Evaluate Average Value: Over Criteria value (Urban drinking water): Over Criteria value (Rural drinking water MAC) * As for average of Coliform Groups, ' < 1' means there are some sites which result is ' TNTC'

***Table 4.13**: Current and projected levels of pollution in the Mt. Elgon aquifer area of Uganda.*

			Year 2015			**Year 2020**			**Year 2035**		
Sub-catchments	BOD Runoff Ration (%)	Average Flow (m3/year)	Pollution Discharge (t/year)	Runoff Pollution Load (t/year)	Predicted BOD Concentration (mg/l)	Pollution Discharge (t/year)	Runoff Pollution Load (t/year)	Predicted BOD Concentration (mg/l)	Pollution Discharge (t/year)	Runoff Pollution Load (t/year)	Predicted BOD Concentration (mg/l)
Awoja	34.04	617,815,404	10,723	3,650	5.9	12,837	4,370	7.1	22,150	7,540	12.2
Mpologoma	2.77	766,034,807	26,801	3,423	4.5	31,323	4,001	5.2	45,171	5,770	7.5
Total	36.81	1,383,850,211	37,524	7,073	10.4	44,160	8,371	12.3	67,321	13,310	19.7

***Table 4.14**: Current and projected levels of pollution in the Mt. Elgon aquifer area of Uganda.*

			Year 2020			**Year 2035**		
Sub-catchments	BOD Runoff Rate (%)	Average Flow (m^3/year)	Pollution Discharge (t/year)	Runoff Pollution Load (t/year)	Predicted BOD Concentration (mg/l)	Pollution Discharge (t/year)	Runoff Pollution Load (t/year)	Predicted BOD Concentration (mg/l)

Awoja	34.04	617,815,404	18,338	6,242	10.1	31,643	10,771	17.4
Mpologoma	2.77	766,034,807	44,747	5,716	7.5	64,529	8,242	10.8
Total	36.81	1,383,850,211	63,085	11,958	17.6	96,172	19,013	28.2

4.6.4 Groundwater depletion

On the Kenyan side, groundwater monitoring is not well established in the Mt. Elgon aquifer region. However, there is a dedicated monitoring borehole with a depth of 100 mbgl in Bungoma Town. A report on Kenya Groundwater Governance (2011) indicated the possibility of groundwater depletion. Although there exists only one dedicated monitoring borehole in the aquifer region, Water Resources Authority carries out routine groundwater monitoring by measuring the static water levels for selected production boreholes across the area of their jurisdiction. Table 4.14 illustrates groundwater level monitoring data for a production borehole in Moi's Bridge Town. The data shows that there is a general decreasing trend in groundwater levels in recent years (Fig. 4.7). From findings of field investigations during the current study, indications are that spring discharges have decreased, baseflow in the streams and rivers reduced and shallow wells dry-up more frequently. For the shallow, phreatic aquifer, this could be linked to the decreasing recharge occasioned by changes in land cover although there is evidence of increased abstraction given the increasing number of motorized shallow wells.

***Table 4.15**: Groundwater level monitoring for a production well in Moi's Bridge town.*

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018	31.5				15				15	10	26.75	
2017	19.5	17.47	33.64		29.3	17.7	20.02		30.33	15.8	31.04	
2016				18.26	15.16		10.64	14.35	21.6	14.1	19.57	
2015		16.5	23.22	23.14	24.5	13.46	15.43	16.3	15.8	7.2	15.3	10.5
2014										13.45	12.9	
2013	22	14.46	15.25	14	16.6							
2012	17.3	17.5	21.85		22.6	10	15.4	14.6	14.5	14.8		
2011					20.2			20.75	14.4			
2010	17.82	18.6	18.2	18.1	21.2	20.1	19.8	21.08	22.37	22.1	17.6	21.3
2009	17.05	17.5	17.41	17.53	17.3	17.42	17.38	17.41	17.76	17.78	17.78	17.75
2008	16.62	17.14	17.01	17.15	17.03	17.05	16.82	16.8	16.81	16.62	16.66	17.08

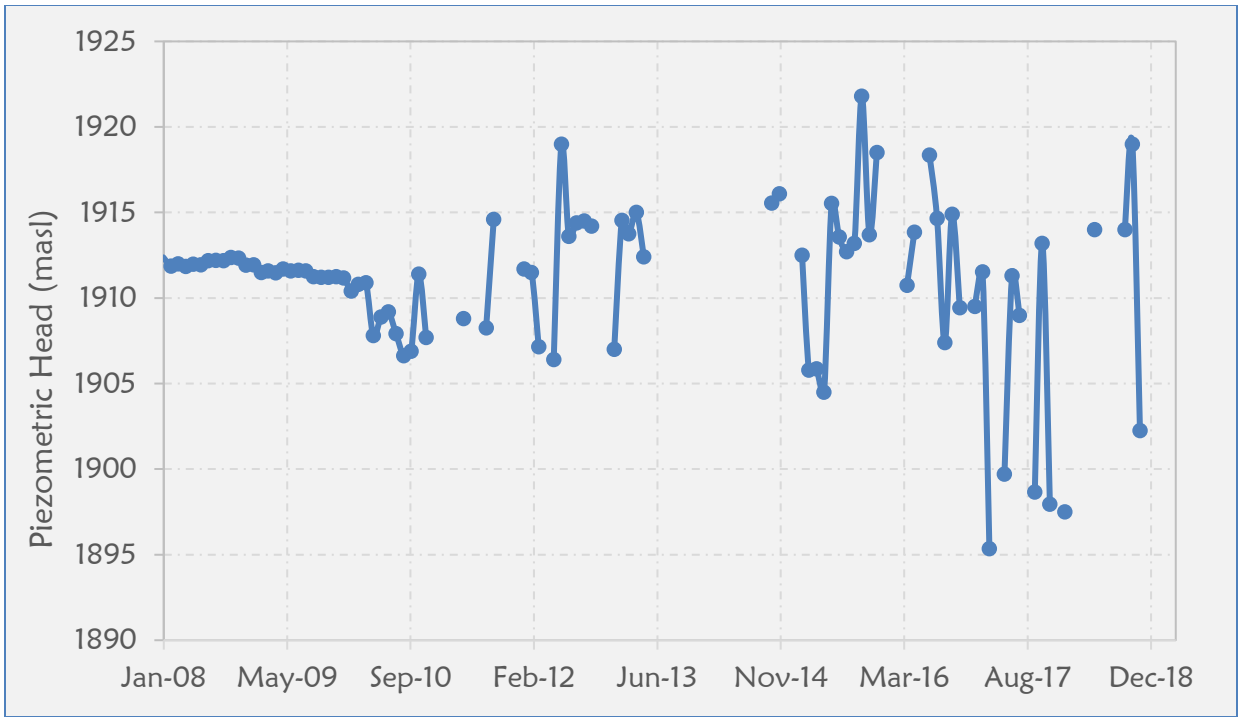


Figure 4.7*: *Groundwater level monthly fluctuations for a production well in Moi's Bridge town, Kenya.

Natural discharge mechanism

The main natural discharge mechanism includes streams, wetlands and springs (Fig. 4.8). There are numerous springs in the area especially on the slopes of the mountain. Most of the rivers in the study area are perennial and thus flow in the dry season is maintained by groundwater discharge as baseflow. There are several wetlands of key ecological importance in the study area.

***Figure 4.8**: A protected spring as a natural discharge mechanism of the phreatic aquifer groundwater storage in Kenya.*

4.7 Groundwater surface water conjunctive management practices and options

The interaction between groundwater and surface water systems like rivers, wetlands and lakes has not been considered adequately. As there continues to be an increase in demand, surface water resources will be outstripped, and groundwater holds the potential of filling the demand and supply gap.

Kenyan side has good groundwater potential for boreholes, shallow wells and springs and other surface water sources consisting of water pans and dams. The aquifer system area has several dams, water springs, and shallow wells. Despite of this, there is inadequate development with regard to surface and ground water infrastructure (Trans Nzoia CIDP, 2018). Initially, there was a very high dependence on surface water within the three study Counties (Bungoma, Trans-Nzoia and Busia) but as a result of high pollution levels, the water is becoming unfit for human consumption. In the urban areas, everyone wants to have access to water. As a result, a majority of residential buildings including apartment and flats have sunk boreholes and shallow wells, making the abstraction level too high thereby and potentially affecting water levels within the Mt. Elgon aquifer system. The main uses of groundwater in the three study counties include small scale irrigation for horticultural crops, domestic usage (e.g. drinking water), and livestock watering. Key challenges affecting water use and management include poor quality, limited access of surface water in some areas necessitating the use of boreholes, and poor coordination of water resources management authorities in the region.

5. EXISTING GROUNDWATER MANAGEMENT POLICIES AND MANDATES

Groundwater management is a complex endeavour as it requires coordination across many sectors and users (e.g. water supply, agriculture, energy, industry, and environment) and it needs to integrate with surface water management. Trying to do this at the international level poses another dimension of challenges in terms of coordination and integration. Groundwater traditionally has been considered a national matter, but the need for international cooperation on groundwater is increasingly recognised. This is particularly the case where:

- Groundwater resources evidently flow across borders, as in the case where groundwater is primarily recharged in one country but discharges in another
- Groundwater development in one country has (or could have) significant implications and adverse impact in the other country
- Significant ecosystems in one country depend on groundwater influx from another country
- Significant groundwater development or land-use changes with implications for groundwater resources (quantity or quality) in neighbouring countries is planned in one country
- Groundwater is a significant resource in drought management and generally for human development for one or more of the sharing countries

The principles of international law for cooperation on transboundary aquifers build on the general principles of cooperation on surface water. Some of these principles relate to:

- Cooperation on the basis of sovereign equality, territorial integrity, mutual benefit and good faith;
- The concept of 'equitable and reasonable use';
- The concept of 'no-harm', i.e., that all resource development and management is done with no prior intention of harming the other part;
- Prior notification, i.e. that states have an obligation to inform each other before implementing major investments and interventions that may affect the resource in a transboundary sense. Notification also refers to immediately informing other states of emergency conditions related to the watercourse that may affect them, such as flooding
- Sharing of data, i.e. institutionalised mechanisms for regular sharing of new data and knowledge related to the TBAs;
- The precautionary principle, i.e. that development is not done if insufficient knowledge exists to show that environmental and socio-economic impacts will be low. These protections can be relaxed only if further scientific findings emerge that provide sound evidence that no significant harm will result;
- Stakeholder involvement, i.e., that stakeholders are involved and have a say in decisions related to the development of the resource;
- Dispute settlement.

However, it is important to bear in mind that groundwater has some particular inherent characteristics that necessitate strong emphasis on certain of these principles, i.e. the precautionary principle, long-term monitoring of the resource, joint monitoring/ registration of users, prior notification, and prioritized protection. In order to achieve full and efficient cooperation on TBAs,

states need to formulate joint (or separate but coordinated) plans and programmes for groundwater development, use and protection, to implement common/harmonised groundwater management policies, the joint training of technical personnel and the joint undertaking of environmental studies.

5.1 Kenyan policies and legislation

5.1.1 The Constitution 2010

The constitution of Kenya 2010 recognizes water and sanitation services as a basic right; provides for access to a clean and healthy environment, and water resources for all citizens of the country; and assigns the responsibility for water supply and sanitation service provision to 47 newly established counties (Government of Kenya, 2010). Other key provisions in the Constitution that touch upon water include: affirmative action programs to ensure water for marginalized groups; the responsibility of the national government for management of the use of international waters and water resources and definition of national versus county public works.

5.1.2 Water Act 2016

The passage of Kenya's 2010 Constitution has had a wide set of implications for the water sector. Primarily, the Constitution acknowledges access to clean and safe water as a basic human right and assigns the responsibility for water supply and sanitation service provision to 47 newly established counties. The purpose of the 2016 Water Act is to align the water sector with the Constitution's primary objective of devolution. The act recognizes that water related functions are a shared responsibility between the national government and the county government. It also gives priority to use of abstracted water for domestic purposes over irrigation and other uses.

Other key provisions in the Constitution that touch upon water include: affirmative action programs to ensure water for marginalized groups; the responsibility of the national government for management of the use of international waters and water resources and definition of national versus county public works. The Water Act 2016 provides for Integrated Water Resources Management along the River Basin that is the best practice worldwide and in accordance with Dublin Principles. Prior to reforms in the water sector, water supply and sanitation and water resources management in Kenya faced huge challenges among them being institutional weaknesses, inadequate funding, conflicts due to overlapping roles and responsibilities of key public sectors in the water Act (GoK, 2016). The purpose of the 2016 Water Act is to align the water sector with the Constitution's primary objective of devolution. The act recognizes that water related functions are a shared responsibility between the national government and the county government. It also gives priority to use of abstracted water for domestic purposes over irrigation and other uses. Important highlights of the Act relevant for groundwater resources include the following:

- Every water resource is vested in the State, but subject to any rights of user granted by or under this Act or any other written law.
- The WRA is established as a body corporate to manage water resources in Kenya; develop principles, guidelines, and procedures for its allocation; monitor the national water strategy and carry out other functions

- The Authority may designate catchment areas and shall formulate a strategy for each area. Each area shall have an advisory committee. Protected catchment areas may be declared by the Authority.
- The national water services strategy provides for national monitoring and information systems on water services.
- Other provisions of Part IV concern rights and duties of holders of licenses to provide water and some other matters relating to water supply.

5.1.3 National Water Resources Management Strategy

The national water resources management strategy (NWRMS) is formulated in accordance with which Kenya's water resources shall be managed, protected, used, developed, conserved, and controlled. The strategy shall further provide for, (a) determining the reserve; (b) classifying water resources; and (c) identifying areas to be designated protected areas and groundwater conservation areas. The NWRS is under the WRA and includes the following activities with respect groundwater:

- Define and describe groundwater bodies in Kenya
- Define and quantify the Reserve for each groundwater body
- Identify groundwater bodies which are at risk of over abstraction or water quality deterioration
- Produce a hydrogeological map of Kenya
- Produce a groundwater vulnerability map of Kenya, in detail as and where required identify groundwater bodies that have been subject to significant pollution
- Develop a classification scheme for Kenya's groundwater resources
- Develop a monitoring network for groundwater quantity and quality
- Develop an overview of the status of groundwater quantity and quality in Kenya

5.1.4 The Water Services Regulations 2021 (Legal Notice No. 168 of 2021)

This regulation outlines the following regulations: county government framework for water services provision; establishment, operation and financing of water services providers; application for licence; systems and standards for operation of water services; effluent; implementation and review of tariffs; clustering of water service providers; applicable levies and fees; administration of certain water supply and infrastructure services; approvals of construction works affecting infrastructure; inspection, evaluation and monitoring; offences relating to conduct of employees of a water services provider; general offences; bulk water supply; reporting and record keeping; complaints; consumer engagement; compliance and enforcement; and penalties.

5.1.5 The Water Harvesting and Storage Regulations 2021 (Legal Notice No. 169 of 2021)

This regulation made pursuant to section 142 of the Water Act 2016, gives effect to the mandate to the national government under the Constitution of Kenya 2010 concerning policy and law making, and obligations including to enhance the protection and conservation of water catchments and ensure availability of ground and surface water for water supply through enhancement of harvesting and storage capacity. The regulations provide the details and guidance for implementation of the Water Act No. 43 of 2016, which include implementation of the functions of the national and county governments, e.g. harvesting and storage; and water for emergency drought interventions.

5.1.6 The Water Resources Regulations 2021 (Legal Notice No. 170 of 2021)

Pursuant to section 142 of the Water Act 2016, the regulations gives effect to the mandate to the national government under the Constitution of Kenya 2010 concerning policy and law making, and obligations including to ensure the protection and conservation of water catchments, prevention of pollution, regulating water abstraction, criteria for prioritization and allocation of water resources. The regulations provide the details and guidance for implementation of the Water Act No. 43 of 2016, which include implementation of the functions of the national and county governments on soil and water conservation.

5.1.7 The Irrigation Act 2019

The Act gives the Cabinet Secretary in charge of irrigation the powers to develop general principles, guidelines and standards for promoting development and for the coordination of irrigation planning, promote the use of efficient irrigation systems across the country, ensure availability and adequacy of water for irrigation, issuance of irrigation licences for irrigation schemes, develop and maintain databases on irrigation water supplies, demands, projects, irrigated areas, management performance, potential for expansion and human resources, technical and management audits of irrigation schemes, and maintain storage investments for their proper use implementation.

5.1.8 The Climate Change Act, 2016

The Act is the first climate change-dedicated legislation in Africa and is the legal foundation of the Climate change action plan 2018-2022. The Act is applied for the development, management, implementation and regulation of mechanisms to enhance climate change resilience and low carbon development for the sustainable development of Kenya. The Act establishes the Climate Change Council and the Climate Change Directorate.

5.1.9 The Environmental Management and Co-ordination Act (EMCA) 1999 (amended 2015)

The Act of parliament that provides for the establishment of an appropriate legal and institutional framework for the management of the environment, which also covers groundwater resources and the Mt. Elgon aquifer.

5.1.10 The Agriculture Act 2012

The Act recognises the provisions the Water Act and emphasizes that the Act shall prejudice or affect the provisions of the Water Act, and where anything in the Agriculture Act or any rule is inconsistent with any such provision that provision shall prevail. The Act also recognises water under the Agriculture (Basic Land Use) Rules of 1965 including protection of water courses and protection against erosion by run-off water.

5.1.11 National Water Master Plan 2030

The Master Plan is the product of an intensive study of Kenya's water resources and meteorological conditions to facilitate planning for development and management of water resources including groundwater. It proposes that less groundwater recharge should be employed for planning to avoid the excessive groundwater development.

5.1.12 Regional level

The policy instruments that are geared towards the protection, conservation and use of water resources in the Nile River Basin, also covering the Mt. Elgon aquifer includes the NBI Environmental and Social Policy June 2013; NBI Wetland Management Strategy June 2013; NBI Communication and Stakeholder Engagement Strategy 2018-2023; NBI Information Disclosure Policy; NBI Climate Change Strategy June 2013; National Gender Policies of project countries; NBI Gender Mainstreaming Policy and Strategy July 2012; NBI Strategy for Management of Environmental Flows; International policies and procedures related to the ESMF; Indigenous/Vulnerable People Policies.

5.1.13 County level

At the counties level, Busia County has developed the Water and Sewerage Services Act 2015, Bungoma County has developed a Draft Water Policy 2020 while Trans-Nzoia County is yet to develop a Policy or an Act. There is need to finalize the Kenya draft groundwater policy to guide the development and review of county-level policies in the three study Counties, and to inform the trans-boundary nature of the shared Mt. Elgon aquifer.

Bungoma County Water Policy (Draft, 2021)

The County draft policy recognizes the need for water quality management and proposes that all necessary measures shall be adopted to preserve both surface and groundwater quality by strengthening and enforcing improved monitoring networks, laboratories, effective databases and indicators within the County Government of Bungoma.

Busia County Water and Sewerage Act, 2015

The County Act provides legal framework for water companies, soil and water conservation, sewerage services and pollution control, and recognizes groundwater under storm water management plan.

5.2 Kenyan related policies and plans

5.2.1 The Sessional Paper No.1 of 2021 on National Water Policy

The Policy addresses issues that would lead to realization of the human rights to water, and reasonable standards of sanitation through taking steps to protect, respect and fulfil these rights, as enshrined in the Constitution. It also addresses universal coverage of the entire population with access to water and sanitation.

5.2.2 National Land Policy

Section 3.4 of the adopted land policy (2013) deals with land management issues, and states that problems of rapid urbanization, inadequate land use planning, unsustainable production, poor environmental management, and appropriate ecosystem protection and management are commonplace and require policy responses. Similar issues have been identified in the national water policy as impeding sustainable management of water resources, including groundwater resources. The policy calls for putting in place the necessary mechanisms for effective coordination across sectors. The key issue is that notwithstanding the recognition of the need for coordinated management, land-based resources are still managed on a sector-specific basis and thus sustainable management of groundwater resources.

5.2.3 Policy on Environment and Development

Another important policy paper in the context of groundwater management is the environmental management policy – Environmental Management and Coordination Act (GOK, 2015). Whereas specific mention is made of the protection of water Kenya, catchments and wetlands as objectives, no mention is made of groundwater conservation. Groundwater resources are not addressed even in the context of the discussion on rangeland resources, whose effective utilization is often dependent on groundwater resources. Neither is groundwater mentioned in the discussion on land degradation, drought, and desertification.

5.2.4 Policy on Climate Change

At present there are no overarching policies or laws explicitly for the management of climate change. The National Climate Change Response Strategy (GoK, 2010) proposes that the EMCA is reviewed in light of the need for response to climate change. The Kenya climate change response strategy for water resources will be discussed.

5.2.5 Rainwater Harvesting and Storage Strategy (2019)

NWHSA under section 30 of the Water Act 2016 has mandate to undertake on behalf of the National Government, the development of National Public Water Works including Water Resources Storage and flood control. Although the strategy focuses on capturing of flood water, there is no mention on the utilization and flood water to replenish and recharge groundwater resources (GoK, 2019), e.g., through Managed Aquifer Recharge (MAR).

5.2.6 The Environmental Management and Co-ordination Act 2015 (EMCA)

It is an Act of Parliament that provides for the establishment of an appropriate legal and institutional framework for the management for the environment, which also covers groundwater resources and the Mt. Elgon aquifer region.

5.2.7 Public Health Act Chapter 242

Section 129 of the Act states that it is the Local Authorities' duty to take all lawfully, necessary and reasonable practicable measures to prevent pollution of any public water supply within its area of jurisdiction.

5.2.8 National Policy on Gender and Development, 2020

The National Policy on Gender and Development was adopted in 2000 is meant to provide a legitimate point of reference for addressing gender inequalities at all levels of government and by all stakeholders, and further provides an avenue for gender mainstreaming across all sectors in order to generate efficient and equitable development outcomes for all Kenyans. This policy is applicable for involving women in groundwater and related projects and their sustainable management.

5.2.9 Other Legal Instruments

The other legal instruments which are relevant to ensuring sustainable management and equitable use of groundwater resources at the local and national levels includes Land laws; Environmental Impact Assessment Guidelines; Cultural Heritage laws; National Labour and employment Laws; National Child Protection Laws; National Laws on Vulnerable and Marginalized groups;

5.3 Kenyan Groundwater Governance

Kenya does not have policies, laws, and institutions dedicated specifically to the management of its groundwater. Rather, groundwater management is subsumed under broader policy, legal, and institutional frameworks dealing with the management of water resources, or more broadly, natural resources, and with land use and physical planning. Existing policy, legal, and institutional frameworks are deficient from the perspective of groundwater management (Olago, 2019). An overhaul is required to bring them in line with the requirements of frameworks for sound groundwater management. Deficiencies have been identified in key areas. Groundwater management decision making is sector-based and on the whole ad hoc; there is no mechanism for coordination and for fostering cross-sector linkages.

Consequently, the management of groundwater resources has continued to be carried on in isolation from the management of land and other land-based resources, with the inevitable consequence that the implications of management decisions in critical areas such as physical planning, land use planning, and agricultural activities have often been overlooked. At the same time, groundwater decision making remains overly centralized, with limited real involvement of stakeholder units, such as catchment area advisory committees (CAACs) and water resources user associations (WRUAs). Kenya shares over 50 percent of its water resources with other states, which greatly complicates water management. Although the National Water Policy recognizes that Kenya has shared water resources, no specific proposals for the management of shared groundwater resources are included in the policy objectives.

5.3.1 Groundwater management instruments

The Water Act gives the WRA specific mandates to develop instruments for groundwater management. These are also related to the policies and plans of other sectors as highlighted in the previous section and the related legislation such as the Physical Planning Act and the Environmental Management and Coordination Act (2015).

5.3.2 Catchment areas and catchment management strategies

The WRA has a mandate to formulate a catchment management strategy for the management, use, development, conservation, protection and control of water resources within each catchment area. The strategy shall include inter alia to:

a) contain water allocation plans that set out principles for allocating water; and
b) provide mechanisms and facilities for enabling the public and communities to participate in managing the water resources within each catchment area.

The legislation provides for the formulation of water resources management plans, which are referred to as catchment management strategies (CMS) and sub-catchment management plans (SCMPs). There is no different treatment accorded to groundwater, though at the same time there is no specific mention of groundwater management planning. There is therefore a risk that groundwater resources would not be optimally managed in accordance with the CMS or SCMP, since the key focus is surface water resources.

5.3.3 Groundwater development and allocation

For the regulation of groundwater development, the Water Act states that the WRA will determine in the allocation plan for a given aquifer the spacing of boreholes or wells to be equipped with motorized plant. The WRA would be guided by: a) existing borehole or well spacing; b) individual aquifer characteristics, including water quality; c) existing aquifer use; and d) existing bodies of surface water.

5.3.4 Groundwater conservation areas (GCAs)

The WRA is mandated to enforce special measures for the conservation of groundwater where necessary in the public interest. The WRA can, following public consultations, declare an area as a GCA; impose such requirements and regulate or prohibit such conduct or activities that it may deem necessary for the protection of the GCA area and its groundwater. The only gazetted GCA in the country is Nairobi. GCAs are linked to land use planning and therefore related to other legislation like the Physical Planning Act and Environmental Management and Coordination Act. The analysis shows that both acts make no specific mention of the conservation of groundwater resources as a relevant consideration in formulating physical developments plans and environmental planning.

5.4 Kenyan Regulation and Controls

There are still few regulations in place that effectively control groundwater management, allocation, and protection. One of the obstacles to this is the effect of the common law on groundwater, which states that a private landowner effectively owns the resource and can abstract it and put it to his own use without having to take account of the wider social requirements. This underscores the perception that groundwater is a private resource. This common law position has been qualified by the statutory provisions dealing with groundwater management.

5.4.1 Water rights and water permits

Under the Water Act, water rights may only be acquired through a permit. Statutory law deals with groundwater in a way that is markedly different from surface water, notwithstanding that the ownership of both groundwater and surface water is vested in the state. Section 27 makes it an offense to construct or use works to abstract water without a permit. Section 26 makes three exceptions to the permit requirement, one of which relates specifically to the use of groundwater.

5.4.2 Regulating the construction of wells and boreholes

The construction of wells and boreholes are regulated under the Water Act, which contains rules governing the abstraction of groundwater that apply even in areas that fall outside GCAs. The regulatory guidelines stipulate a number of conditions for the person/drilling contractor constructing a well/borehole. Through these requirements, the WRA is required to regulate the abstraction and use of groundwater. The weakness of this system, however, is that it is dependent on landowners coming forward with the information regarding their intention to abstract groundwater. Since boreholes are located within the boundaries of private property, there is a good chance that the WRA and neighbouring landholders may not know that a borehole has been drilled. The WRA's ability to enforce these rules through its own inspection, monitoring efforts and collaboration with neighbouring landholders in providing information therefore becomes critical for enforcing regulation.

5.4.3 Wastewater licensing

The Water Resources Management Rules (WRMR) include a set of provisions for waste water to (a) control the pollution of water; (b) impose a requirement for an effluent discharge permit; and (c) stipulate that effluent may only be discharged into a water resource if it meets prescribed standards. However, for these rules to provide the protection required it would be necessary to identify strategic and vulnerable aquifers and groundwater abstraction points and focus the implementation and enforcement on such aquifers for maximum effect. At present, these rules have not been applied to any of the CSAs. Artificial recharge can also potentially threaten the quality of groundwater. Regulation 78 of the WRMR (GoK, 2007) deals with artificial groundwater recharge and states that no person shall undertake to construct works for the purpose of conducting artificial groundwater recharge of an aquifer in a GCA unless the person has been authorized by the WRA to do so. This enables the WRA to regulate the practice of artificial recharge.

5.4.4 Controls on development in recharge/discharge zones and pollution

The protection of recharge and discharge zones of groundwater from pollution could also be achieved under the powers given to Water Services Regulatory Boards (WASREB) to make regulations that protect any water against degradation (whether on the surface or underground). The regulations would define the area within which the licensee deems it necessary to exercise control. Within that area, it would prohibit or regulate any act prescribed by such regulations and provides penalties. Although these regulations are appropriate for protecting groundwater from pollution, no WSPs have gazetted any regulations to protect groundwater from which they abstract water for public water supply. This is even more difficult with devolution that has created more conflict of mandate a situation that that impedes sustainable water resources management.

5.4.5 Strengths and weaknesses of current regulation

Kenya has a comprehensive legal framework for the management of groundwater resources. The laws recognize groundwater as a water resource that is distinct from surface water resources. There are provisions for requiring authorizations and permits to be obtained for the abstraction and use of groundwater. The law recognizes the value of groundwater and imposes a charge for its abstraction and use. There are also provisions for groundwater conservation and protection. However, enforcement has been weak, and many of the provisions have not been implemented. Weak implementation is due to a perception that groundwater is an inexhaustible resource. This perception is rooted in a poor knowledge of groundwater resources, weak institutional capacity, poor funding, and weak political commitment at the senior policy-making level. As a result, over abstraction and poor management have continued. The statement made in the National Water Policy thus remains substantially true in regard to groundwater management today. It states that groundwater is characterized by over-centralized decision-making processes, an inappropriate and run-down monitoring network, inadequate database, discontinuous assessment programs, uncoordinated source development, non-operative water rights, the absence of special courts to arbitrate on water use conflicts, and a generally weak institutional set up. It is even more difficult with water being generally a devolved function.

5.5 Kenyan Institutional and Organizational Arrangements

The reform of the water sector under the Water Act (2002) resulted in the establishment of dedicated agencies with clearly defined roles and responsibilities which has been further revised in Water Act 2016. The Ministry of Water and Irrigation (MoWI) is responsible for the development of legislation, policy formulation, sector coordination and guidance, and monitoring and evaluation. The agencies are as illustrated in figure 5.1.

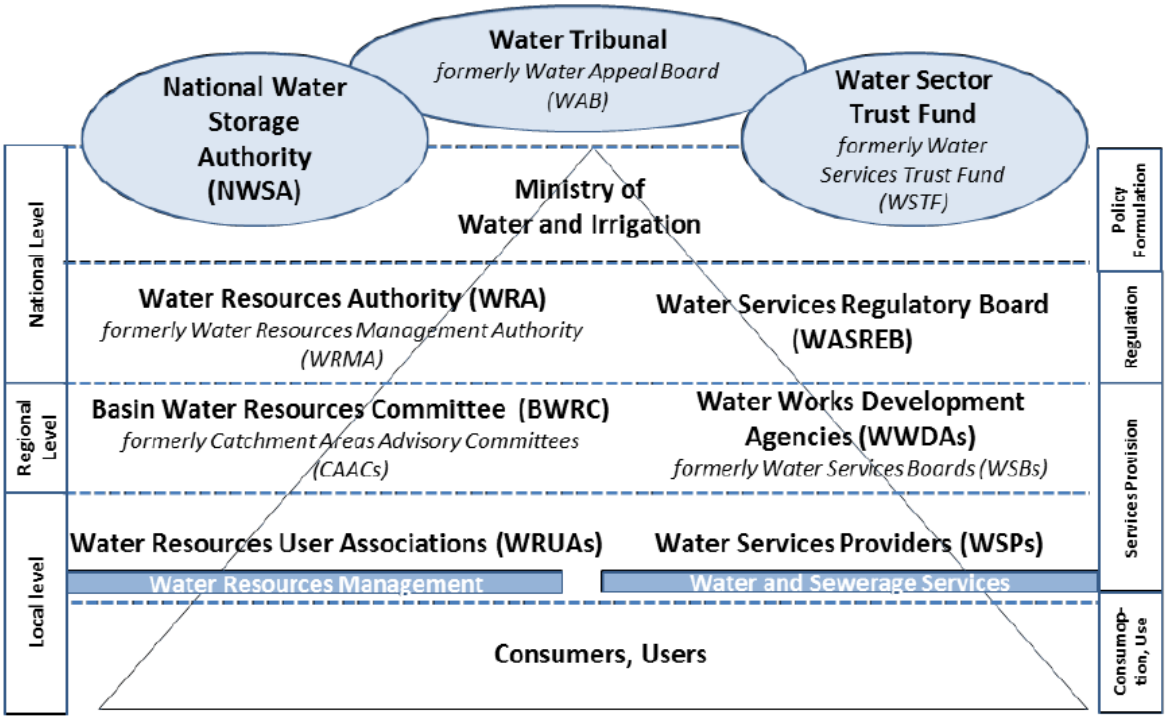


***Figure 5.1**: Refined roles and responsibilities under Water Act 2016 in Kenya.*

5.5.1 Water Resource Management

Water Resources Authority (WRA)
The objective of the new WRA is to protect, conserve, control and regulate use of water resources through the establishment of a national water resource strategy. In addition, the WRA is responsible for:

- formulation and enforcement of standards, procedures and regulation for the management and use of water resources;
- policy development;
- planning and issuing of water abstraction permits; and
- setting and collecting permits and water use fees.

Basin Water Resource Committee (BWRC)
Catchment Areas Advisory Committees, which previously played a regulatory function at the regional level, have been replaced with BWRCs. The latter will be committees of WRA whose members will be drawn from stakeholders within the basin and aim to achieve wide stakeholder

participation in the management of water resources at the basin level. The new BWRCs will retain the same regional functions as the former CAACs, which is:

- to manage catchments
- to facilitate establishment of Water Resource User Associations and
- to play an advisory role to the WRA.

The county government will have a representative in the BWRC whose water resources rest within the county government's geographical jurisdiction.

Water Resource User Associations (WRUAs)
The act provides for establishment of WRUAs, which are community-based associations for collective management of water resources and resolution of conflicts concerning the use of water resources. The BWRC may contract WRUAs as agents to perform certain duties in water resource management.

Implications for the private sector
The act has established several institutions such as BWRCs and WRUAs that provide different fora for private sector participation in issues of water resource management. Devolution of water service provision to the county government will have a huge implication to commercial financing of WSPs. This may have an impact on the risk profile of WSPs leading to either lack of access to commercial finance or high costs of borrowing. By increasing the mandate of the WRA to include flood mitigation, the act strengthens the WRA's regulatory role. This will impact major water abstractors such as large agriculture water users. The new law has made provision for Public-Private-Partnerships (PPPs) such that Water Service Providers shall be able to engage in partnerships with either public or private entities subject to approval by the regulatory board. The Act has also clarified mandates of county and national governments which were required for PPPs to take off.

5.5.2 Water Supply and Sewerage Services

Water Services Regulatory Board (WASREB)
The constitutionally guaranteed right to water and the need to protect consumers provides a strong basis for the national regulation and monitoring of water and sewerage services. This is critical to protect the interests and rights of consumers from exploitation and to set minimum national standards. As such, the functions of WASREB have been maintained in the 2016 act. WASREB holds the mandate to approve tariffs, monitor and enforce water services standards and issue licenses to Water Service Providers.

Water Works Development Agencies (WWDAs)
The 2016 Water act defines national public water works as water works whose water resource is: cross county in nature, financed out of the national government share of national revenue and intended to serve a function of the national government. These may include assets such as water storage and water work for the bulk distribution of water services. Furthermore, it specifies that development and management of national public works will be undertaken by the WWDAs whilst county public works will be a responsibility of the respective county. The 2016 Water Act provides for handing over of national public works upon commissioning from WWDAs to the county

government, joint committee or authority of the county governments if the water works' assets exclusively rest geographically within their jurisdiction. The national government has the responsibility of supporting county governments to perform their respective duties. As such, upon commissioning of cross county assets, in a case where several county governments collectively want to transfer these assets from WWDA, the Act makes provision for establishment of an authority of county governments or a joint committee. Transfer of the ownership and management of these assets from the WWDA can then be done to the authority of the county governments or joint committee. WWDAs are responsible for the:

- development, maintenance and management of national public works;
- operation of the national public waterworks and provision of water services as a water service provider, until the responsibility for the operation and management of the waterworks is handed over to the county government, joint committee or CCA;
- provision of technical services and capacity building to county governments and water service providers within its region.

Water Services Providers (WSPs)
WSPs are now the responsibility of county governments who have the mandate to provide water services. WSPs are responsible for provision of water services within the area specified in their licenses and development of county assets. Currently, WSBs sign service level agreements with WSPs and the regulator issues licenses to WSB. Under the new Water Act 2016, WSPs must apply again for new licenses to WASREB.

5.5.3 Other Relevant Institutions

Water Tribunal
The new Water Tribunal includes more members and is present in more locations to deal with disputes.

Water Sector Trust Fund
Source of funds for the WSTF mandate have been expanded to include inter alia funds from national budget, county government, equalization fund, donations and grants.

National Water Storage Authority
The NWSA is responsible for development and management of national public water works for water resource management and flood control.

Water Service Regulatory Board (WSRB)
Regulation and monitoring of Water Services Boards; Setting standards for provision of water services; Developing guidelines for water tariffs;

National Water Conservation and Pipeline Corporation
The organisation is responsible for the construction of dams and drilling boreholes in different regions in Kenya.

5.5.4 Regional level

At the regional level, the institutions that are responsible for protection, management and promoting equitable access and use of Nile water resources, including shared aquifers includes the Nile Council of Ministers (Nile-COM); The Nile Technical Advisory Committee (Nile-TAC); The NBI Secretariat (Nile-SEC); NELSAP CU; Eastern Nile Council of Ministers (ENCOM); and Eastern Nile Subsidiary Action Programme Team (ENSAPT).

5.6 Kenyan Monitoring

5.6.1 Water level monitoring

Until recent years, the regular monitoring of groundwater resources was not carried out or was only carried out on a somewhat ad hoc basis. WRA has instituted a monitoring program that targets most of the important Kenyan aquifers. The principal disadvantage of the monitoring network currently in place is that the majority of boreholes used are production boreholes and require water levels to return to static levels prior to the measurements. There is an existing dedicated monitoring borehole in Bungoma Town which can be used to give indication on groundwater use in Mt. Elgon Aquifer. WRA attempts to manually collect water-level and quality trends quarterly in some instances.

5.6.2 Data and information sharing

In Kenya, water resources and allocation data of all kinds are theoretically available for purchase, at costs described in the Rules (GoK 2007). However, in reality these data are often difficult or impossible to obtain; some are held by the MoWI, some by the WRA, and some by the WWDAs/WSPs. There is no centralized repository of data, nor is there anywhere a detailed listing of which agency has what data (and at what cost). This means that water allocation decisions may be based on incomplete data or no data. Laws make this the principal responsibility of the WRA, also the agency that has a most definite need for groundwater data for its archiving and must have ready access to it. The ministry which is responsible for the development of legislation, policy formulation, sector coordination and guidance, and monitoring and evaluation (MoWI, 2007a) certainly needs groundwater data to perform its role, but not necessarily in its raw form.

5.7 Ugandan Overview of Water Resources Management Framework

Uganda's national Water Policy is based on integrated Water Resources Management with the basic unit of implementation at the catchment level, provides the overall policy framework and defines the government's policy objective as: "*To manage and develop the water resources of Uganda in an integrated and sustainable manner, so as to secure and provide water of adequate quantity and quality for all social and economic needs of the present and future generations and with the full participation of all stakeholders*."

IWRM within the river-basin context, is defined as "a process that enables the coordinated management of water, land and related resources within the limits of a basin so as to optimise and equitably share the resulting socio-economic well-being without compromising the long-term health of vital ecosystems."

A key feature of the implementation of IWRM in Uganda by the Ministry of Water and Environment through the Directorate of Water Resources (DWRM), was to provide for de-concentration of management of water resources to the lowest possible local catchment level with the full participation of all stakeholders.

Following the recommendations of the National Water Policy, the Water Sector Reform Study (WSR, 2005), the Joint Sector Review (JSR, 2006) and other national and regional policies as well as steps already taken for implementation purposes, the country was delineated into four (4) Water Management Zones (WMZs) based on hydrological boundaries. The four management zones are namely: Albert Water Management Zone (AWMZ) covering part of the country draining into Lake Albert, Kyoga Water Management zone (KWMZ) covering the part draining into Lake Kyoga, Upper Nile Water Management Zone (UNWMZ) covering part of the country draining into Albert Nile and, Victoria Water Management Zone covering the part draining into Lake Victoria (Fig. 5.2). Each zone is further subdivided into smaller hydrological units called catchments, sub-catchments and micro-catchments to ensure management of the water resources at the lowest possible level.

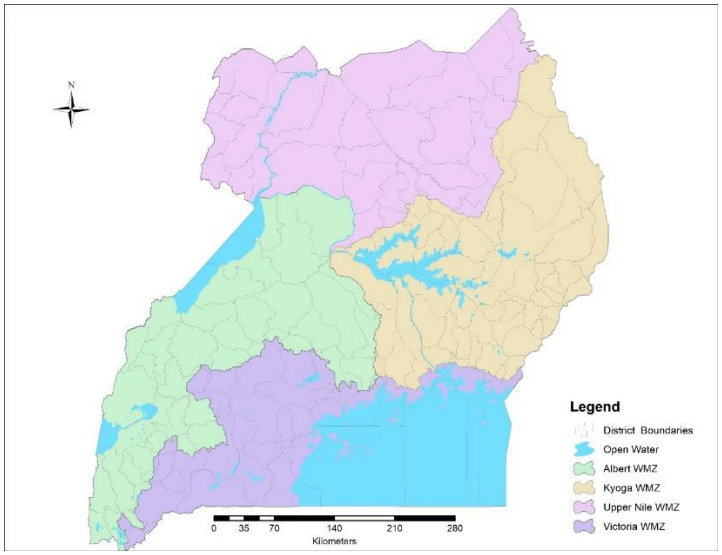


***Figure 5.2**: Map of Uganda showing the Water Management Zones.*

Although groundwater flows do not necessarily coincide with surface water flows, groundwater resources including TBAs are being managed within Catchment based Water Resources Management (CbWRM) framework without due consideration of possible inter-basin transfers. The following sections present the existing policy, legal and institutional framework for management of water resources in Uganda with some additional aspects tailored to management of trans-boundary aquifers in Uganda.

5.8 Ugandan Existing Policy and Legal Framework

5.8.1 Policy and legal context

The Africa Water Vision 2025 states its goal as "*an Africa where there is an equitable and sustainable use and management of water resources for poverty alleviation, socio-economic development, regional cooperation, and the environment*" and the water policy reform initiative is aimed at realising this vision for water management in Uganda within the IWRM framework. Worth noting is the fact that sustainable management of water resources is not limited to physical management but also incorporates legislation, policies, economic tools, institutions, and stakeholders involved in management, regulation, and utilisation of water resources. Whilst water is essential to livelihoods, and always provides for subsistence and survival, it does not solely drive economic development.

Many other factors also have to be in place if the provision of water is to have its full beneficial impact on society. A strong cooperative approach between role-players and especially governmental institutions is, therefore, essential to work together within their respective legislative and policy mandates to promote the approach to IWRM and to ensure the best economic, social and environmental development. A synopsis of the legal context in Uganda under which IWRM is implemented and managed is provided by:

- The Constitution of the Republic of Uganda
- National Policies
- National Legislation
- Trans-boundary considerations, and
- International Conventions

5.8.2 The Constitution of the Republic of Uganda (1995)

The Constitution of the Republic of Uganda sets a number of national guiding principles relating to, and supporting the principles of sustainable development including having balanced and equitable development, which requires that the State adopts an integrated and coordinated planning approach. It further stipulates that the State ensures balanced development between different areas of Uganda and between the rural and urban areas with special measures employed to favour the development of the least developed areas. Through the constitution, the State is entrusted to protect important natural resources including land, water, wetlands, minerals, oil, and fauna and flora on behalf of the people of Uganda. The state must further endeavour to fulfil the fundamental rights of all Ugandans to social justice and economic development, with all developmental efforts directed at ensuring the maximum social and cultural well-being of the people. In terms of the Constitution, all Ugandans have a right to education, health services, clean and safe water, work, decent shelter, adequate clothing, food security, and pension and retirement benefits. The State

must promote sustainable development and public awareness of the need to manage land, air, water resources, as well as use of natural resources, in a balanced and sustainable manner for the present and future generations. All possible measures must be taken to prevent or minimise damage to land, air, and water resources resulting from pollution or other causes. The Constitution entrusts the State to ensure the conservation of natural resources and promote the rational use of natural resources to safeguard and protect the biodiversity of Uganda. Through all this, the Constitution sets the scene for Integrated Water Resource Management in Uganda.

5.8.3 National Policies

National Water Policy (1999)

The 1999 National Water Policy provides an overall policy framework that defines the Government's policy objective as managing and developing water resources of Uganda in an integrated and sustainable manner, to secure and provide water of adequate quantity and quality for all social and economic needs sustainably, with the full participation of all stakeholders (DWRM, MWE, 2012). According to the National Water Policy and the Water Act Cap 152, the responsibilities to provide water services and to maintain facilities were devolved to local councils in districts and urban centres. The role of the Central Government's Agencies is that of guiding and supporting as required. The Act thus emphasises the shared responsibilities in development and management of water resources among stakeholders, including the Private Sector and non-governmental organisations (NGOs) to regulate human activities that can pose risks to water resources. It also provides for pollution control measures with associated penalties and fines. The existing policy and legal framework promote wise use of water resources from the lowest possible level, while considering roles to be played by different stakeholders at different levels. This offers an opportunity to ensure that communities can actively participate in the development and maintenance of water sources within a given catchment.

National Policy for the Conservation and Management of Wetland Resources (1995)

The national policy for the conservation and management of wetland resources (1995) is aimed at restricting the continued loss of wetlands and their associated resources and aims to ensure that benefits derived from wetlands are sustainably and equitably distributed to all people of Uganda. The wetlands policy calls for:

- No drainage of wetlands unless more important environmental management requirements supersede;
- Sustainable use to ensure that benefits of wetlands are maintained for the foreseeable future;
- Environmentally sound management of wetlands to ensure that other aspects of the environment are not adversely affected;
- Equitable distribution of wetland benefits; and
- The application of environmental impact assessment procedures on all activities to be carried out in a wetland to ensure that wetland development is well planned and managed.

Wetland related issues have been incorporated into the National Environmental Statute 1995. The Wetlands Policy is strengthened by a supplementary law specifically addressing wetland concerns. Wetland resources are regarded as forming an integral part of the environment and is recognised that present attitudes and perceptions of Ugandans regarding wetlands be changed. Wetland

conservation requires a coordinated and cooperative approach involving all the concerned people and organisations in the country, including the local communities. Within the context of the guiding principles, the National Wetlands Policy set five goals namely:

- To establish the principles by which wetland resources can be optimally used over time;
- To end practices, which reduce wetland productivity;
- To maintain the biological diversity of natural or semi-natural wetlands;
- To maintain wetland functions and values; and
- To integrate wetland concerns into the planning and decision making of other sectors.

Uganda National Land Policy

The Uganda National Land policy provides a framework for articulating the role of land in national development, land ownership, distribution, utilisation, alienability, management, and control of land. The Land Policy has a specific objective that seeks to ensure sustainable utilisation, protection and management of environmental, natural and cultural resources on land for national socio-economic development. It seeks to ensure that all land use practices and plans conform to principles of sound environmental management, including biodiversity, preservation, soil and water conservation, and sustainable land management. Section 6.7, item 140 of the policy promotes optimal and sustainable use and management of environment and natural resources for the present and future generations.

National Forestry Policy

The National Forestry policy provides for the establishment, rehabilitation and conservation of watershed protection forests. It aims at promoting the rehabilitation and conservation of forests that protect the soil and water in Uganda's key watersheds and river systems.

The Renewable Energy Policy for Uganda

The overall goal of the Renewable Energy policy is to increase the use of modern renewable energy. One of the key policy principles (Clause 3.3[8]) is Stakeholder Participation and the Poor which encourages the participation of communities in renewable energy projects and indicates that these should take into account the needs of the poor. Furthermore, as a policy objective, the document seeks to mainstream gender and poverty issues in renewable energy development strategies to improve the socio-economic wellbeing of women and the poor in general. Renewable sources of energy include solar energy, hydropower, biomass, wind, and geothermal as well as peat and wastes.

5.8.4 National legislation

Water Act Cap 152 (1997)

Uganda's Water Act Cap 152 provides for the use, protection and management of water resources and supply; and facilitates the devolution of water supply and sewerage undertakings. Its objectives are:

i. To promote the rational management and use of the water resources of Uganda by:
    - Use of appropriate standards and techniques for the investigation, use, control, protection, management and administration of water resources;
    - Coordinating all public and private activities which may influence the quality, quantity, distribution, use or management of water resources;

- Coordinating, allocating and delegating responsibilities for the investigation, use, control, protection, management or administration of water resources.

ii. To promote the provision of a clean, safe and sufficient supply of water for domestic purpose
iii. To ensure appropriate development and use of water resources other than for domestic use, e.g., watering of stock, irrigation and agriculture, industrial, commercial and mining uses, generation of energy, navigation, fishing, preservation of flora and fauna and recreation in ways which minimise damage to the environment; and
iv. To control pollution and promote the safe storage, treatment, discharge and disposal of waste, which may pollute water or otherwise harm the environment and human health.

According to the National Water Policy (1999) and the Water Act Cap 152, the responsibilities to provide water services and to maintain facilities are devolved to local councils in districts and urban centres, with full mandates to construct, acquire or alter any water supply work. The role of the Central Government's Agencies is that of guiding and supporting as required. The Act thus emphasises the shared responsibilities in development and management of water resources among stakeholders (including the Private Sector and NGOs) to regulate human activities that can pose risks to water resources. It also provides for pollution control measures with associated penalties and fines. Other Water Sector related policies form synergies with the Water Policy include:

- The National Gender Policy of 1999, which recognises women and children as the key stakeholders of water;
- The Local Government Act of 1997, which underscores the role of Local Government in provision and management of water and sanitation, empowering the local authorities to plan and to implement development interventions according to local needs;
- The 1998 Land Act, which stipulates the responsibility of the Central and Local Government in protecting environmentally sensitive areas such as natural lakes, rivers, groundwater, natural ponds, natural streams, wetlands, forest reserves, national parks and any other land reserved for ecological and tourist purposes; and
- The 1998 Water Abstraction and Water (waste) Discharge Regulations for controlling water abstraction and wastewater discharge, to promote sustainable and environmentally friendly development and use of water resources. Some issues feature at the level of the policy and regulatory framework while others are crucial at catchment level. For instance, plans to develop irrigation schemes necessitate the development of a proper mechanism to protect water user rights and to settle disputes, especially between upstream and downstream water users. Issues of equity exist, whereby some users, often powerful up-stream users, put their interests first. In establishing the mechanism to handle user rights and conflict resolution, issues of active participation of all concerned stakeholders, including women, livestock keepers, and youths, should be taken into consideration.

The existing policy and legal framework promote wise use of water resources from the lowest possible level, while considering roles to be played by different stakeholders at different levels. This offers an opportunity to ensure communities actively participate in development and maintenance of water sources.

National Environment Act (1995)

The National Environmental Act provides for "*sustainable management of the environment; to establish an authority as a coordinating, monitoring, and supervisory body for that purpose; and for other matters incidental to or connected with the foregoing*". The Act makes provision for a tiered approach to environmental planning, commencing with a National Environmental Management Plan to be prepared and reviewed every five years. Each district is required to compile a district environmental action plan every three years that compliments the National Environmental Management Plan. Both of these plans are made available to the public. At a project scale, the Act stipulates that developments of a certain nature (as determined under Section 19(7) of the Act) are required to undertake detailed Environmental Impact Assessment process in a prescribed manner. The Act also makes provision for the monitoring of air and water quality and makes provision for the establishment and implementation of minimum standards pertaining to emissions and effluent. Section 34 of the Act deals specifically with limitations in the use of rivers and lake systems and aims to minimise the negative impacts and control activities that have the potential to be detrimental to these systems. The Act goes on to make specific provisions for the protection of river banks and lake shores in Section 35 and protection and management of wetland systems in Section 36 and 37, respectively. Hilly and mountainous areas have also been identified as areas requiring special attention and protection by the Act. The Act makes provision for the restoration of vegetative cover in these areas. This Act coupled with the provisions made in the Prohibition of the Burning of Grass Act (1974) and the Forest Act (1947) and the Cattle Grazing Act (1945) provides a good basis for restoration, protection and management of vegetative cover in hilly and mountainous areas.

5.8.5 Transboundary considerations

The trans-boundary nature of Uganda's water resources is such that there are a number of international conventions relating to management of water resources with which Uganda must comply. Currently, the key conventions/organisations to which Uganda is party are; the Protocol for Sustainable Development of Lake Victoria Basin and Nile Basin Initiative.

5.8.6 Legal Framework for the Sustainable Management of the Nile Waters

Treaties regarding the management of the waters of the Nile basin date back to 1929 when Great Britain and Egypt signed an agreement under which no irrigation, power works or other measures were to be constructed or undertaken on the Nile, and its branches, or on lakes from which it flows in the Sudan, or in countries under British administration except with the previous agreement of the Egyptian government. The Agreement was followed by the 1959 Agreement on the Full Utilisation of the Nile Waters, which was signed between Egypt and Sudan. The 1959 Agreement allocates the waters of the Nile between the two signatory states.

Agreed Curve for the Lake Victoria Release

Before the construction of the Nalubale (Owen Falls) Dam, which began in 1951, the outflows from Lake Victoria were controlled naturally by the Ripon Falls some 3 km upstream of the dam site. After study of the discharge measurements, which had been made since 1923 at Namasagali, about 80 km downstream of the lake outfall, an Agreed Curve was established, which described the natural relation between lake levels measured at the Jinja gauge and simultaneous measured outflows from the lake. Since 1954 (when the Nalubale Dam was completed), water flow from the lake has been constrained to mimic the natural outflows from the lake using a rating "Agreed Curve" that correlates the flow of the Nile at the source with Lake Victoria water level.

Nile Basin Cooperative Framework Agreement
The Nile Basin countries embarked on the process of negotiating and developing a new agreement for the sustainable management and development of the shared Nile water resources in the 1990s. This process is still on-going and it is envisaged that once these negotiations are successfully concluded, the resulting agreement will supersede all the existing Nile water agreements. (NELSAP, 2012).

The Lake Victoria Basin Commission
The Lake Victoria Basin Commission which was established under article 33 of the "Protocol for Sustainable Development of Lake Victoria Basin" has a broad function of promoting, facilitating and coordinating activities of different actors towards sustainable development and poverty eradication of the Lake Victoria Basin. These activities include inter alia catchment management interventions.

5.8.7 International Conventions

Ramsar Convention (1971)
The Convention on Wetlands (Ramsar, Iran, 1971) is an intergovernmental treaty that commits member countries to maintain the ecological character of Wetlands of International Importance and to plan for the "wise use", or sustainable use, of all of the wetlands in their territories. The Convention's mission is "the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world. "The wise use of wetlands is defined as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development." Uganda signed the Convention on the 4th July 1988. It currently has 12 Ramsar registered wetland systems, representing a combined area of 454,303 ha.

UN Framework Convention on Climate Change (UNFCCC) and related Kyoto Protocol
Uganda ratified the UNFCCC in 1993 and is one of the Least Developed Countries (LDCs). The First National Communication to the UNFCCC was developed in 2002. A Climate Change Policy was launched in 2012, with a related prioritisation of outputs under a short (1-5 years), medium (6 to 10 years) and long-term (10-15 years) timeframes. The priorities in the National Climate Change Policy have been integrated in the National Development Plans (NDP) starting with the Second National Development Plan (NDP II) 2015/16 – 2019/2020.

UN Convention on Biological Diversity
The Convention's main objective is to ensure the conservation of biological diversity and sustainable use of its components. The study process should undertake thorough investigation of the sites and come up with lists of biodiversity in the areas and available information indicate that none of the groups are threatened, rare or vulnerable, hence no impact of the project on such groups.

UN SDG 6: Clean Water and Sanitation; Helsinki Declaration on the protection of the ozone layer (1989).

5.8.8 International conventions for shared water resources

There are a number of international conventions relating to management of shared water resources with which Uganda must comply. Currently, the key conventions/organisations to which Uganda is party are; the Protocol for Sustainable Development of Lake Victoria Basin and Nile Basin Initiative referred to above. In addition, the International Law Commission has provided the under listed Draft articles on the Law of Trans-Boundary Aquifers.

Part I: General Principles

Article 3: Sovereignty of aquifer States

Each aquifer State has sovereignty over the portion of a trans-boundary aquifer or aquifer system located within its territory. It shall exercise its sovereignty in accordance with international law and the present draft articles.

Article 4: Equitable and reasonable utilization

Aquifer States shall utilize trans-boundary aquifers or aquifer systems according to the principle of equitable and reasonable utilization, as follows:

a. they shall utilize trans-boundary aquifers or aquifer systems in a manner that is consistent with the equitable and reasonable accrual of benefits therefrom to the aquifer States concerned;
b. they shall aim at maximizing the long-term benefits derived from the use of water contained therein;
c. they shall establish individually or jointly a comprehensive utilization plan, taking into account present and future needs of, and alternative water sources for, the aquifer States; and
d. they shall not utilize a recharging trans-boundary aquifer or aquifer system at a level that would prevent continuance of its effective functioning.

Article 5: Factors relevant to equitable and reasonable utilization

1. Utilization of a trans-boundary aquifer or aquifer system in an equitable and reasonable manner within the meaning of draft article 4 requires taking into account all relevant factors, including:
    a. the population dependent on the aquifer or aquifer system in each aquifer State;
    b. the social, economic and other needs, present and future, of the aquifer States concerned;
    c. the natural characteristics of the aquifer or aquifer system;
    d. the contribution to the formation and recharge of the aquifer or aquifer system;
    e. the existing and potential utilization of the aquifer or aquifer system;
    f. the actual and potential effects of the utilization of the aquifer or aquifer system in one aquifer State on other aquifer States concerned;
    g. the availability of alternatives to a particular existing and planned utilization of the aquifer or aquifer system;
    h. the development, protection and conservation of the aquifer or aquifer system and the costs of measures to be taken to that effect;
    i. the role of the aquifer or aquifer system in the related ecosystem.
2. The weight to be given to each factor is to be determined by its importance with regard to a specific trans-boundary aquifer or aquifer system in comparison with that of other

relevant factors. In determining what is equitable and reasonable utilization, all relevant factors are to be considered together and a conclusion reached on the basis of all the factors. However, in weighing different kinds of utilization of a trans-boundary aquifer or aquifer system, special regard shall be given to vital human needs.

Article 6: Obligation not to cause significant harm

1. Aquifer States shall, in utilizing transboundary aquifers or aquifer systems in their territories, take all appropriate measures to prevent the causing of significant harm to other aquifer States or other States in whose territory a discharge zone is located.
2. Aquifer States shall, in undertaking activities other than utilization of a trans-boundary aquifer or aquifer system that have, or are likely to have, an impact upon that trans-boundary aquifer or aquifer system, take all appropriate measures to prevent the causing of significant harm through that aquifer or aquifer system to other aquifer States or other States in whose territory a discharge zone is located.
3. Where significant harm nevertheless is caused to another aquifer State or a State in whose territory a discharge zone is located, the aquifer State whose activities causes such harm shall take, in consultation with the affected State, all appropriate response measures to eliminate or mitigate such harm, having due regard for the provisions of draft articles 4 and 5.

Article 7: General obligation to cooperate

1. Aquifer States shall cooperate on the basis of sovereign equality, territorial integrity, sustainable development, mutual benefit and good faith in order to attain equitable and reasonable utilization and appropriate protection of their trans-boundary aquifers or aquifer systems.
2. For the purpose of paragraph 1, aquifer States should establish joint mechanisms of cooperation.

Article 8: Regular exchange of data and information

1. Pursuant to draft article 7, aquifer States shall, on a regular basis, exchange readily available data and information on the condition of their trans-boundary aquifers or aquifer systems, in particular of a geological, hydrogeological, hydrological, meteorological and ecological nature and related to the hydrochemistry of the aquifers or aquifer systems, as well as related forecasts.
2. Where knowledge about the nature and extent of a trans-boundary aquifer or aquifer system is inadequate, aquifer States concerned shall employ their best efforts to collect and generate more complete data and information relating to such aquifer or aquifer system, taking into account current practices and standards. They shall take such action individually or jointly and, where appropriate, together with or through international organizations.
3. If an aquifer State is requested by another aquifer State to provide data and information relating to an aquifer or aquifer system that are not readily available, it shall employ its best efforts to comply with the request. The requested State may condition its compliance upon payment by the requesting State of the reasonable costs of collecting and, where appropriate, processing such data or information.

4. Aquifer States shall, where appropriate, employ their best efforts to collect and process data and information in a manner that facilitates their utilization by the other aquifer States to which such data and information are communicated.

Part II: Trans-boundary Aquifer Management

Article 9: Bilateral and regional agreements and arrangements

1. For the purpose of managing a particular trans-boundary aquifer or aquifer system, aquifer States are encouraged to enter into bilateral or regional agreements or arrangements among themselves. Such agreements or arrangements may be entered into with respect to an entire aquifer or aquifer system or any part thereof or a particular project, programme or utilization except insofar as an agreement or arrangement adversely affects, to a significant extent, the utilization, by one or more other aquifer States of the water in that aquifer or aquifer system, without their express consent.

Part III: Protection, Preservation and Management

Article 10: Protection and preservation of ecosystems

1. Aquifer States shall take all appropriate measures to protect and preserve ecosystems within, or dependent upon, their trans-boundary aquifers or aquifer systems, including measures to ensure that the quality and quantity of water retained in an aquifer or aquifer system, as well as that released through its discharge zones, are sufficient to protect and preserve such ecosystems.

Article 11: Recharge and discharge zones

1. Aquifer States shall identify the recharge and discharge zones of trans-boundary aquifers or aquifer systems that exist within their territory. They shall take appropriate measures to prevent and minimize detrimental impacts on the recharge and discharge processes.
2. All States in whose territory a recharge or discharge zone is located, in whole or in part, and which are not aquifer States with regard to that aquifer or aquifer system, shall cooperate with the aquifer States to protect the aquifer or aquifer system and related ecosystems.

Article 12: Prevention, reduction and control of pollution

1. Aquifer States shall, individually and, where appropriate, jointly, prevent, reduce and control pollution of their trans-boundary aquifers or aquifer systems, including through the recharge process, that may cause significant harm to other aquifer States. Aquifer States shall take a precautionary approach in view of uncertainty about the nature and extent of a trans-boundary aquifer or aquifer system and of its vulnerability to pollution.

Article 13: Monitoring

1. Aquifer States shall monitor their trans-boundary aquifers or aquifer systems. They shall, wherever possible, carry out these monitoring activities jointly with other aquifer States concerned and, where appropriate, in collaboration with competent international organizations. Where monitoring activities cannot be carried out jointly, the aquifer States shall exchange the monitored data among themselves.
2. Aquifer States shall use agreed or harmonized standards and methodology for monitoring their trans-boundary aquifers or aquifer systems. They should identify key parameters that

they will monitor based on an agreed conceptual model of the aquifers or aquifer systems. These parameters should include parameters on the condition of the aquifer or aquifer system as listed in draft article 8, paragraph 1, and also on the utilization of the aquifers or aquifer systems.

Article 14: Management

1. Aquifer States shall establish and implement plans for the proper management of their trans-boundary aquifers or aquifer systems. They shall, at the request of any of them, enter into consultations concerning the management of a trans-boundary aquifer or aquifer system. A joint management mechanism shall be established, wherever appropriate.

Article 15: Planned activities

1. When a State has reasonable grounds for believing that a particular planned activity in its territory may affect a trans-boundary aquifer or aquifer system and thereby may have a significant adverse effect upon another State, it shall, as far as practicable, assess the possible effects of such activity.
2. Before a State implements or permits the implementation of planned activities which may affect a trans-boundary aquifer or aquifer system and thereby may have a significant adverse effect upon another State, it shall provide that State with timely notification thereof. Such notification shall be accompanied by available technical data and information, including any environmental impact assessment, in order to enable the notified State to evaluate the possible effects of the planned activities.
3. If the notifying and the notified States disagree on the possible effect of the planned activities, they shall enter into consultations and, if necessary, negotiations with a view to arriving at an equitable resolution of the situation. They may utilize an independent fact-finding body to make an impartial assessment of the effect of the planned activities.

5.9 Ugandan Institutional Context

5.9.1 National Level

The Ministry of Water and Environment (MWE) plans and coordinates all water and environmental sector activities and is the ultimate authority responsible for water resources and environmental management in Uganda. The MWE has the overall responsibility for setting national policies and standards related to water and the environment, managing and regulating all water resources and determining priorities for water development and management. The MWE is divided into three directorates: Directorate of Water Resource Management (DWRM), the Directorate of Water Development (DWD), and the Directorate of Environmental Affairs (DEA).

The DWD has the responsibility for providing overall technical oversight for the planning, implementation, and supervision of the delivery of urban and rural water and sanitation services across the country including water for production. It is responsible for regulating the provision of water supply and sanitation and the provision of capacity development and other support services to Local Governments, Private Operators and other service providers. The Directorate comprises of four Departments: Rural Water Supply and Sanitation, Urban Water Supply and Sewerage Services, Water Utility Regulation and Water for Production.

The DEA is responsible for environmental policy, regulation, coordination, inspection, supervision and monitoring of the environment and natural resources as well as the restoration of degraded ecosystems and mitigating and adapting to climate change. The DEA comprises of three departments of Environmental Support Services (DESS), Forestry Sector Support Department (FSSD) and Wetlands Management Department (WMD).

DWRM is responsible for managing and developing water resources of Uganda in an integrated and sustainable manner in order to provide water of adequate quantity and quality for all social and economic needs for the present and future generations. The Directorate comprises of four departments namely Water Resources Monitoring and Assessment Department (WRMAD), Water Resources Planning and Regulation Department (WRPRD), Water Quality Management Department (WQMD) and the International Transboundary and Water Affairs Department (ITWAD).

The ITWAD is not yet fully operational. At the local level, there are no dedicated management arrangements for trans-boundary aquifers but there exists an opportunity to make use of catchment-based water resources management structures that were established based on surface hydrological boundaries. Though linked, groundwater and surface water rarely share hydrological boundaries which in the current arrangement results in groundwater resources not being accorded adequate attention. There is therefore, need for delineation and gazettement of major aquifers; these groundwater bodies should be accorded special development and management arrangements such as is the case of Edwards Aquifer Authority in San Antonio, USA. For the case of trans-boundary aquifers such as Mount Elgon Aquifer, the development and management arrangements should ensure full participation of the sharing states. For the Mount Elgon aquifer, no groundwater management policies and mandates exist and hence the urgent need to formulate them in order to avoid future conflict among users especially between the sharing states.

The MWE further works closely with four semi-autonomous entities namely: the National Environment Management Authority (NEMA), which is mandated with the coordination, monitoring, regulation, and supervision of environmental management; the National Water and Sewerage Corporation (NWSC) - with the mandate to operate and provide water and sewerage services in the larger urban centres; the National Forest Authority (NFA), whose mandate is to manage Central Forest Reserves and to supply high quality forestry-related products and services; and the Uganda National Meteorological Authority (UNMA), slated to return to the ministry as a department under the new restructuring of government MDAs. UNMA is mandated with weather and climate services (UNMA Act. 2012) and a is focal institution to Inter-Governmental Panel on Climate Change (IPCC), an international body mandated to carryout scientific research on climate change.

Other national entities significantly impacted by technical water management issues are the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF); the Ministry of Tourism and Industry (MTI); and the Ministry of Energy and Mineral Development (MEMD). The Ministry of Education and Sports (MoES) is responsible for the implementation of Water and Sanitation in schools, and the Ministry of Health (MOH) is responsible for sanitation via the environmental health department.

The Ministry of Local Government (MLG) oversees the implementation of Local Government Development Plans, which include water supply and programmes for the improvement of hygiene and sanitation in institutions and public places. There are a number of development partners, private sector, and NGOs that also act in the water sector providing services, advice, and facilitation. A number of NGOs active in the water sector are coordinated at the national level through the Uganda Water and Sanitation NGO Network (UWASNET), an umbrella organisation largely funded by development partners and the MWE. An outline of the national organisations directly or indirectly involved in water management (Fig. 5.3).

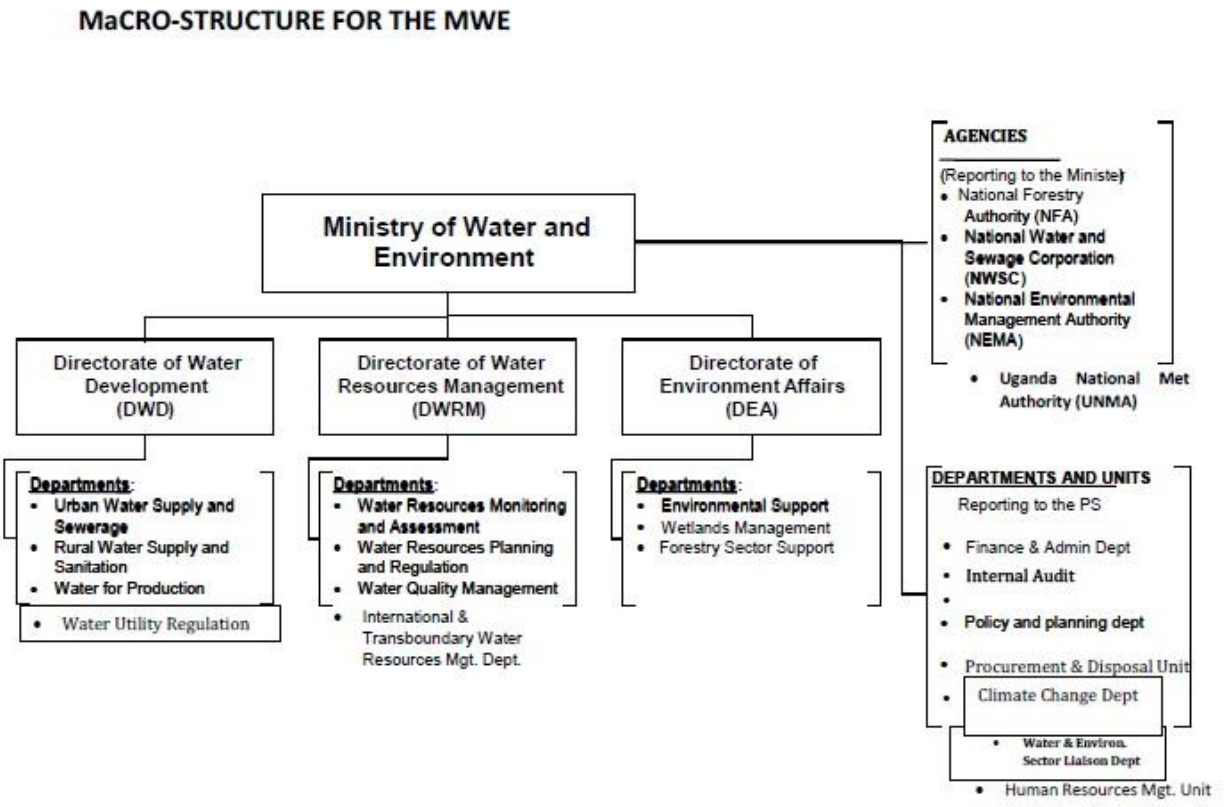


Figure 5.3: *Institutional Setup at a National Level in Uganda (MWE, 2015).*

Coordination is a key process for Integrated Water Resources Management (IWRM), which involves multiple stakeholders from different sectors, on different scales, and with different structures and interests. At the national level, the following committees are relevant to integrated water resources management:

- The Policy Committee on Environment: chaired by the Prime Minister, at the highest level of political decision-making
- The Water Policy Committee, which is composed of directors, and enables high-level and strategic dialogue specifically in the water sector,

- The IWRM Working group, which is an informal working group enabling technicians to coordinate;
- The Water and Environment Sector Working Group (WESWG).
- The Inter-Ministerial Technical Committee regarding Water for Production, comprising members from the MWE, Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), Office of the Prime Minister, National Planning Authority, and Ministry of Finance. It meets on a quarterly basis to coordinate investments and works regarding water for production;
- The Wetlands Advisory Group (WAG), which is a technical group dedicated to wetlands. The WAG improves coordination on wetlands issues, particularly on the issue of dry land rice;
- The MWE-DWRM has created Water Net, a network for building capacities of stakeholders connected to the water sector.

The National Environment Management Authority (NEMA) is the apex body for environmental law enforcement in Uganda. However, several functions have been delegated to other institutions as lead agencies in their respective fields. NEMA is in charge of:

- Review and administrative clearance of environmental evaluations, in conjunction with other lead agencies;
- Delivery of permits (for instance, permits for activities within the legal buffer zones of water bodies); the responsibility of delivering permits is vested into the different lead institutions;
- Monitoring compliance; the responsibility of control is distributed over 375 gazetted inspectors (2014) distributed in many Ugandan institutions (including the MWE). Only 30 of them belong to NEMA.

An Environmental Police has been formed at NEMA, comprising 25 officers. Only five regional Environmental Police officers (liaison officers) have been designated, among which one is based in Mbale (for the eastern region: his area covers 52 districts corresponding to a quarter of the country) and one in Jinja (for the south-eastern region). The liaison officers belong to the regular police but are specifically trained in environmental issues. They are under the command of the territorial police (Regional Police Commander/District Police Commander). Their functions include sensitisation, demarcation, control, issuing warnings, following up of cases, eviction, and prosecution. Within each district, there are offices that are in charge inter alia of the environment, forestry, wetlands, agriculture, fisheries, planning. However, the structure varies from district to district.

5.9.2 Regional Level

As a result of the deconcentration of the management of water resources, DWRM created four Water Management Zones (WMZ) following hydrological boundaries. They operate on regional level with the objective to bring the central services closer to the stakeholders. Their primary role is to facilitate sustainable development of the water resources for the economic and social benefit of the people in the catchment and to implement the water management measures needed to protect and conserve the catchment and its water resources, ensure sustainability, and reduce or resolve conflicts over resource use. The DWD established the Water and Sanitation Development Facility (WSDF) as a mechanism for supporting water supply and sanitation facilities for rural growth centres and small towns, intended to promote a demand responsive approach where Water

Authorities/Town Councils or Town Boards apply for funding. The successful applicant is assisted by the WSDF to develop piped water supply systems. Technical Support Units (TSU) established by DWD at the regional level have the mandate to support capacity building of district-based structures. This involves training, technical advice and support supervision of districts to enable them to effectively implement their roles in the rural sub-sector. The mandate also covers water for production. Umbrella Organizations (UO) are also regional organisations constituted as associations of the local Water Supply and Sanitation Boards (WSSBs) with the principle objective of providing operation and maintenance (O&M) back-up support (training, technical, legal and organisational support, supervision of rehabilitation, and extension works as well as water quality monitoring). The DWD has further deployed staff from its Department of Water for Production to the regions while DEA has also established offices for its Wetlands Department on regional level. These deconcentrated units in the regions are based together for improved cooperation and integration and represent the MWE on a regional level.

5.9.3 Catchment Level

During the catchment management planning process, an institutional framework has to be created, which brings the stakeholders together to present and exchange their views and thus give the process legitimacy. Hence, the WMZ establishes Catchment Management Organisations (CMOs), which builds on and utilises to the maximum practicable extent, existing structures and relationships. The CMOs consists of several bodies (Fig. 5.4):

- The Catchment Stakeholder Forum (CSF) brings together all actors on catchment management. The CSF defines key issues related to water resources in the catchment that require consideration in order to effectively protect, manage, and develop water resources. It provides input to the CMP for coordinated, integrated and sustainable development and management of water and related resources in the catchment, including their implementation status;
- The Catchment Management Committee (CMC) is composed of representatives of all relevant stakeholder groups (government, politicians, and community-based organisations, NGOs, water users, media, academic institutions, and private sector) and collaborates with the WMZ during the formulation of a Catchment Management Plan and plays a steering role during its implementation. The CMC responsibilities include: coordination of stakeholder-driven definition of key issues related to water resources, promotion of coordinated planning, and implementation as well as stakeholder-driven decision making related to integrated and sustainable development and management of water and related resources, development of plans for coordinated, integrated and sustainable development and management of water and related resources. It endorses the CMP and presents it to the Catchment Stakeholder Forum for information purposes. The CMC acts as an Executive Board for the Catchment Management Organisation.
- The Catchment Management Secretariat (CMS) provides support to the Catchment Management Committee in coordinating the planning and implementation of activities in the catchment as well as following up of recommended actions by the stakeholders. The CMS acts as an administrative secretariat for the Catchment Management Committee as well as the Catchment Technical Committee.
- The Catchment Technical Committee (CTC) forms the technical arm of the CMO and supports the CMC in their tasks. The CTC brings technical expertise and knowledge during the formulation of the Catchment Management Plan, operationalises and sometimes

implements programmes and projects from the plan, and generally ensures that the different districts collaborate to implement the plan. It comprises of technical people from government, NGOs, private sector, development agencies, and other relevant organisations in the catchment.

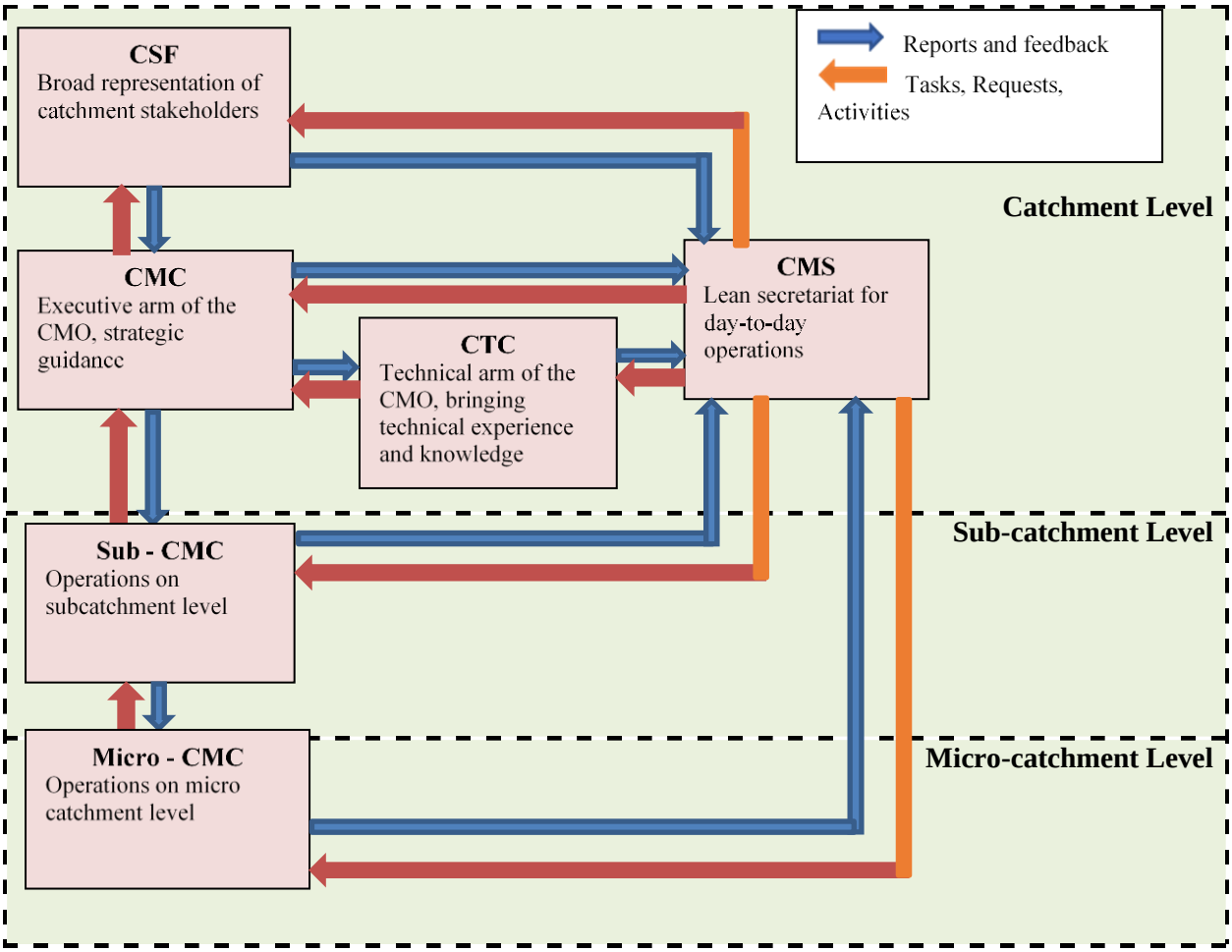


Figure 5.4: *Catchment Management Organisation Structure (DWRM) of Uganda*.

5.9.4 Other relevant institutions

Other relevant institutions on the catchment level are:

- At the District level, the District Natural Resources Department (including the District Environment Office, District Forestry Office, and District Wetlands Office), District Works or Engineering Department under which the District Water Office falls, District Production Department with the District Agricultural Office, District Veterinary Office and District Fisheries Office, District Planning Department, Department of Community Based Services, District Information Department, and District Health Department are key in the implementation of the CMP. However, the structure varies from district to district according to the natural conditions in the district.

- Policies at national level are translated into Sector Development Plans, which are implemented at district level under the Decentralization Policy. Most districts have 5-year district development plans in which all sector plans are integrated. Natural Resources Management activities are mandated to be implemented by every district by Sub-counties, CBOs and CSOs, and Water User Associations.

Additionally, there are a number of private sector and NGOs, which also act in the water sector, providing services, advice and facilitation. They work at catchment and regional level or sometimes combine the two. Many of these NGOs are coordinated at the national level through the Uganda Water and Sanitation NGO Network (UWASNET), an umbrella organisation largely funded by development partners and the MWE.

5.9.5 Institutional Issues

Water resources management in Uganda continues to face some institutional challenges, mainly related with technical capacity, coordination, and enforcement of rules. Table 5.1 summarises the institutional issues and implications highlight some of these challenges.

***Table 5.1**: Ugandan institutional issues and implications.*

Issues	**Background and Implication**
Technical capacity in local authorities	Limited capacity in institutions on local level with limited knowledge base. This has an impact on development and service delivery.
Coordination and cooperation between institutions	Development initiatives by respective institutions are planned independently. Lack of coordination leads to inefficient use of water resources and lack of resource protection.
New institutional framework in water management	CMOs are being established. More direct interaction at local level with institutions will create more awareness and integration. Required capacities are being transferred to the zones.
Water user participation	Formal stakeholder forums are not established yet. Some water sector committees such as water and sanitation advocacy committees need to be expanded. Water sector user groups lack capacity and information on good management practices.
Law enforcement	Limited capacity and political will to enforce legislation lead to degradation of natural resources.
Development of Catchment Management Plans	It is vital that CMPs are implemented to achieve sustainability. All parties need to reach agreement on actual accountability, actual monitoring and actual enforcement as it is here where success or failure of initiatives will be determined.

5.10 Governance conditions of the Mt. Elgon Aquifer

Governance, in this case refers to administrative, economic, social and political systems that are aimed at managing and developing groundwater resources and services at different levels of society. This includes technical capacity, knowledge, financing, and the rights and responsibilities of different players and/or stakeholders in the water sector, specifically covering groundwater resources within the Mt. Elgon aquifer in Kenya. Kenya has an excellent water governance framework, but the issue lies in the implementation of the framework. At the national level, there are overlaps in the responsibilities of the ministry and implementing agencies such as water service providers, Water Resources Authority, and the water boards. The capacity of management of aquifers within the implementing agencies is also relatively low in the country. This creates an inadequacy in the enforcement of legal provisions for controlling abstraction, pollution and borehole drilling in the region, and nationally as well. Additionally, between the public, and staff in the water sector, there is inadequate capacity of the connection between surface water and groundwater, and specific characteristics of groundwater that affects its management.

As an example, Kenya does not have policies, laws, and institutions dedicated specifically to the management of its groundwater. Rather, groundwater management is subsumed under broader policy, legal, and institutional frameworks dealing with the management of water resources, or more broadly, natural resources, and with land use and physical planning. Existing policy, legal, and institutional frameworks are deficient from the perspective of groundwater management. An overhaul is required to bring them in line with the requirements of frameworks for sound groundwater management. Kenya has a draft policy on groundwater protection and provides the requirements for improving groundwater governance in the country. This includes capacity building, empowerment, and increased participation of groundwater users; decentralized management of groundwater resources to the local levels; integrated management of surface water and groundwater; improved monitoring and data collection on groundwater resources.

According to Nsubuga et al. (2014), water resources of a country constitute one of its vital assets that significantly contribute to the socio-economic development and poverty eradication. However, this resource is unevenly distributed in both time and space. Furthermore, they contend that water governance is seen as a range of political, social, economic and administrative systems that are in place to develop and manage water resources and the delivery of water services at different levels of society (Rogers and Hall, 2003). The manner of allocation and regulatory process and interaction in the management of water resources that embraces formal and informal institutions (Turton, et al., 2007) including poverty eradication (Sewagudde, 2011) are a focus of governance. Some of the necessary conditions for good governance are inclusiveness, accountability, participation, transparency, predictability and responsiveness. A major challenge is to understand how all these different processes in concert, determine certain policy outcomes and how change in governance regimes occurs. Nsubuga et al (2014) further observed that for instance policies tend to focus on standard policy solution like liberalization and pricing of water services, which have had counter-productive results. Currently climate change and the related increase in extreme weather events have exposed the vulnerability and lack of resilience of water resource management regimes. At the same time, policies to accommodate the prospects of climate and global change are absent. Consequently, the conditions under which water resources managers have to perform have become increasingly unpredictable especially in a developing country like Uganda.

5.11 Gender considerations

Worldwide, gender equality is considered a human right, and a pre-condition for sustainable development. The aim is to provide women and girls with quality in education, health care, decent work and equal access to resources and opportunities in political and economic decision-making processes will lead to social, economic and environmental sustainability. Gender is a key component in management in water management in general. When President Museveni took over power in 1986, one of his main concerns was gender mainstreaming in all government departments. As a result, the Uganda Gender Policy, 1997 (revised 2007), was developed. In the Second National Development Plan (NDP 11) 2015/16 – 2019/20 all development institutions are required to promote gender equality and women empowerment while executing programmes and activities. The Uganda Gender policy 2007 defines gender as "*the social and cultural construct of roles, responsibilities, attributes, opportunities, privileges, status, access to and control over resources and benefits between women and men, boys and girls in a given society*". Gender attributes attach different roles and responsibilities based on one being either male or female.

Women as well as men have different roles they play in water management in different communities. These roles depend on the water resources available including groundwater. Groundwater sources such as boreholes, well, springs, rain water protected and unprotect springs mainly provide water for domestic and agricultural purposes. Rarely are these sources used for industrial purposes. Women therefore, become the major group of primary users of water and they stand to gain more with improved management of groundwater sources thus making them an important part of water management processes. Children as well especially the girls are directly involved in providing water for household consumption. Women generally take on the pivotal role of the central part in the provision, management, and safeguarding of water (Katusiime and Schütt, 2020).

The Ministry of Water and Environment in Uganda developed a Water and Sanitation Gender Strategy in 2003 which was revised in 2010 and 2017 and an Environment and Natural Resources Gender Strategy in 2015. These guidelines were developed to ensure gender equality and empower women in the different sectors. Uganda's Water and Sanitation Gender Strategy III aims to enable men, women, boys, girls and vulnerable groups through ensuring equity in access to and control of resources in the water and sanitation sub-sector, leading to reduction of poverty levels (MWE, 2018). Therefore, provisions have been made to integrate the gender component in policies, plans and guidelines. Provisions have been through promoting gender mainstreaming in the sector by gender sensitive recruitment, gender responsive work environments, capacity building and knowledge sharing and identifying and appointment of champions.

At the local, district, and government levels, gender mainstreaming has been considered and is included in the WSGS. The district water officers have been tasked with the responsibility of revising all guidelines to include the gender component. Within the work environment, recruitment of district water officers must be carried out in a gender sensitive manner and also appointment of a gender focal person. The water and sanitation and gender strategy also caters for the NGOs/CSOs that are concerned with water management and supply. However, for this particular study in the Elgon region, the field study has not provided a comprehensive picture of gender mainstreaming

in the selected regions to arrive at a representation of the roles played by men, women, children and other vulnerable categories like the old people; their involvement in groundwater either directly or through representation and access.

6. IMPACTS OF CHANGES IN USE, AVAILABILITY AND QUALITY OF GROUNDWATER ON RESOURCE-DEPENDENT COMMUNITIES AND THE ENVIRONMENT

6.1 Identification of gaps in shared aquifers management

Table 6.1*: Gaps identification in the shared management of the Mt. Elgon Aquifer.*

Measure	Problem description	Policy change
1. Data collection/ analysis/ reporting/ management/ resource monitoring	Limited or insufficient skills, knowledge, materials and equipment, resources, collaboration in executing groundwater programs, data not collated and often do not inform policies;	Training and continuous professional development, materials and equipment, approaches (e.g. space technology, geophysics, chemical/isotope tracers) and resources when availed, reconciled with environmental monitoring; the proposed changes could be implemented immediately without consensus
2. Institutional set up and policy/ legal mandates	Need to streamline institutional, policy and legal frameworks; lack of enforcement of existing frameworks due to poor knowledge of groundwater resources, weak institutional capacity, poor funding, and weak political commitment at the senior policy-making level; groundwater is characterized by over-centralized decision-making processes, an inappropriate and run-down monitoring network, inadequate database, discontinuous assessment programs, uncoordinated source development, non-operative water rights, the absence of special courts to arbitrate on water use conflicts, and a	Streamlining and enforcing existing institutional, policy and legal frameworks are changes that require further consensus building and policy change

	generally weak institutional set up.	
3. Shared coordination and shared management	Lack of harmonized coordination and shared management of aquifer system across aquifer region	Harmonising coordination and shared aquifer management arrangements are changes that require further consensus building but no policy change at the national levels; however policy changes are required across the trans-boundary aquifer region
4. Groundwater governance in river basin organizations	Limited emphasis on groundwater; lack of human, technical and financial capacity; limited stakeholder involvement in its management;	Systematic groundwater monitoring and management and stakeholder involvement; data sharing and management; these are changes that require further consensus building but no policy change

6.2 Causal chain analysis

Table 6.2*: Causal chain analysis applied to the Mt. Elgon aquifer system.*

Type of cause	**Major risks to Mt. Elgon aquifer**
a) Immediate or primary causes	
• Reduction of rainfall; • Reduction of spring flow and runoff in rivers; • Reduction of recharge (clogging of the recharge areas due to silting, mass movements and landslides); • Frequent absence/irregularity of rainfall;	Reduction of the water resource
• Natural degradation controlled by geology (e.g. volcanic rocks)	Water quality degradation
• Increase of greenhouse gases in the Troposphere	Impacts of climate variability and changes on groundwater resources
b) Underlying or fundamental causes	
• Increase in water abstraction (increase in the water points); • Increasing water demand (growing population, urbanisation, industrialisation, damming or diversion of streams); • Reduction of the recharge due to silting in human activities on recharge areas	Water quantity reduction and quality degradation

(e.g. land use and land cover, river bank encroachment, deforestation)	
• Pollution from various origins (domestic, industrial, mining, livestock, all kinds of waste water); • Agricultural activities (manures, pesticides, herbicides); • Discharge of pollutants into the rivers having hydraulic connection with the aquifers, mass transport through baseflow; • Land uses and change in land use systems;	Water quantity reduction and quality degradation
• Deforestation (firewood, timber); • Clearing areas for agriculture and other land uses; • Migration of the populations from semi-arid zones to wetland areas; • Mass wasting and landslides from overpopulation and farming unconsolidated volcanic areas; • Land uses and change in land use systems	Water quantity reduction and quality degradation
c) Root causes	
• Weaknesss in consultation and consensus among the riparian countries; • No enforcement of the applicable regulations and policies; • Weaknesses in water governance and awareness; • Decreasing alternative livelihoods;	Water management and governance
• No respect for the current water laws; • Limitations and lack of monitoring and assessment of water quality; • Inadequate water governance; • Decreasing livelihoods;	Water management and governance
• Limited sensitization in groundwater awareness at national and regional levels; • Weakness or lack of commitment of the countries to contribute their financial obligations for research in sustainable solutions; • Shortcomings in use of information derived from datasets to inform policies	Water management and governance

on risk from climatic change/variability and other human-induced activities;	

6.3 Contribution of the TBA in the identification of hydrogeological risk

***Table 6.3**: SWOT Matrix of the SADA contribution.*

Strengths	**Weaknesses**
• The SADA is flexible and offers a wide scope for scaling out across the Mt. Elgon aquifer; • SADA is a participatory approach involving all the key stakeholders for a holistic approach; • The SADA will contribute to a database and a model to management groundwater resources of the Mt. Elgon aquifer region; • Strong political support from regional and national institutions for IWRM; • Local communities are strongly promoting cooperation on groundwater management through existing water users' networks; • Strong policy and legal frameworks exist of water resources and the benefits derived from their use; • Groundwater is generally recognized as supporting the hydrological system; • Experience of collaboration with various stakeholders and partners can foster further joint riparian collaboration and financial capacity;	• The SADA is qualitative, relying on secondary (archived/historical) datasets with minimal inputs from primary field data, thus it does not explore sufficiently the risks faced by the aquifer; • The limited timeframe associated with the SADA does not explore the applicability of the process within a physical environment; • No explicit mandate to address groundwater in legal framework; • Groundwater development is associated mostly with incremental and often private informal, development, not large infrastructure projects; • Little understanding of the TBAs and their potential for human development, as well as their physical extent, connection with other aquifers and surface water and their vulnerabilities to development; • Most water users' associations do not have a water resources strategy or action plan that explicitly considers groundwater; • Limited cooperation between water users' associations and national authorities on groundwater issues; • Limited collaboration between water users' associations on similar water management issues; • Lack of tradition in applying data for management of joint groundwater – surface water resources; • Few resources put into data and knowledge management; • Data monitoring on groundwater is not coordinated across borders leading to limited concerted knowledge on transboundary impact;

	• Understaffing of institutions with respect to hydrogeology expertise; • Little stakeholder involvement at all levels;
Opportunities	**Threats**
• The subsequent components of the program after the SADA provides an opportunity to address some of the issues identified; • The SADA has encouraged cooperation among local, national and regional institutions managing water resources, as well as NBI; • Cooperation with international bodies involved in management of transboundary aquifers is also expected; • Water users' associations provide a suitable platform for integrating management of groundwater into IWRM; • With groundwater becoming of increasing interest for other uses than dispersed domestic use and with already emerging groundwater issues of overuse and degradation, there will be greater emphasis on its management; • Groundwater and TBAs management receive increasing attention from multilateral donors; • There is expressed interest in water users' associations to get more understanding of surface water - groundwater interactions; • Local development communities can emphasize groundwater in their IWRM framework; • Better tools for assessing surface water - groundwater interactions and interdependencies are being developed (e.g., through IAEA on isotopes and tracers); • TBA focus may enhance collaboration at local, national and international levels on groundwater, improving overall management;	• There is need for all stakeholder countries to provide data on groundwater for the success of the initiative; • A comprehensive SADA approach is usually required to be eligible for GEF funding; • Too little national political commitment and support; • Duplication or confusion of roles and responsibilities of existing (national) organizations, e.g., on data management; • General under-capacity of water users' associations for addressing transboundary water management; • Disparities on the capacity and commitment towards joint groundwater resources management; • Financing is not continuous and secured; • Conflicting interests between different stakeholders; • Science/technology is not integrated into management; functions independent of policies and regulation; • Funding requirements for groundwater management is seen as a competitor to surface water alternatives; • National water authorities are largely surface water-centred; • Little collaboration between the surface water and groundwater communities;

7. CONCLUSIONS

Key stakeholders were mapped as follows;

- On the Ugandan side were indentified in categories of: primary (directly affected by IWRM activities) and secondary (indirectly affected); and level of engagement, including national, regional, district and community levels; indigeneous gropus (e.g. Bagisu, Sabinyi, and Benet also known as Ndorobo, Musobishiek, or Ogiek).
- The Kenyan side had categories of indigenous groups (e.g. Ogiek, Sengwer, Yaaku Waata, and the Saanya, Sabaot and pastoralists, e.g. Endorois, Turkana, Maasai and Samburu); and local groups working in the region (e.g. Government and intergovernmental institutions, Community and Civil Society Organizations).
- Stakeholder analysis on the Kenyan side was generated based on their importance (primary, secondary, tertiary) and level of influence (low, high to very high) on groundwater resources development and management issues.
- Groundwater management requires the participation and involvement of various stakeholders from the aquifer/local, county/district and national levels.
- Many stakeholders are involved in groundwater usage and management and their opinions should be considered to enhance trans-boundary aquifer management. For example, the indigenous communities have complained of what they called "*systematic discrimination and marginalization*" in accessing resources including but not limited to water.
- Groundwater sources constructed by both the central and local governments are managed by district/county water officers; some water sources constructed by the NGOs or individual people are managed by the people appointed by funders or such communities elect their own water user committees.

Key drivers and pressures on the aquifer included, agriculture, tourism, mining, manufacturing, trade related activities, water scarcity, climate, population, household needs, industial development, and land degradation.

Shared aquifer characteristics was defined over a working area of 37,486 km^2 of the Mt. Elgon aquifer region well beyond the estimated area of about 4,900 km^2 during the IAEA Project No. AF39.

- In Uganda, the aquifer system lies within the Lakes Kyoga and Turkana basins, largely within the two catchments of Awoja and Mpologoma and underlies at least 9 districts of Kapchorwa. Kween, Amudat, Bududa, Bukwo, Bulambuli, Nakapiripirit, Namisindwa and Sironko; on the Kenyan side it is within the Lakes Victoria and Turkana basins and spans four counties, of West Pokot, Busia Trans-Nzoia and Bungoma.
- Physiography of the region is dominated by Mt. Elgon with its craters, deep valleys and ridges and lies from <1,040 masl to over 4,321 masl at the peak of Wagagai; the terrain to the north and east is lower lying and more rugged than the terrain to the east and south which is higher and slopes more gently away from the volcanic massif.
- Climate follows a bimodal pattern with long (heavier) rains from March to May and the short (lighter) rains from October to November, mean annual rainfall is 687 to 2,544 mm. Mean monthly temperatures in the southern part range between 15 °C and 27 °C while at the northern extreme part, is up to 32^{o}C. Mean annual actual evapotranspiration and interception varies between 460 and 1800 mm.

- Rivers on the Kenyan side include Kuywa, Sosio, Kibisi, Sio-Malaba/Malakisi, Ewaso-Rongai Noigamaget and Sabwani, forming the main tributaries of River Nzoia which drains into Lake Victoria. River Suam also originates from the Mt. Elgon slopes. River Nzoia flows southwards to Lake Victoria while River Sipi originates from the northeastern part of Mt. Elgon and flows towards the central Nile Basin.
- Land use and land cover shows that the southern parts of the Mt. Elgon aquifer region is highy cropped and built up. Around Mt. Elgon is a thick tree cover with shrubs towards its peak. The low-lying northern parts of the region is largely covered by shrub and grasslands.
- The soils are >50% underlain by haplic vertisols; other key soil types include haplic ferralsols, eutric gleysols, albic plinthosols, rhodic ferralsols, haplic acrisols, plinthic acrisols, eutric fluvisols, chromic and cambisols.
- The geology is grouped into main lithologic units; (i) volcanic rocks (volcanic lava, tuff, agglomerates, mudflow and nephelinite); (ii) sediments (alluvial and lacustrine sediments, outwash debris and laterite); (iii) gneissic basement (gneiss, granulite, migmatite, charnokite and basement); (iv) intrusive igneous rocks (granite, gabro, diorite, granodiorite, granitoid, pegmatite, fenite and ijolite); (v) extrusive igneous rocks (carbonatite, phonolite, nephelinite, basalt, rhyolite, marble and metasomatic rocks); (vi) meta sedimentary and volcanic rocks (amphibolite, schist, quartzite and metavolcanic rocks); and (vii) sedimentary rocks (sandstone, mudstone, arkose, conglomerate and grit).

Groundwater replenishment originates from the region around the volcanic massif considered to form the recharge area, which discharges to the outlying catchment areas.

- The aquifer is considered a multi-layered hydraulically connected, largely semi-confined aquifer whose lithology is predominantly crystalline rocks, that unconformably overlies the basement complex, which in the highland sections of agglomerate lava forms an aquitard offering the aquifer, semi-confined/ leaky conditions.
- Depth to the water table ranges from ground level to 90 mbgl, with mean and median values of 9.4 and 7 mbgl, respectively.
- The depth of the aquifer is up to 300 mbgl, with mean and median values of 60.5 and 55.6 mbgl, respectively.
- Vertical thickness of the aquifer has mean and median values of 29.9 and 28.0 m, respectively.
- Thicknes of confining layers ranges up to 65.8 m, with mean and median values of 20.4 and 21.0 m, respectively.
- Local residual of rainfall and evaporation on the Kenyan side ranges from 100 to 567 mm yielding an average of approximately 300 mm. Locally, the recharge of the aquifer is generally very low to medium, estimated to vary between 0 to 100 mm/ annum. Regionally, previous works estimate recharge volume for Kenya and Uganda at 230 and 240 km^3/decade, respectively; depth for Kenya and Uganda is 400 and 960 mm/decade, respectively.
- Natural discharge is mainly through spring and stream flows especially on the mountain slopes. This discharge goes untapped in the rainy season and is wasted, yet it has a high potential for becoming a regional water reservoir. There is need to expand and protect more water sources so that water wastage is controlled and conflicts are reduced among these communities.

- Groundwater infrastructure is mainly gravity flow schemes and protected springs predominantly at higher altitudes on mountain slopes while boreholes and shallow wells are located in the flat plains.
- Regionally, the yield of groundwater boreholes ranges up to 43.3 m^3/hr, with mean and median values of 2.6 and 1.5 m^3/hr, respectively.
- Regionally, the mean and median transmissivity values are 9.7 and 2.4 mbgl, respectively; secondary data for storativity derived from the Kenyan side averages 0.0027.

The preliminary conceptual hydrogeological model of the Mt. Elgon aquifer system depicts main recharge in the higher volcanic mountain areas, with slopes dominated by runoff and springs, that flow and infiltrate into the low-relief region underlain by deeply weathered and fractured crystalline rocks, forming semi-confined systems, and discharge through alluvial and lacustrine sediments, and wetlands. The region underlain by deeply weathered extrusive igneous rocks and gneissic basement have fairly similar and slightly higher permeability compared to the intrusive igneous rocks which is the most dominant hydrogeological formation.

Socio-economic considerations for groundwater development include; population, literacy and poverty; agriculture; tourism; mining; manufacturing; and governance of groundwater resources. Socio-economic pathways (SEPs) is centred on population; education; infrastructure and energy; land use and land cover; agriculture, irrigation infrastructure and industries; water supply and access; industry and trade; and financial services.

Key threats to sustainability of shared groundwater aquifers include; overabstraction; decreased recharge; climate change leading to erratic rainfall; increasing pollution levels, poor land use practices and land use/cover change, rapid population growth, inadequate management capacity, inadequate financial support to manage proposed water use stakeholder activities.

Current and projected groundwater abstraction is based on various usage; agriculture and livestck watering, domestic use and health purposes, rural water supply, different commercial industry uses, and ecosystem support. Demand for water from rain and groundwater for agricultural production is high especially in the dry seasons, leading to conflicts between the communities in the area. Priority is often given to water resources utilization and development for domestic water supply for both human consumption and livestock.

Groundwater monitoring at 6 stations had; at Serere daily groundwater level fluctuates from 0.7 to 9.9 mbgl with mean and median values of 6.5 and 6.7 mbgl, respectively; at Soroti groundwater levels vary between 4.8 and 8.6 mbgl, with mean and median of 6.9 and 7.0 mbgl, respectively; at Moroto Prisons groundwater level fluctuates from 8.0 to 13.5 mbgl with mean and median values of 10.4 mbgl, respectively; at Pallisa groundwater level fluctuates from 8.9 to 13.9 mbgl with mean and median values of 11.5 and 11.4 mbgl, respectively; at Kangole groundwater level fluctuates from 6.1 to 12.4 mbgl, mean and median values are 8.9 and 9.1 mbgl, respectively; at Bungoma, monthly groundwater levels vary from 7.2 to 33.6 mbgl, with mean and median of 18.1 and 17.4 mbgl, respectively.

Baseline water quality parameters include physico-chemical (alkalinity, pH, hardness, EC, TDS) and chemical (total Fe and F), and chemical (F and NO_3) constituents in groundwater at well

completion, in addition to major chemical consitituents (e.g. Ca, Mg, Na, K, HCO_3, SO_4, Cl and NO_3). Groundwater is largely fresh with a TDS of <1,000 mg/l.

Existing groundwater management policies and mandates in each of the two-shared countries is different and require harmonisation and include;

- Kenyan policies and legislation; Kenyan related policies and plans; Kenyan groundwater governance Kenyan regulation and controls; Kenyan institutional and organisational arrangements; and Kenyan monitoring.
- Ugandan policy and legal framework; Ugandan water resources management framework; Ugandan institutional context.
- Other reflections included the governance conditions of the Mt. Elgon aquifer, and gender considerations.

Gaps are identified in the shared Mt. Elgon aquifers management, in terms of measure, problem and required policy change. A causal chain analysis summarised the types of cause and major risks to the Mt. Elgon aquifer in terms of (a) immediate or primary causes, (b) underlying or fundamental causes, and (c) root causes. A SWOT matrix of the SADA contribution identified the strengths, weaknesses, opportunities and threats to the Mt. Elgon aquifer.

- Access to and availability of surface water is limited in most areas within the Mt. Elgon aquifer system due to rainfall seasonality as a result of climatic changes, water pollution, long distance for access, and limited safe water supply by the water supply companies; utilization of groundwater resources thus remains the key solution to fill the existing accessibility gaps.

8. RECOMMENDATIONS

Sensitization and capacity building/strengthening

There is need for education and outreaches on the need for groundwater recharge, and the practices to employ to ensure there are measures taken by the different stakeholders including the managing bodies, communities and civil society organizations towards achieving this. In particular, the groundwater management water user committees are in need of capacity building on the management of the groundwater resources. Training is the key component of capacity building identified for the existing social context within the Mt. Elgon aquifer. However, engagement with the existing social contacts through local workshops and field surveys indicated that it requires matching funds for follow up. Capacity building also needs to be continuous in order to match changes in technology. Continuous professional development ought to start with some prioritized training options. With the right engagement of stakeholders, various stakeholders can be engaged to carry them forward. Some capacity building areas e.g. proper waste disposal need the participation of the larger community with the government taking the lead. The engagements should be cognisant of some stakesholders who are illiterate and require illustrative approaches for capacity building.

The following training areas have been identified for the existing social context in the Mt. Elgon aquifer:

a) Groundwater management
    - Data collection and monitoring of groundwater and surface water resources
    - Water pollution, sanitation and health
    - Sensitization and awareness creation on co-management of groundwater and surface water resources
b) Natural resources management
    - Water resources development
    - Groundwater management and practical concepts
    - Integrated water resource management
    - Wastes disposal and management
    - Tree planting and management, and soil erosion control
    - Protection, conservation and management of riparian areas
    - Conflicts and conflicts resolution/management
    - Alternative sources of energies to reduce over dependence on forest products
    - Indigenous knowledge in preserving water
    - Gender issues and control of gender-based violence
c) Governance and community policing
    - Group development and group dynamics
    - Local, national and trans-boundary water resources policies and governance
    - Management of water resources and facilities
    - Group development and group dynamics
    - Gender awareness and roles
d) Entrepreneurship and innovation
    - Entrepreneurship using local (natural) resources

- Innovation on livelihood strategies, e.g. water bottling, and water vending to enhance access

e) Resource mobilization and management
   - Local mobilization of resources
   - Fund-raising/resource mobilization strategies e.g. proposal writing, and lobbying
   - Financial management of funds received
   - Funding the implementation of reviewed Sub-Catchment Management Plans (SCMPs)

f) Climate change
   - Climate change adaptation strategies
   - Climate change mitigation strategies

g) Protecting the Indigenous groups
   - Giving support to the indigenous communities to access and utilize the natural resources as per their customs and practices.
   - Joint management of resources between the local and indigenous communities.

h) Financial Management
   - Membership and user fees
   - Resource mobilization and budget allocation
   - Governance and accountability

Other key capacity building needs include the following:

- Capacity building of water user committees and other stakeholders for revision of the expired SCMPs;
- Marketing water user committee programs among schools through involvement of the youth; providing motivation (e.g. trophy, incentives) to form school clubs for involvement;
- Sensitization of local communities and other stakeholders on surface water protection and environmental conservation;
- Initiate user committee exchange programmes for learning and information sharing within the aquifer, nationally and cross-boundary;
- Revival of dormant water user committees through training and support, and policy familiarization;

Planning for local needs and resources mobilization assessments

A resources and local needs assessment process should be developed. This will greatly benefit when there is full participation from community (including indigenous groups) and other stakeholders. Among those who should be involved in this assessment process include the following:

- Those who livelihoods are likely to be affected by any development projects in the area. These include the local communities. The use of local and indigenous knowledge of water preservation should be explored. These categories of people are well acquainted with what effects those water related conditions (e.g. water access, availability, quality, quantity, and affordability) have on their lives, and including them in the planning process is more likely to produce a plan that actually speaks to their needs.
- Health and human service providers; These individuals and organizations, especially those that are community-based, often have both a deep understanding of the community and a

strong empathic connection with the populations they serve. They can be helpful both by sharing their knowledge and by recruiting people from marginalized and indigenous populations to contribute to the assessment.

- Government officials, both central and local government are in most cases involved in the formulation and implementation of government related water facilities. At this point, the involvement of the local politicians who are elected by the communities should be part and parcel of this process. They are very important in making pronouncements which can either support or derail any planning process. Therefore, they should take part in in planning and carrying out an assessment which helps to ensure that they will take the effort seriously and work to make it successful.
- Influential people; these include individuals who are identified as leaders because of their positions, prestige of their professions or because they are known to be people of intelligence, integrity, and good-will who care about the community.
- People whose livelihoods or lives could be affected by the eventual actions taken as a result of the assessment. These include elected leaders, teachers, local community-based organizations (CBOs), faith-based organizations (FBOs), provincial administration including chiefs and village elders who might have to react if new community policies or procedures are put in place.
- The civil society organizations are important actors when it comes to planning. It would therefore be prudent to include these categories when planning for local needs and resources mobilization assessments
- Community activists; People who have been involved in addressing policy or issues related to water, which could come up in the course of the assessment.
- Businesses, especially those that employ people from populations within the aquifer. The livelihoods of local business owners could be affected by the results of the assessment, as could the lives of their employees.
- Industrialists who run and manage many businesses, which consume a lot of water and employ many people within the aquifer should equally be involved. This is important because many of these people's livelihoods depend on the success of local industries and so the owners of such businesses could be affected by the results of the assessment, as well as the livelihoods of their employees.

Communication needs/strategies

The existing social contexts include stakeholders, the relevant people affiliated with the project whose opinions and actions will directly impact the project outcome. These include the local communities mainly represented by local institutions (e.g. WRUAs, and CFAs), state (government) and non-state (non-governmental organizations and community-based organizations) actors. In order to effectively communicate with the above stakeholders and those defined in stakeholder analysis, the following strategies are proposed:

a) Communicate project information by holding meetings with stakeholders. Where feasible, contact information of key stakeholders should be made available. This will allow sharing of information through short message services (SMS) and the social media platforms, e.g. WhatsApp, Facebook;
b) Carry out local radio and TV talk shows to inform the stakeholders on the where the status of the project development, including the challenges being faced and the way forward.

c) The project should define and distribute periodic newsletters with project information and other related information to relevant stakeholders;
d) Provide project summary reports and planned activities to keep the stakeholders abreast with the project performance and the future activities;
e) Conduct screen-to-screen meetings or group video calls where necessary to provide periodic project information and updates.
f) The key stakeholders can be involved at different levels and information can be passed through the available community channels, e.g. use of the local councils, churches, and the mosques.

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10. ANNEXES

Annex 10.1: A summary of the schedule of the national and Mt. Elgon Aquifer deliverables.

National Deliverable	Date	Mt. Elgon Aquifer Deliverable	Date
Brief inception report (methodology and phases of work including workshops details)	9 Jul 2021	Brief inception report (methodology and phases of work including workshops details, stakeholder's consultation plans and report structure)	15 Jul 2021
Draft report (A): **Physical science:** • Prepare a list of stakeholders and their level of engagement in groundwater management • Identification of existing groundwater management policies/systems and mandates/legal context **Social science:** • A description report of the key social context and their concerns regarding groundwater. • The consultants should present a report identifying key indigenous groups, local NGOs, youth & women groups, representatives of the public and other active groups concerned with groundwater management at the local level. • In the description report, attention should be paid to the present socioeconomic, and governance conditions of the shared aquifers and their interactions with surface waters. Where ever applicable, the data will be gender disaggregated and clearly show how women are involved (or lack of it) in the use, protection and management of groundwater resources.	6 Aug 2021	Review report and validation for national reports	15 Aug 2021
Draft report (B): **Physical science:** • To document the current groundwater recharge/discharge and flow regime, aquifer geology and characteristics, abstraction/use and anticipated groundwater abstraction	17 Sep 2021	Draft of first (SADA) report based on the fact-finding reports presented by national consultants	24 Sep 2021

National Deliverable	Date	Mt. Elgon Aquifer Deliverable	Date
trends (in irrigation, industry and drinking water), conjunctive use and development **Social science:** • Status of utilization of groundwater resources, the information on governance structure for management of shard aquifers will include role of women in management of groundwater in general and shared groundwater bodies, in particular. GW/SW conjunctive management practices and options for further improvements.			
Draft Report (C): **Physical science:** • Training materials on data collection and policy making at different levels **Social science:** • Provide operational recommendations for strengthening contacts with the social context existing in all study areas, including public forums, meetings, capacity building and awareness sessions.	24 Sep 2021	Draft of Final (SADA) report	7 Oct 2021

Annex 10.2: National Final SADA Reports C of the Mt. Elgon aquifer study.

The draft National Final SADA Reports C for both Physical Sciences and Social Sciences sections of the Ugandan and Kenyan sectors of the Mt. Elgon Aquifer are each attached separately.

Annex 10.3: List of datasets collected by Kenyan physical sciences.

The Kenyan physical sciences datasets were further gathered from relevant institutions which included the Water Resources Authority, County Government, Ministry of Water and Sanitation.

10.3.1 Borehole Inventory

The inventory of the existing boreholes has been acquired from WRA head office. Although the inventory is not up to-date, additional inventory has been requested from the sub-regional office in Kitale. WRA also requires that all motorized shallow wells and therefore an inventory of all licensed shallow wells shall be provided. There is an existing conflict of mandate between WRA and the County Governments. As such, most of the boreholes drilled by WRA are not licensed an indication that they have an independent inventory with wells that do not exist in WRA data base. For instance, Trans-Nzoia County has drilled 150 boreholes from 2015 and none of them has been licensed. In-addition to the well inventory, we have requested the borehole completion reports that contain log information and water quality analysis for selected boreholes.

10.3.2 Hydrogeological Reports

Permitting is a continuous process and thus WRA has a number of requests pending approval. For instance, Bungoma County has applied for permits to drill 40 boreholes across the county. Therefore, WRA will also provide hydrogeological reports for the selected sites across the area of interests.

10.3.3 Other Relevant Reports

Other reports relevant to the study have also been acquired. These reports include but not limited to:

1. Sub-catchment management plans for WRUAs (WRA)
2. Abstraction and pollution survey reports for selected catchments (WRA)
3. Bungoma County Water Master Plan (County Government of Bungoma)
4. County Strategic Plans (Respective County Governments)
5. Policy Documents
6. Legal Framework Documents
7. Policy briefs relevant to the study

10.3.4 Topographical data

Topographical sheets for the study area have been acquired. Further a 30 m Digital Elevation model for the area has been downloaded from Earth Explorer Website – USGS.

10.3.5 Hydro-meteorology

The area of study has a good network of river and rainfall gauge stations. The stations have been mapped (Figure 2.4) and a list of the stations provided in the appendix.

10.3.6 Land use, soils and geology

Soil has been acquired from http://geoportal.icpac.net/layers/geonode%3Asoils. Similarly, land use information was acquired from http://geoportal.rcmrd.org/layers/ servir%3Akenya_sentinel2_ lulc2016. Land use data represents land cover map for the year 2016. This layer was clipped from Sentinel-2 global land cover data. The soil data was done by Kenya soil survey (KSS) in 1982 and revised in 1997.

Annex 10.4: Rainfall gauge stations within the Kenyan side of the Mt. Elgon aquifer boundary.

NAME	NUMBER	Year Opened	Year Closed	Lat	Lon
SUAM ESTATE, KITALE	8834000	1920	1937	1.233333	34.85
NORTH MOUNT ELGON	8834001	1929	----	1.15	34.76667
ELGON DOWNS MANAGEMENT SERVICE	8834009	1931	----	1.066667	34.86667
KITALE O.H. KNIGHT	8834010	1935	1967	1.166667	34.98333
KASSOWAI ESTATE, KITALE	8834011	1936	1958	1.016667	34.83333
KITALE SABWAMI A.D.C.	8834012	1925	----	1.083333	34.9
CHORLIM A.D.C.	8834013	1926	----	1.033333	34.8
ENDEBESS, E.W. DOLIER	8834014	1936	1937	1.066667	34.96667
GIDEA ESTATE, KITALE	8834016	1937	1939	1.133333	34.96667
A.D.C. NAMANDALA FARM	8834017	1937	----	1.05	34.93333
NALUWA FARM ENDEBESS	8834018	1938	----	1.116667	34.86667
THE THORNS, ENDEBESS	8834019	1938	1947	1.083333	34.86667
ENDEBESS FARM 66	8834028	1946	----	1.05	34.9
KITALE, PUMUZIKA RIDGE	8834033	1948	1962	1.133333	34.96667
LUNYU FARMER'S CO-OP. LTD.	8834035	1950	----	1.166667	34.98333
FARM 1930, KITALE	8834036	1949	1955	1.116667	34.93333
HILL BROOKE FARM ENDEBESS	8834045	1955	1956	1.033333	34.83333
ENDEBESS, L.R.5535/25	8834050	1951	1961	1.116667	34.85
KIMILILI, MOORLANDS	8834052	1960	1967	1	34.63333
ENDEBESS SUAM GROUP FARM	8834063	1965	1976	1.216667	34.75
KANYARKWAT POLICE POST	8834071	1969	----	1.266667	34.91667
SUAM BUKWA FARM	8834072	1969	----	1.25	34.8
KANYERUS CHIEF'S CAMP	8834092	1972	----	1.35	34.81667
RENJU SITATI FARM	8834093	1975	----	1.05	34.96667
SUAM FOREST STATION	8834096	1973	----	1.216667	34.73333

NAME	NUMBER	Year Opened	Year Closed	Lat	Lon
KITALE SOIL CONSERVATION	8834097	1948	----	1.016667	34.98333
KITALE METEOROLOGICAL STATION	8834098	1950	----	1	34.98333
LIYAVO SHIRIKA FARM	8834099	1926	----	1.083333	34.98333
NAKAMI FARM NO.1	8834100	1981	----	1.016667	34.86667
KITALE D.C.	8835001	1920	1945	1.016667	35
KAPCHELIBA	8835002	1912	1931	1.483333	35.01667
KOITOKOS FARM, KITALE	8835011	1936	----	1.016667	35.05
ST. MICHEALS MOUNT, KITALE	8835015	1934	1940	1.116667	35.06667
KITALE KEIYO FARM	8835016	1939	1978	1.25	35
KITALE METEOROLOGICAL STATION	8835038	1947	1965	1	35
LEISSA FARM, KITALE	8835039	1964	----	1.166667	35.03333
KERINGET POLICE POST	8835048	1972	----	1.216667	35.05
KITALE KANDIE ESTATE	8934005	1918	----	0.983333	34.83333
KA-LU-A ESTATE	8934006	1910	1939	0.833333	34.83333
KITALE GLOUCESTER VALE ESTATE	8934008	1914	----	0.9	34.91667
SIBOT FARMERS COOP.SOCIETY	8934011	1925	----	0.966667	34.81667
SALVATION ARMY MALAKISI	8934015	1931	1955	0.683333	34.41667
GRANGE FARM, LUGARI	8934017	1932	1938	0.8	34.88333
SABOTI FOREST STATION	8934033	1936	----	0.983333	34.78333
KAVUJAI DISPENSARY KAKAMEGA	8934036	1939	1952	0.866667	34.55
KIMILILI AGRIC. DEPARTMENT.	8934060	1940	----	0.8	34.71667
KITALE MUROKI FARM	8934065	1942	1968	0.916667	34.8
KITALE GREENHAM FARM	8934067	1942	1963	0.95	34.9
KITALE, NDALU FARM	8934069	1940	1963	0.833333	34.98333
CHEMICHEMI S.F.T FARM	8934070	1946	1983	0.916667	34.81667
KAMA KOIWA, LUGARI	8934074	1947	1977	0.766667	34.86667
KITALE MET. STATION	8934076	1947	1961	0.966667	34.95

NAME	NUMBER	Year Opened	Year Closed	Lat	Lon
KIMLILI FOREST STATION	8934098	1959	----	0.866667	34.68333
KAMUSINGA FRIENDS SEC. SCHOOL	8934107	1961	1967	0.8	34.7
KOLONYA BOY'S SEC. SCHOOL	8934110	1962	----	0.7	34.4
ANGORAI CHIEF'S CENTRE	8934111	1962	----	0.716667	34.35
LUGULU INTERMEDIATE SCHOOL	8934112	1962	1963	0.666667	34.75
KAPSAKWONY CHIEF'S OFFICE	8934113	1962	----	0.85	34.71667
CHEPKUPE COFFEE GROWERS COOP LTD	8934117	1961	1962	0.833333	34.43333
SIRISIA CHIEF'S CAMP	8934118	1962	----	0.75	34.5
WEBUYE HEALTH CENTRE	8934119	1962	----	0.616667	34.76667
CHWELE HEALTH CENTRE	8934120	1962	----	0.733333	34.58333
LUGARI SETTLEMENT SCHEME	8934121	1962	1965	0.65	34.63333
NZOIA FOREST STATION	8934138	1968	----	0.75	34.93333
GITWAMBA FARM CO LTD.	8934154	1972	----	0.933333	34.76667
AMAGORO D.O'S OFFICE	8934155	1974	----	0.633333	34.33333
CHEPTAIS CHIEF'S OFFICE	8934173	1976	----	0.8	34.46667
LUUYIA GIRL'S SCHOOL	8934178	1978	----	0.65	34.63333
NAKAMI FARM KIMININI	8934185	1972	----	0.95	34.86667
SOSIO FOREST STATION	8934186	1981	----	0.95	34.73333
MALAHA LUSWET'S FARM	8934193	1982	----	0.633333	34.73333
NALONDO WAFULA'S FARM	8934195	1978	----	0.65	34.58333
BUKOLI CHOKES FARM	8934196	1979	----	0.716667	34.66667
HOEY'S BRIDGE, BRINDLEY PARK	8935005	1923	1965	0.783333	35.05
KITALE DECKHAM	8935032	1920	1969	0.966667	35.06667
KANDY FARM, KITALE	8935034	1925	1942	0.95	35.01667
KITALE WATERBECK	8935090	1948	1965	0.85	35.01667
HOEY'S BRIDGE ANKERDINE FARM	8935113	1948	1962	0.9	35.11667
MITONI MITATU FARM	8935182	1972	----	0.916667	35.03333

NAME	NUMBER	Year Opened	Year Closed	Lat	Lon
NAITIRI SECONDARY SCHOOL.	8935183	1969	----	0.783333	35.03333
KITALE NATIONAL AGRIC.RES.STN.	8935206	1934	----	0.983333	35.01667
NDURIO SEC. SCHOOL	8935227	1986	----	0.983333	35.03333

Annex 10.5: River gauge stations on the Kenyan side of the Mt. Elgon aquifer region.

Region	Station ID	Name	Long/Easting	Lat/Northing
LVN	1AA01	Malaba	34.2708	0.6417
LVN	1AD02	Malakisi	34.3419	0.625
LVN	1FG01	Yala	34.5451	0.808
RVCA	2B33	Suam	35.0167	1.4667
LVN	1BE06	Kwoitobus	35.0903	0.9653
LVN	1BH01	Kamukuywa	34.8028	0.7847
LVN	1DB01	Kuywa	34.7	0.6236
LVN	1BG07	Rongai	34.925	0.774
LVN	1AD03	Malakisi	34.3389	0.6236

Annex 10.6: Soil types of the Mt. Elgon aquifer region of Uganda and Kenya from the Soil Atlas of Africa and its associated Soil Map (ESDAC, 2014).

Symbol	Soil type
ACfr	Ferric Acrisols
ACha	Haplic Acrisols
ACpl	Plinthic Acrisols
ACum	Umbric Acrisols
ALha	Haplic Alisols
ALum	Umbric Alisols
ARfl	Ferralic Arenosols
ARha	Haplic Arenosols
ARwl	Hypoluvic Arenosols
CMcr	Chromic Cambisols
CMdy	Dystric Cambisols
CMeu	Eutric Cambisols
CMgl	Gleyic Cambisols
FL	Undifferentiated Fluvisols
FLeu	Eutric Fluvisols
FRha	Haplic Ferralsols
FRro	Rhodic Ferralsols
FRum	Umbric Ferralsols
GLeu	Eutric Gleysols
GLmo	Mollic Gleysols
HSsa	Sapric Histosols
LPeu	Eutric Leptosols
LPli	Lithic Leptosols
LVcr	Chromic Luvisols
LXha	Haplic Lixisols
LXpl	Plinthic Lixisols
NT	Undifferentiated Nitisols
NTro	Rhodic Nitisols
NTum	Umbric Nitisols
PHha	Haplic Phaeozems
PHlv	Luvic Phaeozems
PLdy	Dystric Planosols
PLeu	Eutric Planosols
PTab	Albic Plinthosols
PTeu	Eutric Plinthosols
RGdy	Dystric Regosols
TC	Undifferentiated Technosols
UMcm	Cambic Umbrisols

VRha	Haplic Vertisols
WR	Water body

Annex 10.7: Borehole Inventory of the Kenyan side of the Mt. Elgon aquifer region.

ID	ALT (m)	Total Depth (m)	Water Struck Level (m)	Water Rest Level (m)	Yield (m3/day)	Drawdown (m)	Basin CODE	Long	Lat
10188	1570	65	33	9	5.32	40.9		34.771	0.6124
9596	1175	37	27	11.6	1.02	25.5		34.333	0.6285
10669	1885	80	40	10.4	0	64.6		34.95	1.1667
9609	1460	48	18	4.5	9	28.9		34.383	0.6891
10710	1465	100	50	16.8	0.43	73.4		34.866	1.0042
5251	1657	79	39	28.5	5	0		34.572	0.7348
595	1850	40	33	12	2.28	0	1BG	34.95	1.05
604	1840	88	76	3	3.12	0	1BE	34.9	1.0667
664	1900	145	79	9	1.38	0	1BE	34.866	1.0667
1288	536	55	37	30	0.24	0	1BE	35.016	0.9833
1289	552	37	29	11	0.9	0	1BG	34.95	0.9833
1351	1730	35	25	12	0	0	1BG	34.95	0.8667
1730	579	79	70	23	0.54	0	1BE	35.016	0.9833
1764	1970	93	61	25	4.08	0	2B	34.966	1.2333
1783	549	40	34	8	11.3	0	1BG	34.883	0.9667
1814	1900	110	109	55	0.66	52	1BE	34.85	1.2167
1824	1940	61	44	27	0.24	0	1BE	34.983	1.2
1860	1890	201	24	9	0.12	182	1BE	34.833	1.2167
1903	1981	92	76	31	4.08	56	1BC	35.05	1.1667
1928	549	79	76	32	3.6	29	1BG	34.883	0.9833
1964	1880	55	52	27	0.24	0	2B	34.85	1.2333
1966	1880	59	0	0	0	0	1BE	34.883	1.2167
1968	1960	72	0	0	0	0	1BE	34.816	1.2
1969	1900	73	69	32	2.82	0	2B	34.9	1.2333
2016	2180	32	0	0	0	0	1BE	34.783	1.1667
2018	555	70	69	12	1.8	0	1BG	34.966	0.9833
2102	561	26	23	15	0.66	0	1BG	34.95	0.95

ID	ALT (m)	Total Depth (m)	Water Struck Level (m)	Water Rest Level (m)	Yield (m3/day)	Drawdown (m)	Basin CODE	Long	Lat
2103	567	21	17	14	1.56	0	1BE	35.066	0.9333
2105	1920	16	3	3	3.42	0	1BC	35	1.2167
2106	579	41	31	27	0.66	0	1BE	35.016	0.9833
2107	506	25	18	9	0.72	0	1BE	35	0.9667
2195	1900	171	24	18	0	9	1BG	34.85	1.05
2228	1840	15	9	8	2.76	1.5	1BE	34.9	1.0833
2230	567	36	0	0	0	0	1BG	34.983	0.9333
2231	1981	18	9	9	3.18	1.5	1BC	35.016	1.2167
2673	1700	30	24	20	7.98	0	1BC	35	1.2
2677	838	30	23	9	7.74	1.8	1BC	35.033	1.2
2698	1910	131	0	46	1.56	21.3	1BG	34.833	1.0167
2723	1707	38	30	18	1.08	12.1	1BH	34.85	0.8167
3063	536	61	46	12	1.62	45	1BG	34.916	0.8833
3134	613	195	35	0	0.12	0	1BG	34.816	0.9
3867	1616	94	35	22	0	0	2B	34.916	1.25
8997	1850	62	25	0	7.98	14	1BE	35.116	0.8833
1229	564	61	44	15	1.68	0	1BD	35.033	0.8
4942	1200	74	12	4	2.7	26	2BC	34.95	1.5333
5217	1200	84	80	24	3.6	7	1BE	35.066	0.9667
5218	1200	128	0	13	0	0		35.05	1.25
5219	1200	105	80	24	0.72	19	1BC	35.05	1.2
5220	1450	120	72	26	2.04	3.7	2BC	34.933	1.2833
5221	1450	78	27	17	1.56	29	2BC	34.966	1.2833
5223	1500	120	96	18	2.28	30	2BC	35.033	1.3333
5224	1500	66	42	37	2.04	4	2BC	35.016	1.2667
5226	1300	60	33	26	0.66	8	1BE	34.983	1.1833
5227	1500	60	30	33	0.54	20	1BE	35.033	1.15
6252	0	63	36	30	0.06	30	2BC	35.016	1.3833
964	1372	55	35	3	0.96	0	1AB	34.4	0.7167

ID	ALT (m)	Total Depth (m)	Water Struck Level (m)	Water Rest Level (m)	Yield (m3/day)	Drawdown (m)	Basin CODE	Long	Lat
1728	530	46	30	10	0.72	0	1BH	34.883	0.7833
1759	463	46	8	6	0	0	1AF	34.533	0.6167
1915	520	61	18	6	1.26	0	1DB	34.716	0.7833
3222	530	46	0	0	0	0	1BG	34.9	0.7333
3468	488	89	81	1	13.6	32	1DA	34.8	0.6667
3469	347	107	68	4	1.08	96	1AD	34.266	0.6333
4114	1480	150	52	15	0.54	114	1DB	34.65	0.6167
5288	1588	58	22	12	0.5	0	1	34.456	0.8095
5385	0	64	49	15	1.5	5.4	1DC	34.583	0.7667
5387	0	70	70	22	0.43	11	2BC	34.65	0.7333
5389	0	60	33	6	1.5	0	2BC	34.433	0.6
5390	0	65	62	5	0.43	0	2BC	34.466	0.7166
5392	0	58	56	8	0.43	0	1AC	34.58	0.7166
5436	0	49	7	4.2	0	0	2BC	34.516	0.6166
5987	0	46	24	6	1.13	0.5	2BC	34.483	0.5833
5989	0	46	24	5.6	1.03	6	2BC	34.45	0.6333
6106	0	73	67	8	0.54	21.8	1AC	34.516	0.6833
6108	0	37	34	6	0.94	8.6	2BC	34.516	0.6167
6121	1580	73	62	34	0	0	1AC	34.55	0.75
6137	1480	39	0	0	0	0	1AA	34.4	0.75
6138	1420	53	28	10	0.5	27.8	1AA	34.4	0.7333
6139	1430	61	40	12	0	0	1AA	34.416	0.75
6147	0	64	37	0	0	0	1AC	34.516	0.65
6148	0	46	18	0	0	0	1AC	34.533	0.6667
6149	0	52	32	0	0	0	1AC	34.566	0.7
6150	0	48	0	0	0	0	2BC	34.533	0.65
6188	1580	58	43	34	0	0	1DD	34.55	0.65
6189	1570	49	36	16	1.7	0	1DD	34.566	0.6667
6190	1540	46	38	16	0	0	1DC	34.6	0.6833

ID	ALT (m)	Total Depth (m)	Water Struck Level (m)	Water Rest Level (m)	Yield (m3/day)	Drawdown (m)	Basin CODE	Long	Lat
6191	1580	91	43	0	0.85	0	1AC	34.566	0.7333
6193	1580	58	46	0	0	0	1AC	34.583	0.7167
6194	1510	91	79	29	0	0	1AC	34.516	0.7167
6195	1530	91	75	48	0	0	1AC	34.533	0.7
6198	1650	40	36	10	0	0	2BC	34.566	0.7833
6199	1720	49	31	20	0	0	2BC	34.55	0.8
6200	1720	87	0	0	0	0	2BC	34.55	0.7667
6385	1520	70	0	0	0.24	15	1AA	34.483	0.8
6387	1530	61	0	0	0.06	22	1AA	34.433	0.8167
6388	1600	58	0	0	1.8	19	1	34.416	0.8167
6392	1750	58	0	0	0	0	1AA	34.5	0.85
6395	1620	46	0	0	1.98	7	1AA	34.433	0.8333
6396	1650	70	0	0	0.72	23	1AA	34.433	0.8167
6397	1915	34	0	0	0	0	1	34.45	0.8667
6400	2050	55	0	0	1.5	3	1AA	34.466	0.85
6402	1830	82	0	0	0	0	1AA	34.466	0.8333
6403	1860	79	0	0	0	0	1AA	34.483	0.8167
6406	1630	85	0	0	0	0	2BC	34.533	0.8
6407	2090	100	0	0	0	0	1DC	34.583	0.8
6408	2280	97	0	0	0	0	2BC	34.566	0.8333
7041	1360	52	26	18	1.08	27	2BC	34.616	0.7833
7055	1500	46	0	0	0	0	1AC	34.533	0.6833
7056	1540	76	20	8	1.8	31	1DC	34.65	0.7167
7058	1540	91	0	4	1.5	42	2BC	34.5	0.75
7075	1565	37	16	7	15	18	2BC	34.816	0.8833
7881	1290	45	0	4	0.6	36	2BC	34.466	0.6
8382	0	60	52	19	0	0	2BC	34.716	0.7
8386	1580	40	16	12	0	0	1DD	34.566	0.65
8389	1550	62	56	9	0	0	1DC	34.666	0.6833

ID	ALT (m)	Total Depth (m)	Water Struck Level (m)	Water Rest Level (m)	Yield (m3/day)	Drawdown (m)	Basin CODE	Long	Lat
8393	1780	85	0	0	0	0	1AA	34.466	0.8167
8395	1580	55	45	13	0.9	0	1	34.4	0.8
8396	1580	43	35	5	3.18	0	1AA	34.383	0.7833
8405	1360	40	0	0	0.6	0	2BC	34.466	0.6333
8413	1400	58	0	0	0.12	0	2BC	34.5	0.65
8532	400	73	0	0	0	0	1AA	34.4	0.7
8566	1380	30	27	3	0	0	1DD	34.566	0.6667
8567	0	61	55	12	4.5	10	1DD	34.616	0.6167
6129	1280	49	17	7	0.18	25	1AA	34.333	0.7333
6326	1900	71	43	12	13.5	18	1DA	34.783	0.6667
10839	0	32	0	4.1	0	0		34.986	1.2314
10838	0	45	0	4.1	0	0		34.977	1.2297
11326	1848	85	60	14.5	4.6	25.1		34.919	1.0889
11324	2100	87.4	68	24.4	5.5	11.1		35.016	1.1181
10609	1430	64	44	6.8	3	54.2		34.769	0.6151
10976	1840	84	76	16.6	3	42		35.02	0.9733
11239	1880	80	56	9.7	1.2	61.9		35.066	1.075
7806	0	0	0	0	0	0		34.954	0.9512
11347	1860	65	0	0	0	0		35.011	1.0254
11338	1840	66	48	21	0	0		35.059	1.0157
6383	1350	61	0	11.8	0.3	13	1AA	34.35	0.7333
6384	1470	64	0	15	0.24	34	1AA	34.383	0.7667
5948	1300	58	39	5	0	0	2BC	34.416	0.6
1740	532	46	35	9	0.9	0	1BH	34.866	0.8167
1916	402	82	2	56	0.66	0	1AD	34.4	0.65
3934	448	102	3	2	4.98	61.3	1DA	34.783	0.6
5386	0	64	53	20	0.43	11.8	2BC	34.55	0.7667
5388	0	91	91	15	1.5	0	1DC	34.65	0.7
5391	0	85	83	28	0.43	0	2BC	34.533	0.75

ID	ALT (m)	Total Depth (m)	Water Struck Level (m)	Water Rest Level (m)	Yield (m3/day)	Drawdown (m)	Basin CODE	Long	Lat
5393	0	62	25	0	0	0	1AC	34.51	0.7166
5988	0	52	45	5.2	1.04	6.1	2BC	34.483	0.6333
6120	1560	52	28	5	0.48	25.5	1DC	34.6	0.7333
6151	0	49	28	7	0.28	17.6	2BC	34.55	0.6167
6196	1640	76	62	51	0	0	1AC	34.5	0.7333
6389	1650	76	0	0	0.18	37	1	34.433	0.85
6393	1830	82	0	0	0	33	1	34.45	0.8667
6398	1850	34	0	0	0	0	1AA	34.45	0.85
6401	0	49	0	0	1.02	4	1AA	34.466	0.8333
6405	2060	64	0	0	0	0	1AA	34.483	0.8333
7887	1330	46	0	4	1.38	10	2BC	34.466	0.6
8383	1510	79	0	0	0	0	1DD	34.55	0.65
8392	1880	85	0	0	0	0	1AA	34.466	0.8167
8404	1320	46	0	0	0	0	2BC	34.45	0.6167
8526	1420	55	42	10	3.6	31	1AA	34.416	0.7167
6197	1640	73	61	24	0	0	2BC	34.55	0.7667
6386	1600	61	0	0	0.18	18	1AA	34.416	0.8
6390	1750	57	0	0	0	22	1	34.433	0.85
6394	1580	73	0	0	0	0	1AA	34.383	0.7667
6399	1850	73	0	0	0	0	1AA	34.466	0.8333
6404	1880	81	0	0	0	0	1AA	34.483	0.8167
7886	1360	46	0	4	0.78	19	2BC	34.483	0.6
8353	1717	85	0	31	1.98	4	1AC	34.573	0.737
6105	0	31	31	6	1.11	1.8	1AC	34.5	0.6833
6140	1410	58	0	0	0	0	1AA	34.433	0.75
6141	0	49	36	14	0.77	4.7	1AC	34.516	0.6667
6192	1741	50	20	7	0	0	1AC	34.559	0.7465
8388	1480	37	25	13	0	0	2BC	34.416	0.6167
8406	1400	55	0	0	6	0	2BC	34.466	0.6333

ID	ALT (m)	Total Depth (m)	Water Struck Level (m)	Water Rest Level (m)	Yield (m3/day)	Drawdown (m)	Basin CODE	Long	Lat
8564	1560	30	0	0	0	0	1AC	34.55	0.7
7057	1656	81	37	29	13	14	1AC	34.572	0.7349
12448	1370	54	32	7.1	3.9	35.7		34.557	1.0569
12442	1250	46	20	11	1.2	20.6		34.419	0.6764
12439	1225	42	40	21.3	9	7.5		34.438	0.6569

Annex 10.8: List of stakeholders and their level of engagement on the Ugandan side of the Mt. Elgon aquifer region.

S. No.	Stakeholder	Level
	Government MDAs	
	Ministry of Water and Environment (MWE)	National
	Climate Change Department	
	Directorate of Environment Affairs (DEA)	
	• Forestry Support Services Department (FSSD)	
	• Wetlands Management Department (WMD)	
	Directorate of Water Development (DWD)	
	• Water for Production	
	• Rural Water Supply and Sanitation Department	
	• Urban Water Supply and Sewerage services Department	
	• Urban Water Utility Regulation department	
	Directorate of Water Resources Management (DWRM)	
	• Water Resources Monitoring & Assessment	
	• Water Resources Planning & Regulation	
	• International Transboundary Water Affairs Department (ITWA)	
	Ministry of Agriculture, Animal Industry and Fisheries (MAAIF)	
	• Department of Agricultural Infrastructure, Mechanisation, and Water for Agricultural Production	
	Ministry of Energy and Mineral Development (MEMD)	
	• Renewable Energy Department	
	• Directorate of Geological Survey and mines (DGSM)	
	Ministry of Lands, Housing and urban development	
	• Directorate of Physical Planning	
	Ministry of Finance, Planning and Economic Development	
	Ministry of Trade Cooperatives and Industry (MoTCI)	
	Ministry of Tourism and Antiquities (MoTA)	
	National Forestry Authority (NFA)	
	Uganda National Meteorological Authority (UNMA)	
	National Environment Management Authority (NEMA)	
	National Water and Sewerage Corporation (NWSC)	
	Uganda Water and Sanitation NGO Network (UWASNET)	
	Private Sector Foundation of Uganda (PSFU)	
	Government Deconcentrated Structures	Regional
	Kyoga Water Management Zone (KMZ)	
	Water and Sanitation Development Facility East	
	Rural Water Regional Center (RWRC) 3 (formerly TSU 3)	
	Water for Production Regional Centre East	
	NEMA regional Office	
	NFA Mbale Sector Office	
	DEA Regional Wetlands Office	
	Buginyanya Zonal Agricultural Research and Development Institute (ZARDI)	
	Local Government Structures	
	Bulambuli DLG	District Level
	District Water Officer	
	District Production Officer	
	District Natural Resources Officer	
	District Forest Officer	
	District Environment Officer	
	Chairperson District land Board	
	District Physical Planner	

	Sironko DLG	
	District Water Officer	
	District Production Officer	
	District Natural Resources Officer	
	District Forest Officer	
	District Environment Officer	
	Chairperson District land Board	
	District Physical Planner	
	Kapchorwa DLG	
	District Water Officer	
	District Production Officer	
	District Natural Resources Officer	
	District Forest Officer	
	District Environment Officer	
	Chairperson District land Board	
	District Physical Planner	
	Civil Society Organisations	Community/ Local Level
	IUCN	
	Kapchorwa District Landcare Chapter (KADILAC)	
	ECOTRUST	
	Sironko Valley Integrated Projects (SVIP)	
	Donor and Development Partners	International
	BMZ	
	EU	
	World Bank	
	JICA	
	KfW	
	GEF	
	UNDP	
	NBI	
	Others	Various
	Presidential Initiative on Banana Industrial Development	
	ICRAF	
	RAIN	

Annex 10.9: Stakeholders ranked by category on the Ugandan side of the Mt. Elgon aquifer region.

Table 1: Non-Governmental Organisations (NGOs)

Catchment	NGOs	District	Area of operation	Category	Ranking	Sector
Mpologoma	SCORE	Sironko	Bunyafa	NGO	KP	Environment
	World Vision	Sironko	Buwanga	NGO	KP	Environment
	Uganda Red Cross Society	Mbale		NGO	KP	Ecosystems & watershed Mgt conservation
	JICA	Mbale	Bukasakya	NGO	KP	Irrigation and Drainage
	Little big Africa	Manafwa	Buwabwala	NGO	CS	Water supply & waste water management
	ACET (AIDS Care Education & Training)	Manafwa	Buwabwala	NGO	C	Others
	AWUPWAE (Association of Uganda Professional Women in Agriculture & Environment		Buwabwala	NGO	KP	Environment
	JICA			NGO	KP KP	Agriculture Agriculture
	URCS		All Sub Counties	NGO	KP	Environment
	IUCN	Bududa	Busiyi	NGO	KP KP	Agriculture Agriculture
	IIRR		Busiyi	NGO	KP KP	Ecosystems & Water shed Mgt/Flood control Agriculture
	Salvation Army		Bukibukoli	NGO	KP	Health/ Finance
	SCORE		Bukibukoli	NGO	KP	Health/ Finance
	Eco trust		Bukibukoli	NGO	CS	Environment
	LWR			NGO	KP KP	Agriculture Agriculture

Table 2: Youth and Women Groups

Catchment	NGOs	District	Area of operation	Category	Ranking	Sector
Mpologoma	Butahli Farmers' group	Manafwa	Buwabwala	Y&W GP	S	Rain-fed Subsistence Agriculture
	Kibiniko Water User Committee	Mbale	Bukasakya	Y&W GP	S	Water Supply & Waste water management

Table 3: Community-Based Organisation (CBO)

Catchment	NGOs	District	Area of operation	Category	Ranking	Sector
Mpologoma	AMDA	Sironko		CBO	S	Agriculture
	Elgon Education Foundation	Manafwa	Entire District	CBO	C	Education
	Bubulo Tea her SACCO	Manafwa	Entire District	CBO	C	Finance
	Manafwa Diary Farmers' Association	Manafwa	Entire District	CBO	S	Agriculture
	Makubili Farmers' group	Manafwa	Buwabwala	CBO	S	Rain-fed Subsistence

Table 4: Government Institutions

Catchment	NGOs	District	Area of operation	Category	Ranking	Sector
Mpologoma	Mbale DLG	Mbale	Mbale City	Government	C	Health, Education, Environment, Agriculture
	Mbale S.S.	Mbale	Mbale City	Government	C	Education
	Nyondo Sec. Sch.	Mbale	Mbale City	Government	C	Education
	Nyondo PTC	Mbale	Mbale City	Government	C	Private Business
	Mbale High	Mbale	Mbale City	Government	C	Private Business
	Mt. Elgon Hotel	Mbale	Mbale City	Government	C	Others
	NFA-Mbale	Mbale	Bubyangu	Government	KP	Environment
	UWA-Mbale	Mbale	Bubyangu	Government	KP	Tourism
	Mt. Elgon Tech. Sch.	Mbale	Mbale City	Government	C	Education
	LGMSD (Local Government Management & Service Delivery)	Mbale	Bukasakya	Local government	C	Environment
	NWSC	Mbale	Mbale City	Government	KP	Water Supply & Waste water management
	NAADS (National agricultural advisory services)/ OWC	Mbale	Himutu	Government	CS	Rain-fed Subsistence agriculture

Mpologoma	Magale Health Centre IV	Manafwa	Manafwa Town Council	Government Institution	C	Health
	Bugobera Health Centre IV	Manafwa	Manafwa Town Council	Government Institution	C	Health
	Bugobera High Sec. Sch.	Manafwa	Manafwa Town Council	Government Institution	C	Education
	Bubulo Sec. Sch.	Manafwa	Manafwa Town Council	Government Institution	C	Education
	Bukoto Sec. Sch.	Manafwa	Manafwa Town Council	Government Institution	C	Education
	Bumbo High Sec. Sch.	Manafwa	Manafwa Town Council	Government Institution	C	Education
	Bulo Girls Sec. Sch.	Manafwa	Manafwa Town Council	Government Institution	C	Education
	NWSC	Manafwa	Manafwa Town Council	Government Institution	KP	Water Supply & Waste Water Management
	SLM	Manafwa	Nalondo	Government Institution	-	Agriculture
	UWA	Manafwa		Government Institution	KP	Ecosystems & Watershed Management & Conservation
	Manafwa DLG	Manafwa	Entire District	Government Institution	KP	Health, Education, Agriculture, Environment
	Bududa Local Government	Bududa	All Sub-Counties	Government Institution	KP	All Sectors
	UWA	Bududa	Bushinyi	Government Institution	KP	Tourism/ Recreation

Table 5: Faith-Based Organisations (FBO)

Catchment	NGOs	District	Area of operation	Category	Ranking	Sector
Mpologoma	KIFANGO	Manafwa	Wesswa	FBO	C	Agriculture
	Brywood-Village Mosque	Mbale	Bubyangu	FBO	C	Water Supply & Waste water management

Table 6: Private Sector

Catchment	NGOs	District	Area of operation	Category	Ranking	Sector
Mpologoma	African Textile Mill	Mbale	Mbale City	Private Developer	C	Private Business
	Sun Rise Hotel	Mbale	Mbale City	Private Developer	C	Other
	Double Star Hotel	Mbale	Mbale City	Private Developer	C	Other
	Mbale Resort	Mbale	Mbale City	Private Developer	C	Other
	Rafiki Factory (Soap & Cooking Oil)	Mbale	Mbale City	Private Developer	CS	Private Business

	Bugisu Cooperative Union	Mbale	Mbale City	Private Developer	CS	Private Business
	Wash and Will	Mbale	Mbale City	Private Developer	C	Private Business
	Pretoria	Mbale	Mbale City	Private Developer	C	Private Business
	Umukuka	Mbale	Mbale City	Private Developer	CS	Other
	Child Care Project	Mbale	Mbale City	Private Developer	C	Private Business
	UMI	Mbale	Mbale City	Private Developer	C	Education
	Khaukha Cave Tourism Site	Mbale	Mbale City	Private Developer	C	Environment
	Mototo Cultural site	Mbale	Bunghoko	Private Developer	C	Environment
	Muwambe Cultural site for Skulls	Mbale	Muwambe	Private Developer	C	Environment
	Bulindwa Cultural Site	Mbale	Bulindwa	Private Developer	C	Environment
	Kyagalanyi Coffee Cooperation	Mbale	Mbale City	Private Developer	CS	Agriculture
	Masaba Cooperative Union	Mbale	Mbale City	Private Developer	CS	Agriculture
	Mbale Farmers' Association	Mbale	Mbale City	Private Developer	CS	Agriculture
	Mt. Elgon Millers Limited	Mbale	Industrial Division	Private Developer	C	Private Business

Table 7: Institutions of Academia

Catchment	NGOs	District	Sub-County	Category	Ranking	Sector
Mpologoma	Uganda Christian University	Mbale	Mbale City	Academia	KP	Education
	Uganda Martyrs University	Mbale	Mbale City	Academia	KP	Education
	Uganda Management Institute		Mbale City	Academia	CS	Education
	Islamic University in Uganda		Industrial Division	Academia	KP	Education
	NAFORRI	Manafwa	Namabya/ Butta	Academia	KP	Education

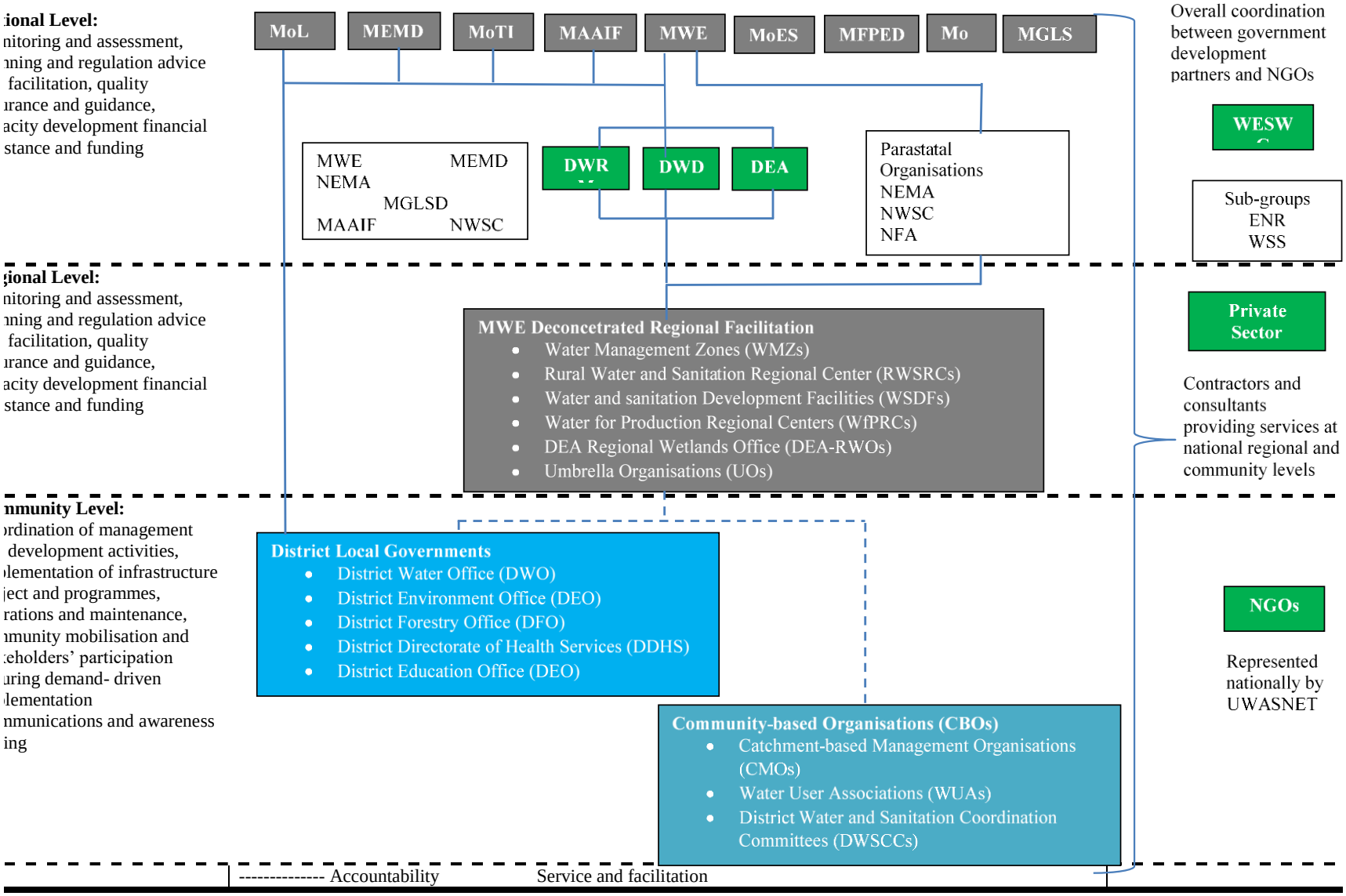
Table8: Culture and Tourism Institutions

Catchment	NGOs	District	Sub-County	Category	Ranking	Sector
Mpologoma	Nabolosi Tourist site for Bull fighting	Manafwa	Nabolosi	Culture and Tourism	CS	Ecosystem and Water conservation

	Terajamungu Scenery Site	Manafwa	Bukoho	Culture and Tourism	CS	Ecosystem and Water conservation
	Kangulu Tourism Site		Mbale City	Culture and Tourism	CS	Other
	Khaukha Cave Tourism Site		Mbale City	Culture and Tourism	CS	Environment
	Mototo Cultural site	Manafwa	Bungokho	Culture and Tourism	CS	Environment
	Muwambe cultural site for skulls		Muwambe		CS	Environment
	Bilindwa wood cultural site		Bilindwa		CS	Environment

[2] KP = Key players, CS = Context Setters, S = Subjects, C = crowds

Annex 10.10: An Overview of Uganda's Water and Environment Sector (MWE, 2020).



Annex 10.11: Groundwater abstraction permits in the Kenyan side of the Mt. Elgon aquifer region.

APPLICANT NAME	CATEGORY	HOROLOGICAL UNIT	VOL. (M3/DAY)
ALEX E. K. MUNYOROKU	B	1BE	20
Bread Of Life Church Water Project	B	1BH	20
Catholic Diocese of Bungoma	B	1DD	20
Catholic Diocese of Bungoma	B	1DD	15
Cleophas Charles Barasa Wangila	B	1DB	12
Creadis Agribusiness and Development Services Limited	B	1AA	20
Gidee Guest House	B	1AA	20
St Martin's Mwibale Secondary School	B	1DD	15
Toloso Secondary School	B	1DB	20
West Pokot County Assembly	B	1BB	18
Constant Okwedo Osiala	B	1BE	20
Ephantus Mwangi Muchiri	B	1BE	20
Kitale School	B	1BE	30
Maloho Secondary School	B	1DB	20
Milani Fym Primary School	B	1DB	20
Mrs Rose Khasaya Khagali	B	1BH	20
Ndarara Holdings Co. Limited	B	1DD	20
Richard Engomo Etiir	B	1BB	20
Valentine Adhiambo Magina	B	1DD	20
Aic Kiptenden High School	B	1BB	20
Alex And Elizabeth Igunza	B	1BB	20
Amagoro Park Limited	B	1BB	20
Amukura Orphanage Home	B	1DA	15
Everlyne Nasambu Wamalwa	B	1DD	20
Holy Rosary Health Centre	B	1BE	20
Jafred Erima Maliro	B	1BE	15
Joseph Kahiga Kiruki	B	1BE	20
Joseph Wandabwa	B	1BB	20
Kitale Jamia Mosque	B	1BE	0
Mbakalo Friends Secondary School	B	1DA	15
Onesimus Kipchumba Murkomen	B	1BB	20
Tegla Loroupe Peace Center	B	1BC	20
Central Division Waters Users Association'	B	1BH	20
Khetia Drapers Limited	B	1BE	20
Khetia Drapers Limited	B	1DD	20
Khetia Drapers Limited	B	1BE	20
Nathaniel Kipkorir Tum	B	1BE	20
Roda Rabwonga Wafula	B	1BG	20

APPLICANT NAME	CATEGORY	HOROLOGICAL UNIT	VOL. (M3/DAY)
St Anthony School Webuye	B	1DA	20
Wiyeta Girls Sec.School	B	1BE	20
Ally Babuh	B	1BG	20
Avungana Mushira	B	1BB	13
Babuh Freigters	B	1BG	20
Ben Okeyo Ossome& Batrice Ossome	B	1BB	15
Bharti Mahendra Khetia	B	1BG	15
Bungoma Silent Resort Ltd	B	1DA	20
Celestinus Luswet Wose	B	1DD	20
Hotel Levantes Kidee Investment Ltd	B	1AD	20
Kaitet Tea Estate [1977] Ltd	B	1BE	20
Livephix Kenya Limited	B	1BG	20
Mark Sichangi	B	1BE	20
Matete Community Water and Sanitation Services	B	1DA	20
Nairobi Aviation College Ltd Ground	B	1BE	20
Noah Mahalang'ang'a Wekesa	B	1BG	20
Peter Kipchirchir Magut	B	1AB	20
Philip Kundu B. Kinisu	B	1BE	18
Pro Benson Estambale	B	1BB	15
St. Philips Ack Tuuyo Koony Secondary School	B	1DA	20
St. Veronica Weonia Primary School	B	1BG	13
Viterlis Wafula Sitati	B	1DA	20
Samuel Losem	B	1BE	20
Ac Butong Secondary School	B	1AA	20
Chweya Josphat Ludeki	B	1BB	11
Fredrick Wafula Mzee	B	1DD	25
Hon Wafula Wamunyinyi	B	1DD	20
International Child Support	B	1AD	20
Kaitet Tea Estate [1977] Ltd	B	1BE	20
Kilavuka Maurice Agushoma Inuani	B	1DB	11
Makutano Dispensary	B	1BB	20
Musasia Albert Abwavo	B	1BE	15
Phillip Odhiambo Munyasia	B	1BE	20
Wanambisi Stephan Juma	B	1DD	20
International Child Support	B	1AD	20
Organic Technology Extension and Promotion Of Initiative Cen	B	1BB	18
Salvation Army (Kolanya)	B	1AA	20

APPLICANT NAME	CATEGORY	HOROLOGICAL UNIT	VOL. (M3/DAY)
Image Innovations Limited	B	1DD	20
Isegeretoto School- Malaba	B	1AA	15
Mateka R.C Primary	B	1AD	10
Col. Richard Angaka Abnery	B	1BG	20
Little Sister of Assisi	B	1DA	20
Mercy Rescue Society	B	1BE	20
Nyamweya Samson Ragira	B	1BE	20
Peter Simiyu Wanyonyi	B	1BG	20
Stephen Kamau Thindiu	B	1BB	20
Sylvia A. Onsuru.	B	1BE	11
Vipul Dodhia	B	1BE	20
`Eliud Wabukala Wamuhkekhe	B	1AD	20
Kolanya Boys High School	B	1BE	20
Seedco Limited	B	1BE	20
St. Patrick Netima Secondary	B	1AD	20
Hilltop Preparatory School	B	1BE	25
Kolanya Girl's High School	B	1AD	20
Mr Akwara Alungata Ben	B	1AD	20
St. Monica Chakol Girls High School	B	1AD	20
Tabani Rc Primary School	B	1BG	20
Agricultural Development Corporation Ltd	B	1BB	20
Anyira Ben Abuka	B	1DD	15
Catholic Diocese of Bungoma (Samoya)	B	1DD	20
Changara Primary School	B	1AD	20
Community Asset Building $Development Action (CABDA	B	1AD	20
David Ojakaa	B	1AD	15
District Water Office-Teso	B	1AA	24
Emjay Farming Limited	B	1BG	16
Emmanuel Shikuku Wanjala	B	1BE	20
Huruma Children's Centre	B	1BG	20
Isaac Sikuku Kapuru Wanyama	B	1DD	20
J. Henry Kabuga Kurura	B	1BE	20
James I. O Olubayi	B	1AA	20
Jane Nasimiyu Kundu.	B	1DB	20
Joel Luswet Mabonga	B	1DD	20
Kenya Electricity Transmission Company Limited.	B	1BE	20
Khetia Drapers Limited	B	1DD	20
L.V.N.W.S.B (Khalaba Community Water Project)	B	1DD	20

APPLICANT NAME	CATEGORY	HOROLOGICAL UNIT	VOL. (M3/DAY)
Lake North Water Services Board	B	1BE	20
Lean Moronji Singoro	B	1BH	20
Miracle Revival Fellowship Pentecostal Church	B	1BE	20
Nabongo Teachers Training College	B	1DD	20
Nicholas Omonya Etyang	B	1AD	11
Robert Juma Wafula	B	1BG	20
Shah Jiten Rasikial & Mikul Shah Rasikial	B	1BH	20
Sibanga Village Health Self Help Group	B	1AB	20
Soul Winners Evangelistic	B	1BH	18
St James Koteko Primary School	B	1AD	16
St Jude Sec School Napara	B	1AD	20
Steven Musee Mulago	B	1BG	100
Town Council of Sirisia	B	1AD	20
Washington Onyango Bwire	B	1BE	20
Wycliffe Nyongesa Munyasi	B	1DA	20
Rehema Menjo Chepkemboi	B	1AD	10
Clement Gichuhi Ndirangu	B	1BE	20
County Government of Bungoma Musango	B	1DA	20
James Muyesu Kavehi	B	1BB	20
Kennedy Otieno Nyakuti	B	1DD	20
Wilson Jeremia Barang'a	B	1BG	20
David W. Kalabai/Joyce Wamalwa	B	1BG	20
Alfred Wanjala/Rael Moraa	B	1BH	20
Allan Wafula Mabuka	B	1DD	12
Rachel K. Ambeba	B	1BC	15
St. Joseph's Primary School	B	1DA	23
Matulo Secondary School	B	1BH	17
Friends School Naitiri Girls	B	1DA	20
James Mageto	B	1BC	20
Eng. Samwel Okech Omer	B	1BE	20
Namwela Secondary School	B	1AD	20
Eluuya Friends Girls School - Naitiri	B	1DA	15
Ndivisi Secondary and Primary Schools	B	1DA	18
David Russel Khaemba	B	1BG	16
Imbogo Sanyo Amos	B	1BG	20
Wycliffe Asalwa	B	1BE	20
Xaverian Brothers (Bumula)	B	1DD	20
Ronnie Reagan Ondatto Musoma	B	1DD	20
Catherine Machio	B	1BH	20

APPLICANT NAME	CATEGORY	HOROLOGICAL UNIT	VOL. (M3/DAY)
Johndee Mecca Nyongesa	B	1BH	20
Gladys Nafula Nabiswa	B	1DD	15
The Benedictine Sisters of Our Lady of Grace And Compassion	B	1DD	20
International Child Support	B	1AD	20
Jiangxi Zhongmei Construction Ltd	B	1BH	24
Maurice Khisa Makali	B	1AB	20
Benard Wekulo Nasokho	B	1DB	18
Eldoret Grain Limited.	B	1BE	20
Kakapel Community Water Project	B	1AD	12
Mr. & Mrs.Ben Ossome	B	1BE	20
Salvation Army Church Tongaren	B	1BG	20
Soteni (Kenya)	B	1BG	20
West Kenya Teachers	B	1DD	20
World Vision -Angurai Market	B	1AD	23
World Vision-Kakapel Primary School	B	1AD	0
Omwabini Community Based Organisation	B	1BH	20
Rodrich Kundu Wakukha	B	1DD	20
Jairo Ochola Odhiambo	B	1DD	20
Ack Madeleine Forsberg Academy	B	1DB	22
Martin Jowi And Winfred Wakwoma	B	1BB	20
Antigua Falls Company Ltd	B	1DC	20
Dinah Nasike Wabwoba	B	1BB	20
Alfred Momanyi Nyairo	B	1BG	20
Arnold China Wafula	B	1BE	20
Breeders Seed Africa Limited	B	1BG	16
Catholic Diocese of Bungoma	B	1BG	20
Chrispinus Barasa	B	1DD	20
Henry Charles Nato	B	1DA	20
James Luchu Juma	B	1AD	20
John Barasa Munyasia	B	1AD	20
Judith Barasa Ramoya	B	1AD	20
Korisai Primary School	B	1AD	20
Lake North Water Services Board	B	1AD	20
Lake North Water Services Board	B	1DD	24
Lake Victoria North Water Service Board (Nakitumba Community)	B	1DD	20
Lake Victoria North Water Services Board	B	1DD	20
Minata Pub Enterprises	B	1DA	20
Nabing'e Friends Secondary School	B	1AD	20
Nehemiah Danson Obwoge	B	1BB	20
Odenda Lumumba Richard	B	1DA	20

APPLICANT NAME	CATEGORY	HOROLOGICAL UNIT	VOL. (M3/DAY)
Patrick Barasa Milimo	B	1BG	20
Philip Wanjala Wasike	B	1BG	20
Rebeccah Abwaku	B	1AD	20
Scholastica Kate Mungahu	B	1AD	20
Seventh Day Adventist Church	B	1DA	20
Skydrop Company Limited	B	1BB	20
Stanley Echakaria Omunga	B	1AB	20
Thomas Nabangi Barasa	B	1BG	20
Vision Gate Hotel Limited	B	1BB	20
Walter Were	B	1AB	20
Water Missions International	B	1BB	20
West Kenya Sugar Company Ltd	B	1BH	20
Xaverian Brothers Bungoma	B	1DD	20
Abdi Juma Sackim	B	1DD	20
Fr. Okodoi Secondary School	B	1BH	20
Godfrey Wanyonyi	B	1DA	20
Joseph Hendrix Waswa	B	1DA	20
Ndivisi Girls High School	B	1DA	20
St. Elizabeth Lunao Secondary School	B	1AD	20
Zippora Jepchirchir Kittony	B	1BB	20
Antony Tawayi Namukota	B	1BG	20
Intergospel Equipping Ministries	B	1BB	22
James Njoroge Kagia	B	1AA	20
Rehema Menjo Chepkemboi	B	1BG	15
Sibumba S.A Primary School	B	1AD	20
St. Paul Kibisi Primary School	B	1AD	20
St. Peters Sangalo Secondary School	B	1DD	20
Walker Wanyonyi Wafula	B	1BG	20
Hazel Jemutai	B	1BB	20
Woyot Self Help Group	B	1BC	100
Nalwelisie Wekesa Kisito Hanns Munyefu	B	1BB	20
Ndalamia General Suppliess Limited	B	1DD	20
Prof. Ruth Otunga	B	1BG	20
Redeemers Christian Church	B	1BG	20
West Kenya Naitiri (Guest House)	B	1BG	20
West Kenya Sugar (Labour Camp)	B	1BG	20
West Kenya Sugar Naitiri(Site)	B	1BG	20
Open Heart Offene Ferze	B	1DA	15
Chebuyusi High Schhol	B	1DB	22
Pan African Papr Mills 2015 Limited	B	1DA	0
Johana Kipkoech Bitok	B	1BB	20
Moses Kiptanui	B	1BB	20
Mr. Albert Soita Wanyonyi	B	1BB	20

APPLICANT NAME	CATEGORY	HOROLOGICAL UNIT	VOL. (M3/DAY)
Pan African Chemicals Limited	B	1DB	25
Paul Kipyego Sumbeiywo	B	1BE	20
Ruto Kipteimet	B	1BB	20
Sammy Chege Nyumu	B	1BE	20
Benjamin Mukolongolo Mbaya	B	1DD	20
Felix Marango Ette	B	1AB	20
Herbert Wanjala Kibunguchi	B	1DA	20
James Wandera	B	1BB	25
Nasiuma Kasembeli Wafula	B	1DD	20
Philip K Seroney	B	1BB	20
Suam Jenga	B	1BB	20
Wilberforce Maina Mutende	B	1DD	20

Annex 10.12: Surface water abstraction permits of the Kenyan side of the Mt. Elgon aquifer region.

APPLICANT NAME	CATEGORY	HOROLOGICAL UNIT	VOL. (M3/DAY)
Western Seed Co. Ltd.	D	1BG	3000
Kibabii Teachers Training College	D	1DD	120
Panocal International Limited	D	1BG	2528
Nzoia Sugar Company	D	1DB	4200
Koshiro Peace and Development Community Water Project	D	1DB	1180
Maliki Boys Secondary School	C	1BH	45
Namawanga Girls' Secondary	C	1BH	30
Dwo (Kiminini Primary School)	C	1BG	30
Kiminini Water Point (DWO)	C	1BG	30
Lutacho Secondary School	C	1DB	91.55
Friends Sec. School. Kuywa	C	1DB	45
Bungoma Agricultural Training Centre	C	1BH	30
St. Lukes High School Kimilili	C	1BH	30
Lugulu Boarding Primary School	C	1DA	70
			11429.55

Annex 10.13: Borehole Information from the Kenyan side of the Mt. Elgon aquifer region.

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
NAKITARE, CAPT. D.	34.95	1.1667	1885	80	40	10.4	0	0	0
KOTUR PR. SCHOOL	34.312	0.5672	1315	34	20	16.7	0	0	0
A.C.C.K.	35.05	2.1167	1500	102	81	0	0	0	0
	34.236	0.4559	1209	55	33	0	0	0	0
	34.95	0.8667	1730	35	25	12	0	0	0
	34.883	1.2167	1880	59	0	0	0	0	0
	35.216	0.9333	549	41	24	21	0.06	0	0
	35.016	1.3833	0	63	36	30	0.06	0.000535	0.00433
M.O.W.D S.WAMONO	34.433	0.8167	1530	61	0	0	0.06	0	0
	34.833	1.2167	1890	201	24	9	0.12	0	0
	34.816	0.9	613	195	35	0	0.12	0	0
MILUKI VILLAGE	34.5	0.65	1400	58	0	0	0.12	0	0
BUYINGI CLINIC	34.066	0.3	1170	40	0	11	0.12	0	0
NANDINGWA SCH.	34.466	0.5333	1370	38	0	3	0.18	0	0
	34.666	0.3667	0	61	43	30	0.18	0	0
BUKOSIA VILLAGE	34.433	0.3667	1300	39	10	6	0.18	0.000037	0.000286
KAKURIKIT PRI.	34.333	0.7333	1280	49	17	7	0.18	0	0
KAPSONG PRI.	34.433	0.85	1650	76	0	0	0.18	0	0
NORTH MYANGA	34.466	0.55	1340	46	0	7	0.18	0	0
LWANDANYI PRI.	34.416	0.8	1600	61	0	0	0.18	0	0
EBWALILO VILL.	34.483	0.3166	1300	70	58	5	0.2	0	0
	35.016	0.9833	536	55	37	30	0.24	0	0
	34.983	1.2	1940	61	44	27	0.24	0	0
	34.85	1.2333	1880	55	52	27	0.24	0	0
KABURNET PRI.	34.483	0.8	1520	70	0	0	0.24	0	0
EJINJA SCHOOL	34.45	0.4333	1350	52	22	10	0.24	0.000159	0.00154
URANGA PRI.SHOOL	34.316	0.3	1265	52	0	0	0.24	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
LWANDANYI	34.383	0.7667	1470	64	0	15	0.24	0	0
MWIHANGA VILLAGE	34.55	0.6167	0	49	28	7	0.28	0.000066	0.0002
	35.133	2.15	1600	36	15	0	0.3	0	0
NAMBACHA PRI.SCH.	34.683	0.4167	1505	61	0	18	0.3	0	0
MATEKHA PRI.SCH.	34.766	0.4833	1540	73	51	6	0.3	0	0
KODEDEMA	34.216	0.5333	1311	85	43	9	0.3	0	0
KAKOIT PRI.	34.35	0.7333	1350	61	0	11.8	0.3	0	0
NANDEREMA	34.116	0.15	0	58	45	34	0.31	0.0025	0.0171
SIKURA VILLAGE	34.333	0.4	1225	52	40	16	0.35	0	0
	35.5	1.5	1981	46	0	0	0.36	0	0
BWALIRO PRI	34.316	0.3833	1260	52	0	6.3	0.36	0	0
M.O.W.D.	34.143	0.4452	1156	42	26	5.1	0.42	0	0
SOUTH MYANGA	34.45	0.5333	1320	45	0	4	0.42	0	0
ST.JOSEPH HOSPITAL	34.866	1.0042	1465	100	50	16.8	0.43	0	0
SANANDIKI SCH.	34.65	0.7333	0	70	70	22	0.43	0	0
MANGENI SCHOOL	34.466	0.7166	0	65	62	5	0.43	0	0
WABUKHONYI SCHOOL	34.58	0.7166	0	58	56	8	0.43	0	0
KWANGAMOR VILLAGE	34.3	0.5166	0	43	31	2	0.43	0	0
ATELAITI SCHOOL	34.2	0.5333	0	37	30	13	0.43	0	0
NAMWELA MARKET	34.55	0.7667	0	64	53	20	0.43	0	0
SIBUMBA SCHOOL	34.533	0.75	0	85	83	28	0.43	0	0
CHILIBA SCH.	34.416	0.55	0	49	42	4	0.43	0	0
	35.183	2.0167	1600	60	36	20	0.48	0	0
MUSAGA PRI.	34.733	0.45	0	50	0	9	0.48	0.000134	0.000906
IMANGA	34.5	0.2667	1345	61	21	8	0.48	0	0
EKERO	34.516	0.3333	1340	58	40	10	0.48	0	0
SHIMBEMBE VILLAGE	34.466	0.1833	1370	35	23	0	0.48	0	0
SANANDIKI VILLAGE	34.6	0.7333	1560	52	28	5	0.48	0.000126	0.000883
CHEPTAIS.M.O.W.D	34.456	0.8095	1588	58	22	12	0.5	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
AKOBWAI PRI.SCH..	34.4	0.7333	1420	53	28	10	0.5	0.000112	0.000738
NAMANGARA PRI SCH.	34.866	0.5	0	46	40	17	0.5	0.00624	0.0505
EMUCHIRI VILL	34.45	0.3333	1280	46	18	0	0.5	0	0
KAMARINYANG SCH.	34.3	0.5333	0	49	27	0	0.51	0.000196	0.00122
CHEMUNEKO PR.	34.933	0.3166	0	61	58	11	0.53	0.000299	0.00161
	35.016	0.9833	579	79	70	23	0.54	0	0
	35.033	1.15	1500	60	30	33	0.54	0.000188	0.000901
FARMERS TR. CENTRE	34.65	0.6167	1480	150	52	15	0.54	0	0
NABUKHISA SCH.	34.516	0.6833	0	73	67	8	0.54	0.000227	0.00158
MUNGORE PRI.SCH.	34.416	0.5	1260	61	0	4	0.54	0	0
EKERO	34.5	0.3	1305	70	58	15	0.54	0	0
MABUSI MARKET	34.466	0.6	1290	45	0	4	0.6	0	0
MWIPOPOLO KAY W.GR.	34.466	0.5333	1360	46	0	5	0.6	0	0
SIBOTI VILLAGE	34.466	0.6333	1360	40	0	0	0.6	0	0
MUNDAHA VILL.	34.233	0.35	1250	46	0	0	0.6	0	0
BUSEMBE H.CENTR	34.016	0.2	0	61	52	0	0.6	0	0
SIRIGOI VILLAGE	34.683	0.3667	1465	46	28	17	0.6	0	0
NAKHASIKO VILL.	34.083	0.2833	1160	46	41	34	0.63	0	0
	34.85	1.2167	1900	110	109	55	0.66	0	0
	34.95	0.95	561	26	23	15	0.66	0	0
	35.016	0.9833	579	41	31	27	0.66	0	0
	34.983	1.1833	1300	60	33	26	0.66	0.00002	0.000133
MAUKO MARKET	34.366	0.3833	1280	46	0	0.7	0.66	0	0
PROD.&MILLERS LTD.	34.4	0.65	402	82	2	56	0.66	0	0
BUCHIFI PRI.SCH.	34.45	0.3	0	45	26	8	0.7	0	0
BUMULIMBA SCHOOL	34.033	0.2333	1165	46	33	30	0.7	0.00948	0.0488
	35	0.9667	506	25	18	9	0.72	0	0
	35.05	1.2	1200	105	80	24	0.72	0	0
BOYCE W.N.	34.883	0.7833	530	46	30	10	0.72	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
KAPSESOI SCH.	34.433	0.8167	1650	70	0	0	0.72	0	0
NORTH KANDUYI	34.833	0.4833	1500	46	34	6	0.72	0	0
TABUTI SCH.	34.483	0.55	1340	54	0	3	0.72	0	0
BUTULA MUANDAS	34.333	0.3333	1300	58	0	4.9	0.72	0	0
	34.216	0.3333	1240	58	0	0	0.72	0	0
SHIBUCHE PRI. SCH	34.483	0.2667	1330	46	0	12	0.72	0	0
ISONGO VILLAGE	34.6	0.3	1370	43	23	15	0.72	0	0
SHIKOTI VILLAGE	34.733	0.35	1480	64	20	9	0.72	0	0
TUMBENI PRI.SCH.	34.883	0.4333	0	49	39	11	0.75	0.000347	0.00219
NALONDO MARKET	34.55	0.4	0	49	23	0	0.77	0	0
NALONDO MARKET	34.516	0.6667	0	49	36	14	0.77	0.000743	0.00427
SUKURA SCHOOL	34.333	0.3833	1220	55	42	10	0.78	0.000221	0.00127
LIGEGA COMMUNITY	34.266	0.3	1265	57	0	0	0.78	0	0
MUNGAMBO SCHOOL	34.35	0.3167	1260	43	0	4	0.78	0	0
OKWATA PRI	34.183	0.6	1128	43	23	3	0.78	0	0
MAYANJA,KIBUKE	34.483	0.6	1360	46	0	4	0.78	0	0
AKITES SCHOOL	34.2	0.5833	0	46	29	0	0.8	0.000539	0.00305
MAKHULIS VILL.1	34.05	0.1666	0	92	84	59	0.83	0	0
MATUGA CHIEFS CAMP	34.466	0.3833	1330	35	17	2	0.83	0	0
D.W.D. (KEFINCO)	34.083	0.1333	0	64	63	35.3	0.83	0	0
D OF LODWAR/COMMUN.	35.533	1.8	0	70	55	43	0.84	0	0
BUHUMA VILL.	34.233	0.3333	1240	45	0	0	0.84	0	0
SHIKOMARI PRI SCH.	34.63	0.3166	0	40	33	13	0.84	0.0045	0.017
LUTHEHE PRI.SCH.	34.383	0.2833	1260	64	0	0	0.84	0	0
SENGETETI SCHOOL	34.566	0.7333	1580	91	43	0	0.85	0	0
BILIMBO SCH.	34.516	0.45	1370	52	38	7	0.85	0.000388	0.00266
NAVAKHOLO P.SCH.	34.683	0.4	0	56	47	20	0.85	0.00033	0.00244
MASUMO VILLAGE	34.4	0.4833	0	34	20	2.6	0.85	0.000302	0.00162
MUYANGA SCH.	34.416	0.5833	1260	40	29	6	0.87	0.000254	0.00145

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
NAMASALI MARKET	34.033	0.2333	1160	49	36	24	0.87	0.00388	0.0235
NAKHODU VILL.	34.033	0.2166	0	55	52	0	0.88	0.000714	0.00428
KHAYO MARKET	34.416	0.5166	1285	58	22	8	0.89	0.000104	0.000642
WEKELEKHA VILLAGE	34.433	0.5333	1320	58	46	8	0.89	0.000585	0.00419
	34.95	0.9833	552	37	29	11	0.9	0	0
	35.216	2.2667	0	60	30	33	0.9	0.000444	0.00196
M.O.W.D MYANGA	34.566	0.5833	1798	43	37	7	0.9	0	0
MULUYA VILLAGE	34.4	0.8	1580	55	45	13	0.9	0	0
SHIMOI CHURCH	34.833	0.4167	1640	61	35	5	0.9	0	0
BULINDO VILAGE	34.3	0.3167	1305	48	0	0	0.9	0	0
LUGULU CATH.CHURCH	34.316	0.4167	1240	85	62	10	0.9	0	0
D.W.D. (KEFINCO)	34.266	0.3	1235	55	39	17	0.9	0	0
SHINAMWENYULI SCH.	34.483	0.25	1340	46	32	20.6	0.9	0.00439	-0.00652
SHISISIA VILLAGE	34.433	0.3333	1270	31	10	2	0.9	0	0
MR.H HILLIER	34.866	0.8167	532	46	35	9	0.9	0	0
SIREKERESI VILL.	34.083	0.2666	1180	61	45	18	0.92	0.000385	0.00223
BUKUSU SCHOOL	34.516	0.6167	0	37	34	6	0.94	0.00114	0.00693
D OF LODWAR/COMMUN.	35.5	1.7667	0	100	80	16	0.96	0	0
SALVATION ARMY	34.4	0.7167	1372	55	35	3	0.96	0	0
LUBINU	34.075	0.2519	1285	61	29	18	0.96	0	0
INGOTSE VILLAGE	34.716	0.3667	1480	54	16	16	0.96	0	0
CHESERO VILLAGE	34.95	0.4333	1690	49	30	10	0.96	0	0
	34.383	0.25	1285	42	0	0	0.96	0	0
ILEHO P.SCH.	34.95	0.25	0	43	29	12	0.97	0.000224	0.00141
MAKHULIS VILL.2	34.05	0.1833	0	70	69	37	1	0	0
LUCHULULO SCHOOL	34.066	0.2666	0	64	54	23	1	0	0
D.W.D. (KEFINCO)	34.1	0.1666	0	37	36	17.3	1	0	0
D.W.D. (KEFINCO)	34.133	0.2333	0	49	47	16.1	1	0	0
MURAMBA SCHOOL	34.058	0.2677	1270	79	79	32	1	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
M.O.W.D.	34.333	0.6285	1175	37	27	11.6	1.02	0	0
BULWAN MARKET	34.313	0.3601	1269	40	35	11	1.02	0.00465	0.0273
SIGALAME PRI	34.05	0.25	1140	52	0	24.6	1.02	0	0
INUNGO MARKET	34.333	0.3	1264	55	0	0	1.02	0	0
CATHOLIC MISSION	34.288	0.45	1220	46	25	11	1.02	0.000438	0.00215
CHESIRO MARKET	34.466	0.8333	0	49	0	0	1.02	0	0
MARAKARU MARKET	34.533	0.5833	1530	42	37	6	1.02	0	0
BUMULA MARKET	34.45	0.6333	0	46	24	5.6	1.03	0.00162	0.0055
APOKOR MARKET	34.25	0.5166	0	40	32	0	1.03	0.0109	0.0411
AMUKURA VILLAGE	34.266	0.5333	0	49	34	9	1.03	0.00496	0.0231
NAMUNINGE PRI.SCH	34.483	0.6333	0	52	45	5.2	1.04	0.00191	0.00924
ASINGE SCHOOL	34.183	0.5666	0	40	18	0	1.07	0.00131	0.00531
DARIES, MRS. H. C. S.	34.85	0.8167	1707	38	30	18	1.08	0	0
MALABA POLICE POST	34.266	0.6333	347	107	68	4	1.08	0	0
SHIBEV.M.O.W.D	34.616	0.7833	1360	52	26	18	1.08	0	0
SHIBANGA PRI.SCH.	34.866	0.5166	0	49	25	8	1.08	0.00448	0.0245
IGULA VILLAGE	34.233	0.3167	1290	60	0	0	1.08	0	0
NGELECHOM SCOOL	34.166	0.5833	0	46	26	0	1.11	0.00258	0.0102
KIKWECHI MARKET	34.5	0.6833	0	31	31	6	1.11	0.00225	0.013
NAMWITOUTA SCHOOL	34.216	0.35	1240	64	64	16	1.12	0.00392	0.0269
SHIKOTI PRI.SCH.	34.733	0.3166	1500	37	0	0	1.12	0.00342	0.0146
KIBUKE VILLAGE	34.483	0.5833	0	46	24	6	1.13	0.0279	0.011
ANDUNGOSI VILLAGE	34.15	0.5167	0	43	32	11	1.13	0.00539	0.0336
	35.083	1.0833	1951	49	26	15	1.14	0	0
	35.183	0.8833	597	104	79	12	1.14	0	0
ESUMEYA VILLAGE	34.666	0.3167	1420	52	31	11	1.14	0	0
IGULA SCHOOL	34.25	0.3167	1280	49	40	19	1.14	0	0
BUKHWAKUI VILL.	34.216	0.3333	1240	43	0	0	1.14	0	0
BUKATI SCHOOL	34.3	0.3667	1240	52	22	4	1.14	0.000276	0.00146

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
OTINONGO VILLAGE	34.2	0.4833	0	37	26	4	1.16	0.00152	0.00625
D.OF LODWAR/COMMUN.	35.25	2.4944	639	40	24	6	1.2	0.000288	0.00154
BUMULA VILLAGE	34.45	0.55	0	37	32	2.9	1.2	0.00103	0.00479
BUTALI MARKET	34.85	0.4833	0	61	29	7	1.2	0.00599	0.0279
NDENDIO SCH.	34.483	0.45	1330	55	31	11	1.2	0.00388	0.0133
EBUBOLE VILL.	34.5	0.3166	1300	22	16	0	1.2	0	0
KHALABA VILL.	34.55	0.45	1350	33	21	7	1.2	0	0
EBULEMBO CHURCH	34.5	0.2833	1300	46	40	9	1.2	0	0
SHIKOTI GIRLS	34.733	0.3167	1540	57	32	16	1.2	0	0
MULAKA VILL.	34.05	0.1667	1190	72	0	32	1.2	0	0
VERONA FATHERS	35.066	1.075	1880	80	56	9.7	1.2	0	0
BULWANI PRI	34.3	0.3667	1255	34	0	8.9	1.2	0	0
BUKHALALE COMM.	34.266	0.3167	1310	39	0	0	1.2	0	0
BUBURI SCHOOL	34.083	0.2	0	78	76	39	1.2	0	0
KAKUNGA PRI.SCH.	34.85	0.3833	0	58	36	10	1.2	0.000418	0.00294
SHIKALAME PRI SCH.	34.466	0.2666	1340	45	25	12.9	1.2	0.000335	0.00157
DWD-NYAWITA KANJWANG COMM	34.419	0.6764	1250	46	20	11	1.2	0	0
LWANDA PRI.SCH.	34.9	0.4166	0	49	49	6	1.22	0.000196	0.00128
ANDUKUYI VILLAGE	34.133	0.5333	0	40	23	5	1.24	0	0
D.W.D.	34.089	0.3002	1116	52	39	30.3	1.26	0	0
KIMILILI INDIAN ASS.	34.716	0.7833	520	61	18	6	1.26	0	0
ISONGO VILLAGE	34.6	0.3333	1450	55	40	15	1.26	0	0
CHAKOL VILL	34.166	0.5167	0	34	28	10	1.26	0.00399	0.011
MUSIYA MARKET	34.433	0.5167	1300	40	0	3	1.26	0	0
KIMAYUNI VILLAGE	34.466	0.5167	1360	38	0	6	1.26	0	0
SHIKUSA PRISON	34.813	0.3189	1580	70.5	20	5.5	1.3	0	0
DWD-SUBA	34.143	0.5597	1335	84	56	18.5	1.3	0	0
ECHEMO VILLAGE	34.833	0.3667	1580	46	24	9	1.32	0	0
KONJELO CHURCH	34.75	0.4833	1480	49	31	12	1.32	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
SIGALAME SEC. SCH.	34.05	0.25	1173	80	36	32	1.32	0	0
MUGAMBWA PRI	34.25	0.3167	1317	34	13	9	1.32	0.000384	0.00286
IBANDA VILL.	34.283	0.3667	1240	58	33	10	1.32	0.000603	0.00323
NAMUSALA CHURCH	34.283	0.3333	1255	58	0	8.7	1.32	0	0
ODIDI CHURCH	34.1	0.2333	1270	82	0	24	1.32	0	0
	34.866	1.0667	1900	145	79	9	1.38	0	0
	35.033	1.5667	0	51	42	20	1.38	0.000111	0.00108
IKONZA SCHOOL	34.233	0.3333	1240	48	39	18	1.38	0	0
MUGHAKA SCHOOL	34.416	0.4667	1240	55	24	7	1.38	0.00553	0
BUNDIRU PRI	34.25	0.3833	1250	37	0	12.3	1.38	0	0
OSURET PRI	34.245	0.5879	1104	49	34	11	1.38	0	0
IHULA COMMUNITY	34.35	0.3	1270	40	0	0	1.38	0	0
NASIRA A.C. SCHOOL	34.2	0.45	1230	55	48	12	1.38	0	0
INGOTSE VILLAGE	34.733	0.3833	1560	40	20	16	1.38	0	0
KILIBOTI PRI,SCH.	34.766	0.55	1480	64	49	11	1.38	0	0
MAYETA MARKET	34.466	0.6	1330	46	0	4	1.38	0	0
MUTUA PRI.SCH.	34.85	0.6	1540	61	24	5	1.44	0	0
NASIRA A.C. SCHOOL	34.2	0.4667	1220	46	33	11	1.44	0.0132	0.0356
KHABIENYUKA VILL.	34.25	0.3167	1280	69	0	0	1.44	0	0
MACHAKUSI PRI	34.273	0.6072	1266	46	32	8	1.44	0	0
NYAPORA PRI.SCH.	34.383	0.2833	1280	43	35	7.7	1.48	0.000711	0.00397
MAKHONGE SCH.	34.583	0.7667	0	64	49	15	1.5	0	0
KIMWANGO SCH.	34.433	0.6	0	60	33	6	1.5	0	0
MATEKA SCHOOL	34.5	0.5333	0	25	10	8	1.5	0	0
CHESIRO PRI.SCH.	34.466	0.85	2050	55	0	0	1.5	0	0
NORTH KULISURU	34.5	0.75	1540	91	0	4	1.5	0	0
BUSIBINABO VILL.	34.2	0.4333	1200	40	34	5	1.5	0.0103	0.051
NASEWA PRI.SCHOOL	34.233	0.4	1220	40	41	10	1.5	0.00707	0.0249
D.W.D. (KEFINCO)	34.1	0.15	0	49	36	5.4	1.5	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
D.W.D. (KEFINCO)	34.4	0.25	0	46	31	10.7	1.5	0.000784	0.00388
MBUGRA COMMUNITY	34.086	0.3292	1204	78	42	21	1.5	0	0
MALIMALI PRI.SCH.	34.816	0.3667	1500	43	35	7	1.5	0	0
NAMILAMA SCH.	34.65	0.7	0	91	91	15	1.5	0	0
ETETE PRI.SCH.	34.433	0.3833	0	48	38	0	1.55	0.000503	0.00273
	35.066	0.9333	567	21	17	14	1.56	0	0
	34.833	1.0167	1910	131	0	46	1.56	0	0
	34.966	1.2833	1450	78	27	17	1.56	0.0066	0.0416
BUTALII VILLAGE	34.816	0.4667	1580	40	20	5	1.56	0	0
BUSIBI PRI	34.11	0.3376	1164	37	29	13	1.56	0	0
SAKA SCHOOL	34.283	0.3666	1220	34	27	9	1.6	0.0427	0
	34.916	0.8833	536	61	46	12	1.62	0	0
	35.216	1.9667	0	51	33	24	1.62	0.00111	0.00799
MATOLA VILLAGE	34.3	0.3333	1280	40	28	11	1.62	0.0144	0.0591
ELUKHARI SCHOOL	34.35	0.3167	1280	52	42	10	1.62	0.00127	0.00511
SHINOYO PRI.SCH.	34.667	0.35	0	46	37	13	1.62	0.0107	0.00242
NGUVULI VILLAGE	34.866	0.4	1580	49	34	0	1.62	0	0
UTENDE PRI.SCH.	34.416	0.2166	0	39	36	13	1.63	0.0398	0.165
SIKOMA MARKET	34.283	0.3666	1220	40	33	9	1.64	0.00116	0.00603
SHIANDA MARKET	34.533	0.3166	0	43	32	0	1.67	0.00219	0.00612
	35.033	0.8	564	61	44	15	1.68	0	0
	35.083	1.95	0	102	81	12	1.68	0.000659	0.00361
ESUMEYA VILLAGE	34.683	0.3167	1460	60	28	16	1.68	0	0
SAWA VILLAGE	34.733	0.4167	1450	40	34	7	1.68	0	0
BUYAYI VILLAGE	34.333	0.4	1225	37	0	2.6	1.68	0	0
LUBANGA PRI.SCH.	34.366	0.4166	1260	43	35	7.4	1.68	0.000856	0.00488
ATURET MARKET	34.257	0.5865	1178	55	31	8	1.68	0	0
ANDUNGOSI MARKET	34.15	0.5148	1246	40	26	7	1.68	0	0
D.W.D.	34.566	0.6667	1570	49	36	16	1.7	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
MUNAMI PRI.SCH.	34.366	0.45	1240	43	41	6.7	1.71	0.00152	0.003
BUMULA VILAGE-B	34.383	0.3667	1300	46	30	9	1.72	0	0
SHIKOTI GIRLS.SCH.	34.733	0.3166	1547	37	31	13.6	1.72	0.0263	0.0828
IBINZO PRI.SCH.	34.683	0.2666	0	43	33	13.8	1.73	0.0221	0
KINGANDOLE MARKET	34.233	0.35	1240	55	43	23	1.74	0	0
LWANYANJA SCHOOL	34.3	0.4333	1200	34	26	5	1.74	0.0436	0
LUREKO VILL.	34.45	0.3167	1285	49	8	8	1.74	0	0
KADOGO PRI.SCH.	34.366	0.3	1280	49	0	0	1.74	0	0
D.W.D.	34.066	0.2923	1293	80	54	39.9	1.8	0	0
	34.966	0.9833	555	70	69	12	1.8	0	0
	35.05	0.7167	573	111	79	20	1.8	0	0
NALONDO CHURCH	34.416	0.8167	1600	58	0	0	1.8	0	0
BOKOLI VILLAGE	34.65	0.7167	1540	76	20	8	1.8	0	0
SIRIGOI P.SCH.	34.7	0.3833	0	31	28	13	1.8	0	0
MAKHUKHUNI PRI.SCH.	34.766	0.5	1420	37	27	11	1.8	0	0
CHITELESI VILLAGE	34.766	0.4667	1540	43	36	7	1.8	0	0
LUGURU CHURCH	34.3	0.3833	1255	34	0	4.8	1.8	0	0
SIMULI PRI.SCH.	34.716	0.3833	0	34	31	13	1.8	0.00314	0.0159
BUNUKU, CHERERO	34.816	0.4333	0	64	53	10	1.8	0	0
NYAMAITHA MKT	34.35	0.3	1285	43	0	0	1.8	0	0
SHITOTO PRI.SCH.	34.583	0.3	0	46	27	11.6	1.82	0.00159	0.00759
MUSANDA PRI.SCH.	34.45	0.2166	1340	43	43	10.2	1.83	0.0518	0.223
D.BROKERS AGR.HOLD.	34.5	0.3667	1280	116	99	8	1.86	0	0
SHIKUMULO VILLAGE	34.75	0.45	0	46	26	8	1.86	0	0
NELA PRI.	34.283	0.3333	1250	43	0	0	1.86	0	0
ELUCHE UILL.	34.516	0.3333	1370	40	28	10	1.86	0	0
MACHE PRI.SCH.	34.933	0.4333	1620	40	33	8.6	1.86	0	0
EMUKHAWANYI U.P.C	34.5	0.1833	1380	40	29	10	1.86	0	0
D.W.D. (KEFINCO)	34.25	0.3	0	58	32	15.4	1.86	0.0173	0.0604

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
LUNGANYIRO PRI.SCH.	34.4	0.4333	1280	34	24	6.7	1.89	0.0192	0.0418
KAMASHIA VILLAGE	34.5	0.3	0	50	35	9.6	1.9	0.00672	0.0366
MAHIRA PRI.SCH.	34.8	0.4	0	40	18	6	1.92	0.00237	0.012
MUREKU MARKET	34.716	0.4833	0	49	36	5	1.92	0.00158	0.00731
KHABONDI P.SCH.	34.6	0.3666	0	31	29	9	1.92	0.0594	0
VATETA-A	34.833	0.5333	1540	64	54	13	1.92	0	0
SIKARIRA PRI	34.316	0.3167	1290	32	0	7.1	1.92	0	0
BUKHAKUNGA S.SCH.	34.733	0.4166	0	43	25	18	1.92	0.00361	0.0146
MALAVA	34.783	0.4833	1560	37	17	11	1.92	0	0
NAHERA T.SCHOOL	34.066	0.1333	0	46	42	24	1.95	0.00147	0.00925
KISONGO POLY.	34.433	0.8333	1620	46	0	0	1.98	0	0
BISUNU PRI.SCH.	34.85	0.5166	0	46	35	11	1.98	0.0095	0.0333
NAMBACHA VILLAGE	34.666	0.4167	1500	79	42	9	1.98	0	0
IKOLI VILLAGE	34.933	0.4	0	43	35	10	1.98	0	0
BUKHUAMI VILLAGE	34.75	0.5	1460	46	38	9	1.98	0	0
RUMBIE VILL.	34.083	0.2167	1220	61	0	12	1.98	0	0
	34.416	0.2	1300	42	0	0	1.98	0.00329	0.0208
ESHIREMBE PRI.SCH.	34.483	0.2167	1370	70	0	15	1.98	0	0
CHWELE W/S	34.573	0.737	1717	85	0	31	1.98	0	0
	35.066	0.8833	561	46	9	9	2.04	0	0
	34.933	1.2833	1450	120	72	26	2.04	0	0
	35.016	1.2667	1500	66	42	37	2.04	0.000891	0.00612
SHAMONI PRI.SCH.	34.8	0.3667	1580	40	32	9	2.04	0	0
	34.416	0.2	1310	51	0	0	2.04	0	0
EKERO	34.516	0.3333	1405	43	22	14	2.04	0	0
CHESERO VILLAGE	34.916	0.3667	1610	43	34	34	2.04	0	0
BULANDA PRI.SCH.	34.483	0.3	0	55	30	0	2.06	0	0
IHONJE PRI.SCH.	34.45	0.2833	0	31	26	8	2.07	0.0105	0.0324
SHIBINGA PRI.SCH.	34.533	0.3	0	61	41	0	2.1	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
LONYA POLICE	35	2.4833	1067	43	38	25	2.16	0	0
LUBAO MARKET	34.8	0.3333	1550	31	22	12	2.16	0	0
BUNGOMA C.DIOCESS	34.633	0.6	454	60	25	11	2.16	0	0
NAMIRAMA P.SCH.	34.616	0.4333	0	40	31	8	2.2	0.0686	0.136
MUNYU PR. SCH.	34.95	0.3	0	52	31	6	2.2	0.00717	0.0274
EBUKHORO PRI.SCH.	34.483	0.1667	1365	49	44	9	2.22	0	0
MUNDASI VILLAGE	34.266	0.3667	1245	52	0	4.7	2.22	0	0
MATETE PRI.SCH.	34.8	0.55	0	40	28	12	2.25	0	0
	34.95	1.05	1850	40	33	12	2.28	0	0
	35.033	1.3333	1500	120	96	18	2.28	0	0
	35.033	1.5667	0	45	42	6	2.28	0.000213	0.00157
ISHINYIKHA VILLAGE	34.7	0.25	1480	39	26	11	2.28	0	0
NAMAKHUDU VILL.	34.083	0.1833	0	42	36	28	2.28	0	0
MALAVA PRI.SCH.	34.433	0.3333	0	40	20	7	2.28	0	0
BUMAYENGE SCHOOL	34.033	0.2166	0	49	47	0	2.3	0	0
SAMITSI VILLAGE	34.75	0.4333	1490	46	0	9	2.34	0	0
LIMALANDA PRI.	34.316	0.3333	1305	37	28	9	2.34	0	0
MUSAMBA MARKET	34.566	0.45	1360	55	0	0	2.34	0	0
LUNAO SCH.	34.416	0.5667	1260	45	0	6	2.4	0	0
EMAFU VILLAGE	34.466	0.3	1285	55	0	10	2.4	0	0
UASHEILE PRI.SCH.	34.75	0.5	1500	46	23	9	2.4	0	0
NANGINE W/S.	34.083	0.25	1200	61	55	2	2.4	0	0
	35.166	0.8	582	61	21	5	2.46	0	0
	35.116	1.1167	1500	63	57	29	2.46	0.0156	0.103
EKERO	34.516	0.3167	1310	46	23	9	2.46	0	0
INGOTSE VILLAGE	34.716	0.3667	1500	64	49	14	2.46	0	0
KAKAMEGA W/S	34.75	0.2667	0	61	0	8	2.46	0	0
MUSIDI VILLAGE	34.716	0.4167	1480	43	37	12	2.46	0	0
BURUNDU	34.083	0.2667	1190	67	0	20	2.46	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
MALAVA C.KABRAS	34.9	0.6667	1620	46	32	4	2.52	0	0
LUPIDA MARKET	34.35	0.5833	1270	37	25	8	2.52	0	0
A.C.C.K	34.966	2.2833	1450	78	27	17.5	2.52	0.00641	0.0414
St. AGUSTINE	34.25	0.3333	1280	40	32	15	2.52	0	0
EKERO	34.5	0.3	1300	43	18	12	2.52	0	0
EKERO	34.516	0.3	1330	55	34	13	2.58	0	0
SIBALE	34.116	0.2833	1230	55	0	12	2.58	0	0
EBUDODE VILL.	34.133	0.3	1240	48	0	10	2.58	0	0
MALANGA PRI.	34.133	0.2667	1220	45	27	11	2.58	0	0
MALAVA	34.883	0.4833	1600	40	22	11	2.58	0	0
EKERO	34.5	0.3	1285	46	32	7	2.64	0	0
MADA HOLDING LTD	35.189	1.4297	1510	63.5	40	7.6	2.7	0	0
	35.283	0.9667	634	67	55	27	2.7	0	0
	35.083	0.6833	585	92	82	12	2.7	0	0
	34.95	1.5333	1200	74	12	4	2.7	0.000712	0.00165
SIRIGOI VILLAGE	34.683	0.3833	1491	49	39	12	2.7	0	0
KODEDEMA VILL.	34.3	0.5833	1180	40	32	11	2.7	0	0
	34.9	1.0833	1840	15	9	8	2.76	0	0
	35.116	1.7667	0	75	64	59	2.76	0	0
MUTINGONGO CHURCH	34.816	0.4	1540	37	29	10	2.76	0	0
MASINDERALI PRI	34.366	0.3333	1305	43	0	5.5	2.76	0	0
LUKURE VILL.	34.05	0.2333	1200	61	0	11	2.76	0	0
INGOTSE VILLAGE	34.7	0.3667	1485	49	17	13	2.76	0	0
KONYANGO MAINGA	34.866	0.3458	0	79	57	34.7	2.78	0	0
	34.9	1.2333	1900	73	69	32	2.82	0	0
URSULINE SISTERS	34.75	0.2167	1524	68	68	12	2.82	0	0
SHINOYI VILL.	34.45	0.3	1400	64	43	11	2.82	0	0
MWITUA VILLAGE	34.583	0.2833	1360	61	20	6	2.82	0	0
CHEMURONI PRI,SCH.	34.916	0.45	0	37	29	6	2.88	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
SEGERE VILL.	34.133	0.2833	1250	49	0	20	2.88	0	0
LWANDA PRI.	34.233	0.3667	1225	70	0	0	2.88	0	0
MATUNGU PRI.SCH.	34.466	0.3833	1320	37	29	8	2.95	0	0
KITINDA DAIRY	34.533	0.5667	1420	64	28	0	3	0	0
MWIKUNDA VILLAGE	34.466	0.3333	1300	23	17	8	3	0	0
MATENDE VILLAGE	34.783	0.3667	1540	46	34	5	3	0	0
BUSIA TOWN W/S	34.083	0.4667	1268	70	55	12	3	0	0
EMASINDE VILLAGE	34.266	0.3833	1240	49	41	14	3	0	0
ALUPE RURAL	34.13	0.4943	1167	49	27	6.1	3	0	0
ST. JOSEPH BORD. P S.	34.769	0.6151	1430	64	44	6.8	3	0	0
TUM, NATHANIEL	35.02	0.9733	1840	84	76	16.6	3	0	0
BUTERE HEALTH CENTRE	34.5	0.2167	1330	61	53	0	3	0	0
SHIANDA	34.816	0.4167	1550	43	0	12	3.06	0	0
SHITOCHI VILLAGE	34.766	0.2	1590	67	0	20.9	3.06	0	0
EMUNUKU PRI.SCH.	34.583	0.2333	1430	58	44	12	3.06	0	0
	34.9	1.0667	1840	88	76	3	3.12	0	0
LURAMBI PRI.SCH.	34.75	0.2833	1597	42	0	11	3.12	0	0
BUMAMU SEC.SCH.	34.566	0.2167	1390	53	38	6	3.12	0	0
MUMBAO VILL.	34.75	0.5	1250	34	26	4	3.12	0	0
IMANGA	34.483	0.3	1500	64	49	15	3.12	0	0
	35.016	1.2167	1981	18	9	9	3.18	0	0
	35.083	0.7	573	62	56	8	3.18	0	0
CHEBUKUYI VILLAGE	34.383	0.7833	1580	43	35	5	3.18	0	0
EKERO	34.5	0.3167	1325	36	24	7	3.18	0	0
BUNDONGA VILLAGE	34.6	0.3833	1320	51	26	7	3.18	0	0
INGOTSE VILLAGE	34.716	0.3667	1480	67	50	17	3.24	0	0
MALAVA	34.883	0.4667	1600	43	32	3	3.24	0	0
EBUBALA VILLAGE	34.466	0.2333	1335	58	0	13.4	3.3	0	0
ICHINGO VILLAGE	34.483	0.3167	1280	33	27	8	3.3	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
BUNDONGA VILLAGE	34.65	0.3833	1430	46	36	11	3.36	0	0
	35	1.2167	1920	16	3	3	3.42	0	0
SHIBEYE VILLAGE	34.65	0.2667	1380	40	16	14	3.42	0	0
INGOTSE VILLAGE	34.75	0.3833	1540	40	24	13	3.42	0	0
MAHIRA VILLAGE	34.85	0.4167	1540	49	20	1	3.42	0	0
ESUMEYA VILLAGE	34.716	0.3333	1460	40	21	10	3.48	0	0
TOMBO PRI. SCH.	34.833	0.5666	0	58	40	17	3.5	0.00565	0.0337
LUREKO VILL.	34.416	0.3167	1260	31	16	9	3.54	0	0
MANYULIA FULL.GOSPEL	34.516	0.1667	1420	51	27	13	3.54	0	0
	34.883	0.9833	549	79	76	32	3.6	0	0
	35.066	0.9667	1200	84	80	24	3.6	0.0019	0.0145
NYAKWAKA	34.45	0.3333	1280	40	28	4	3.6	0	0
INDANGALASIA SCH	34.405	0.362	1353	49	47	9	3.6	0	0
NAMBUYA VILAGE	34.416	0.7167	1420	55	42	10	3.6	0	0
ELUCHE UILL.	34.566	0.3333	1380	43	27	9	3.66	0	0
SHIBEYE VILLAGE	34.633	0.2833	1390	49	12	11	3.66	0	0
SHIRAKARU PRI.SCH.	34.566	0.1833	1400	43	33	21	3.66	0	0
EKERO	34.5	0.3167	1325	46	37	7	3.72	0	0
MATAYOS H. CENTRE	34.17	0.3359	1198	61	52	15	3.72	0	0
SHIKOTI VILLAGE	34.666	0.2833	1305	43	33	12	3.78	0	0
ESHIKUFU VILLAGE	34.5	0.3	1280	25	22	8	3.84	0	0
DWD NYANDUONG COMMUNITY	34.557	1.0569	1370	54	32	7.1	3.9	0	0
INGOTSE VILLAGE	34.766	0.3667	1540	49	37	11	3.96	0	0
MAUTAMA, KALIBOTI	34.983	0.75	0	79	67	49	4.02	0	0
	34.966	1.2333	1970	93	61	25	4.08	0	0
	35.05	1.1667	1981	92	76	31	4.08	0	0
LUREKO VILL.	34.483	0.35	1290	34	10	4	4.14	0	0
BUKOLWE SEC.SCH.	34.516	0.2333	0	52	42	10	4.14	0	0
BUNGOMA HOSPITAL	34.55	0.5833	436	62	24	16	4.2	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
EKERO.KAKAMEGA	34.483	0.3167	1300	34	0	10	4.26	0	0
TUMBENI VILLAGE	34.866	0.4333	0	46	41	9	4.26	0	0
MWANDA CHURCH	34.516	0.5667	1360	46	0	9	4.26	0	0
INGOSI PRI,SCH.	34.466	0.2333	1320	58	0	8.2	4.32	0	0
ESHITARI PRI.SCH.	34.6	0.25	1420	25	21	11	4.32	0	0
KHALABA VILLAGE	34.533	0.4	1300	40	32	5	4.38	0	0
BUNGOMA F.T CENTRE	34.616	0.6167	0	61	55	12	4.5	0	0
NYAPERA KHANODI	34.35	0.35	1280	40	24	7	4.5	0	0
PROFSSOR OREMBO R J	34.919	1.0889	1848	85	60	14.5	4.6	0	0
BUTURA W/S	34.343	0.3393	1175	52	48	0	4.62	0	0
BULEMA VILL.	34.316	0.3333	1280	49	41	12	4.68	0	0
D.OF LODWAR/COMMUN.	35	2.5	900	90	68	54	4.8	0.000349	0.00217
IMBIAKALO,LUKUME	34.75	0.4167	1320	49	41	13	4.8	0	0
DWD-SUBA	34.85	0.3347	1190	68.8	57	37.7	4.96	0	0
MAKHWABIYE VILL.	34.8	0.45	1560	46	40	0	4.98	0	0
BUSHITINYI MARKET	34.6	0.2167	1430	64	50	12	4.98	0	0
PAN AFR PAPER MILL	34.783	0.6	448	102	3	2	4.98	0	0
BUSAKALA PRY.SCH.	34.572	0.7348	1657	79	39	28.5	5	0	0
BUSINDA VILL.	34.051	0.2661	1182	29	25	13	5.1	0	0
BUTERE W/S	34.5	0.2333	1341	73	36	15	5.16	0	0
BULANDA MARKET	34.6	0.2	1460	58	46	16	5.16	0	0
SAMITSI VILLAGE	34.783	0.4667	1540	40	0	9	5.28	0	0
NANGINGINI VILL.	34.15	0.3167	1290	44	20	4	5.28	0	0
WEBUYE LOC. COMM.	34.771	0.6124	1570	65	33	9	5.32	0	0
	34.916	0.3833	1590	49	9	0	5.34	0	0
SHIKOTI VILLAGE	34.716	0.2333	1480	58	7	3	5.4	0	0
MSHIMULI VILLAGE	34.483	0.1667	1370	58	38	16	5.46	0	0
BUSIADA AREA	34.266	0.3166	0	60	48	11	5.5	0	0
KUZA FARM LTD	35.016	1.1181	2100	87.4	68	24.4	5.5	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
EBOKOLO PRI.SCH.	34.516	0.25	1380	31	18	11	5.52	0	0
NAMASAI VIL.	34.033	0.2333	1140	40	0	15.4	5.52	0	0
KHAREKA MARKET	34.333	0.3167	1285	37	0	0	5.52	0	0
EBUDOBE VILLAGE	34.4	0.3	0	22	18	6	5.52	0	0
CHERERO	34.883	0.4167	1610	46	9	0	5.58	0	0
TESO LEPR. INST.	34.133	0.5	1160	36	21	4	5.64	0	0
ESHIRO PRI.SCH.	34.516	0.2167	1370	58	52	8	5.7	0	0
D.W.D. (KEFINCO)	34.7	0.4333	1480	67	46	14.2	5.7	0	0
MURAAMA VILLAGE	34.5	0.3167	1280	40	35	6	5.82	0	0
BUNGOMA D/HOSPITAL	34.559	0.5736	1420	35	21	23	6	0	0
D.OF LODWAR/COMMUN.	35.5	1.5	0	55	49	39	6	0.00282	0.0132
MUSOKOTO PRI	34.316	0.6	1230	40	21	2	6	0	0
BUTERE W/S NO.2	34.5	0.2167	1340	73	45	15	6	0	0
WAMBUKHONYI VILLAGE	34.466	0.6333	1400	55	0	0	6	0	0
EMACHINA SCH.	34.516	0.2833	1310	34	21	11	6.12	0	0
SHIATSATSA VILLAGE	34.483	0.1833	1400	50	23	7	6.18	0	0
MAKHAMBI PRI.SCH.	34.583	0.3166	0	40	31	0	6.21	0.0309	0
BUSIA TOWN W/S	34.083	0.4667	1189	63	55	9	6.36	0	0
KAMASIA VILLAGE	34.516	0.2833	1290	49	30	10	6.48	0	0
KORU GIRLS SEC.SCH.	35.263	2.1992	1420	66	59	8.3	6.5	0	0
SHIEKUMULO VILLAGE	34.3	0.3667	1240	37	0	7.4	6.54	0	0
SHIENYWE PRI.SCH.	34.766	0.4833	1520	31	21	6	6.78	0	0
NAMALASIRE SCH.	34.433	0.4333	1230	31	24	8	6.8	0	0
W.KENYA JAGGERY	34.483	0.3333	1372	61	58	8	6.84	0	0
LUKUME	34.783	0.4333	1495	46	0	7	6.84	0	0
VIHIGA MARKET	34.933	0.3	1500	51	36	9	7.08	0	0
ESHINGANGANIA MISSN.	34.3	0.3	1500	61	25	13	7.08	0	0
MATETE H/CENTRE	34.8	0.5667	1420	49	40	0	7.2	0	0
MUKUMU PRI.SCH.	34.766	0.2167	0	72	54	6	7.2	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
	35.133	0.85	576	48	43	12	7.26	0	0
WAKHUNGU PRI	34.133	0.2666	0	37	33	10	7.3	0	0
MWIKHALIKHA VILL.	34.65	0.1833	1450	64	0	7	7.38	0	0
	35.033	1.2	838	30	23	9	7.74	0	0
MUKHALANYA PRI.SCH.	34.766	0.5667	1440	34	26	10	7.8	0	0
MATENDE SCHOOL	34.325	0.4705	1374	40	30	8	7.92	0.00397	0.0128
	35	1.2	1700	30	24	20	7.98	0	0
	35.116	0.8833	1850	62	25	0	7.98	0.00509	0.0216
RUWE MARKET	34.433	0.2	1320	61	39	15	7.98	0	0
	34.083	0.4667	0	54	54	7	7.98	0	0
SHISESO VILLAGE	34.683	0.25	1460	49	32	8	7.98	0	0
	35.033	0.65	567	30	27	8	8.04	0	0
LORUGUM CATH.MISSION	35.266	2.4	610	46	41	6	8.16	0	0
BUNGOMA TOWN W/S	34.566	0.5667	430	87	18	10	8.64	0	0
BUNGOMA TOWN W/S	34.55	0.5333	439	71	70	13	8.64	0	0
D.W.D.	34.271	0.56	1232	55	31	8.5	9	0	0
D.W.D.	34.383	0.6891	1460	48	18	4.5	9	0	0
BURIYA CHURCH	34.416	0.2167	1320	43	30	18	9	0	0
	34.833	0.45	1640	46	28	11	9	0	0
LUNZA MARKET	34.566	0.25	1420	34	23	13	9	0	0
MARACHI EAST	34.266	0.3667	1245	42	0	5	9	0	0
ASIRIAN PRI	34.166	0.5	1380	37	28	5	9	0	0
NANGIWA W/S	34.083	0.2667	1240	52	39	1	9	0	0
ONGARIAMA	34.15	0.2833	1158	52	38	4	9	0	0
GENERAL HOSPITAL	34.766	0.2833	1550	60	46	15	9	0	0
SHIRAKARU PRI.SCH.	34.566	0.1833	1480	61	31	20	9	0	0
DWD-PAP ALEGO COMMUNITY	34.438	0.6569	1225	42	40	21.3	9	0	0
SIUNGA PRI.	34.35	0.3	1275	43	33	7	9.42	0	0
INGUSI VILLAGE	34.45	0.2167	1360	43	34	8	9.48	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
BUSIADA SCHOOL	34.283	0.3166	0	51	50	10	9.5	0	0
ALUPE HOSP.	34.133	0.5	130	67	59	1	9.66	0	0
KAMBIRI VILLAGE	34.9	0.3833	1610	40	17	11	9.96	0	0
ESHISEVE VILLAGE	34.516	0.3333	1320	31	24	5	10	0	0
ESIDENDE VILL.	34.366	0.45	1240	36	23	6	10.2	0	0
MUNONGO PRI	34.116	0.3667	1140	52	37	14	10.2	0	0
EMAKHWALE VILLAGE	34.7	0.3167	1340	37	30	8	10.8	0	0
COUNTY CON OF BUSIA	34.236	0.457	1209	52	33	7.7	10.8	0	0
MUSINGU H. SCHOOL	34.75	0.2	1540	78	70	9	10.9	0	0
SHIKOTI VILLAGE	34.7	0.2667	1480	40	0	12	11.2	0	0
	34.883	0.9667	549	40	34	8	11.3	0	0
BUTERE N.SCH.	34.5	0.2167	1341	69	54	15	11.4	0	0
NAMBALE H/CENTRE	34.233	0.45	1158	46	40	11	11.7	0	0
MAVIRA VILLAGE	34.816	0.3833	1600	40	20	4	12	0	0
MUMIAS HOSPITAL	34.5	0.3277	1314	48	0	6	12	0	0
EBULOSI VILL.	34.4	0.35	1305	43	27	9	12.6	0	0
CHWELE	34.572	0.7349	1656	81	37	29	13	0	0
BUNGOMA TOWN W/S	34.566	0.5667	433	91	91	6	13.2	0	0
SANGALA VET.FARM	34.566	0.5167	436	79	61	5	13.5	0	0
NYACHAE SIMEON	34.783	0.6667	1900	71	43	12	13.5	0.00275	0.0177
LUGULU SCH.	34.8	0.6667	488	89	81	1	13.6	0	0
D.W.D. (KEFINCO)	34.75	0.2833	1560	46	0	10.1	13.8	0	0
M.O.W.D.	34.143	0.4459	1156	52	29	5.3	13.9	0	0
MALAVA	34.816	0.8833	1565	37	16	7	15	0	0
KAKAMEGA BAKERY	34.75	0.3	0	40	32	14	16	0	0
LUKUME VILLAGE	34.766	0.4	1530	55	0	8	16	0	0
	35.15	2.15	1600	51	27	9	16.3	0	0
PROV GENERAL HOSP.	34.75	0.2833	1555	46	0	14	16.3	0	0
INGOTSE VILLAGE	34.7	0.3667	1485	40	30	15	16.7	0	0

OWNER	DLONG	DLAT	ALT (masl)	TDEPTH (m)	M_WSL (m)	WRL (m)	YIELD (m3/hr.)	TVALUE (m2/day)	SVALUE
BUDEMA VILLAGE	34.283	0.3833	1225	43	0	4.7	18	0	0

Annex 10.14: Water quality data from groundwater sources in the Kenyan side of the Mt. Elgon aquifer region.

BH_NO	DLONG	DLAT	PH	CLR	TURB	PV	COND	FE	MN	THARD	TALK	CL	F	SO4	FCO2	TDS
5451	34.083	0.1333	7.1	5	4.4	6	2700	0.36	0.6	1117	418	323	0.75	66	55	1620
5449	34.1	0.1666	7.6	8	4	16	4000	1	0	444	782	0.9	4.5	620	172	2400
8849	34.483	0.1667	6.4	5	4.1	4.4	195	0	0	91	104	6	0	18	0	117
5961	34.133	0.1833	7	0	0.3	6.32	850	0.12	0.1	370	360	52	0.35	36	26	510
7007	34.65	0.1833	6.4	5	0.1	2.5	220	0	0	90	104	1	0	0	17	132
8846	34.566	0.1833	6.4	5	8	3.16	76	0	0	32	47	13	0	0	0	46
8857	34.5	0.1833	6.7	5	7.7	1.04	181	0	0	100	93	8	0	14	0	108.6
7001	34.483	0.2167	6.3	5	2.6	0	185	0.55	0	64	82	6	0.22	0	15	111
7001	34.483	0.2167	6.6	15	8	0	175	0.1	0	42	72	7	0.2	16	10	105
8537	34.5	0.2167	6.1	5	0.5	9.5	200	0.05	0.4	73	89	2	0	0	28	120
8540	34.5	0.2167	6.5	0	0	0	187	0	0.4	0	33	1	0	1	0	112
8540	34.5	0.2167	6.5	5	3.6	0	220	0.1	0.3	122	0	1	0	0	0	132
8548	34.766	0.2167	6.6	5	0.6	4.42	200	0.1	0.2	96	93	2	0.5	0	21	120
5446	34.133	0.2333	6.9	0	0	7.3	1200	0.07	0	540	400	70	0.3	72	21	720
5458	34.133	0.2333	7.5	17	21	10.1	1660	1.4	0	989	314	400	0.7	270	58	996
7059	34.716	0.2333	5.8	5	0.7	2.2	120	0.4	0	54	61	1	0.15	0	24	72
7059	34.716	0.2333	6.5	10	6.2	0	120	0	0	105	101	4	0.1	0	14	72
5736	34.483	0.25	6.8	0	0.5	0.9	300	0.7	0	123	134	0	0	0	14.5	180
7061	34.683	0.25	6.4	5	0.3	0.95	180	0	0	65	76	1	0.4	0	13	108
5694	34.683	0.2666	6.3	0	1.4	2.2	205	0.3	0	52	72	1	0.13	0	15	123
5735	34.466	0.2666	6.3	5	1	1.6	155	0.21	0.2	57	70	9	0.5	0	15.6	93
7004	34.483	0.2667	6.4	5	2.5	0	187	0.5	0	89	102	0	0.2	0	19	112
7004	34.483	0.2667	6.4	5	1.2	0	145	1.1	0	56	80	1	0.45	0	16	87
5452	34.058	0.2677	6.9	0	0	12	3200	0	0	1610	334	525	0.75	110	22	1920
5703	34.45	0.2833	6.5	5	4	1.26	180	0.6	0	77	82	3	0.35	1	31	108
5713	34.383	0.2833	6.6	5	3.5	1.6	125	0.12	0.1	31	57	0	0.35	3	14.1	75
6429	34.383	0.2833	6.4	5	1	0	105	0.05	0.1	43	0	3.5	0.3	2	0	63
6472	34.75	0.2833	7	5	0.2	0.63	112	0	0	55	62	3	0.15	0	19	67.2
7040	34.666	0.2833	6.8	2	7	0	87	0.05	0.3	0	51	1	0	2	0	52

BH_NO	DLONG	DLAT	PH	CLR	TURB	PV	COND	FE	MN	THARD	TALK	CL	F	SO4	FCO2	TDS
7040	34.666	0.2833	7.6	5	0.2	3.16	115	0.05	0	61	72	3	0.2	0	12	69
8552	34.766	0.2833	6.2	5	1.1	5.1	157	0.5	0.5	104	71	15	0.4	0	12	94.2
8552	34.766	0.2833	6.2	5	1.1	5.1	157	0.5	0.5	104	71	15	0.4	0	12	94.2
8806	34.583	0.2833	6.4	5	4.4	7.9	165	0.09	0	85	86	0	0	0	0	99
5709	34.3	0.3	6.2	10	4.3	2.8	120	0.85	0	32	52	2	0.45	2	12	72
5725	34.25	0.3	5.8	15	5.6	1.58	86	0.6	0	22	48	1	0.2	0	14.5	51.6
5725	34.25	0.3	6.3	20	1	0	93	0.07	0.7	39	65	12	0	1	0	55.6
5728	34.316	0.3	7.2	70	37	3.8	380	2.5	5.15	122	162	6	0	0	13	228
6425	34.35	0.3	6.7	5	0.5	3.79	142	0.01	0	58	74	2	0.25	3	12	85.2
6428	34.366	0.3	6.7	5	3.5	37.92	340	0.09	0	54	87	49	0.5	10	10	204
7016	34.5	0.3	6.1	0	0.5	0	168	0.09	0	70	0	0	0	0	19	100
7016	34.5	0.3	6	5	0.1	0	160	0	0	60	78	3	0.38	30	19	96
7020	34.483	0.3	7.5	5	2.4	0	155	0	0	60	84	2	0.4	6	19	93
7029	34.6	0.3	6.3	10	0.6	0	175	0	0	70	93	1	0	0	17	105
7029	34.6	0.3	6.2	10	4.6	6.2	150	0.5	0.7	55	77	2	0.1	0	18.5	90
7872	34.4	0.3	7.5	200	67	14	260	2.5	0	588	148	42	0	23	0	156
8535	34.4	0.3	6.1	5	0	5	113	0	0	197	36	9	0	0	0	68
8827	34.3	0.3	7.8	5	3.5	3.16	120	0	0	80	0	0	0	0	0	72
8827	34.3	0.3	7.8	5	3.5	3.16	120	0	0	80	0	0	0	0	0	72
5691	34.63	0.3166	6.2	5	1	1.6	163	0.01	0.1	43	74	4	0.4	0	14	98
5697	34.583	0.3166	6.5	0	0.7	1.9	250	0.18	0	67	96	2	0.36	0	15	150
5731	34.733	0.3166	6.5	13	1	0.01	135	0.01	0.1	95	75	70	0.28	1	0	81
5731	34.733	0.3166	6.4	50	24	1.58	132	1.8	0	46	68	2	0.1	2	19	79
5732	34.733	0.3166	6.4	25	13	4.4	173	1	0	54	54	12	0.1	0	14	103.8
5956	34.483	0.3166	7.1	4	1.1	4.7	150	0.3	0	74	84	0.9	1	3	28.5	90
6422	34.333	0.3167	6.6	0	0.4	1	98	0.03	0	34	52	2	0	3	11	59
7009	34.45	0.3167	6.5	5	0.5	0	190	0.01	0	80	102	1	0.14	0	13	114
7009	34.45	0.3167	6.4	5	0.8	0	160	0	0	62	84	1	0.2	0	15	96
7012	34.5	0.3167	6.1	5	0.2	0	140	0.01	0	60	78	3	0.15	1	20	84
7012	34.5	0.3167	6.1	5	0.5	0	140	0.02	0	52	72	1	0.25	0	19	84

BH_NO	DLONG	DLAT	PH	CLR	TURB	PV	COND	FE	MN	THARD	TALK	CL	F	SO4	FCO2	TDS
7012	34.5	0.3167	6.1	0	1.2	0	148	0.07	0	61	0	0	0	0	19	88
7012	34.5	0.3167	6.2	5	0.6	3.16	145	0	0	75	84	3	0.1	0	20	87
5959	34.45	0.3333	7.4	5	2.4	3.16	400	0.3	0	201	218	2	0.3	0	13	240
7023	34.516	0.3333	6.98	17	18	0	136	0.01	0.1	95	151	7	0	1	0	82
7023	34.516	0.3333	5.8	350	160	0	145	0	0	56	72	2	0	0	20	87
7026	34.516	0.3333	6.2	5	1.5	0	200	0	0	57	106	3	0	0	20	120
7026	34.516	0.3333	6.1	0	0.4	0	160	0.09	0	61	0	0	0	0	17	96
7044	34.716	0.3333	6	5	0.5	0	128	0	0	54	57	1	0.1	0	14	77
8384	34.483	0.3333	6.6	5	5	0	175	0.1	0	85	0	2	0	2	0	105
8394	34.433	0.3333	6.5	40	19	15.8	220	0.3	1	125	128	4	0.7	0	29	132
8403	34.516	0.3333	7	5	0.5	7.9	550	0.1	0.5	288	482	3	0.7	0	47	330
8545	34.433	0.3333	6.1	70	90	20.8	183	0.7	0.5	73	98	8	0.2	6	24	109.8
8573	34.8	0.3333	6.2	70	18	14.2	92	0.05	0	58	52	2	0	0	45	56
8369	34.252	0.3335	6.8	10	1.4	0	320	0.12	0.2	161	0	2	0	0	0	212
11377	34.85	0.3347	7.4	-5	0	0	780	0.092	0.01	262	424	26	1.5	0	20	550
5318	34.344	0.3407	6.4	0	3.3	4.1	145	0.35	0	80	62	1	0.1	0	4	87
5690	34.667	0.35	7.1	15	26	3.16	97	5.5	0	52	62	5	0	0	21	58
7867	34.433	0.35	7	5	1.8	9.48	98	0	0	217	153	0.1	0	0	0	59
6180	34.633	0.3667	6.15	10	5.2	1.9	134	1.42	0	40	66	2	0.5	0	15	80
6180	34.633	0.3667	6.3	0	20	0	135	0.3	0	46	0	0	0	0	14	81
6180	34.633	0.3667	6.4	0	0	0	155	0.2	0	60	0	3	0	0	0	0
7031	34.7	0.3667	6.26	0	4.1	0	150	0.3	0	56	0	0	0	0	18	90
7031	34.7	0.3667	6.9	5	0.8	0	143	0.05	0	73	83	2	0.1	0	12	86
7031	34.7	0.3667	6.3	5	1.5	4.7	85	0.05	0	23	42	1	0.2	0	22	57
7031	34.7	0.3667	6.01	10	4.4	0.32	187	0.64	0	66	58	10	0.2	0	0	112
7034	34.683	0.3667	6	1	1	0.01	77	0.01	0.2	0	42	39	0.12	1	0	46.2
8568	34.916	0.3667	6.2	5	1	6.32	130	0.2	0.5	80	64	2	0	5	28	78
6183	34.466	0.3833	6.3	15	7.5	1.3	155	1.02	0	50	84	1	0.25	0	17	93
6183	34.466	0.3833	6.2	50	27	0.9	154	3	0	50	84	1	0.35	0	16	92
6183	34.466	0.3833	7.24	5	2.8	4.1	210	0.1	0.1	61	106	1	0.3	1	24	126

BH_NO	DLONG	DLAT	PH	CLR	TURB	PV	COND	FE	MN	THARD	TALK	CL	F	SO4	FCO2	TDS
6183	34.466	0.3833	6.1	5	3.3	1.58	145	0.75	0	34	84	2	0.4	0	20	87
6183	34.466	0.3833	6.1	10	5.2	0	152	0.82	0	0	0	0	0	0	0	91
6183	34.466	0.3833	6.52	10	4.8	0.6	157	0.8	0	52	88	1	0.4	2	15	94
7037	34.6	0.3833	6.4	30	25	3.16	140	4	0	69	102	5	0.15	0	11	84
7037	34.6	0.3833	6.6	5	0.4	2.2	132	0.02	0.2	49	72	1	0.1	0	10	79
7047	34.733	0.3833	5.7	5	0.5	0	90	0	0	41	47	1	0.1	0	17	54
7047	34.733	0.3833	5.7	5	0.9	0	120	0	0	32	41	1	0.2	0	12	72
7047	34.733	0.3833	6.62	1	3	0.01	142	0.04	1.8	74	328	1	0.29	1	0	85.2
7064	34.816	0.3833	6.14	5	0.8	0.32	95	0.07	0	28	46	1	0.12	0	11	57
7064	34.816	0.3833	6.1	5	4.5	2	87	0.1	0.1	26	68	1	0.1	0.7	0	52
7082	34.9	0.3833	5.6	5	0.6	0	50	0.05	0	12	28	1	0.02	0	15	30
8371	34.333	0.4	6.7	40	20	0	115	0.2	0.5	71	0	2	0	2	0	69
5482	34.733	0.4166	6.4	4	1.6	4.42	124	0.5	0	42	0	3	0.1	0	20	73
5485	34.9	0.4166	6.4	5	0.6	0.95	125	0.1	0	42	67	2	0	0	14	75
5710	34.366	0.4166	7.6	0	1.2	1.9	162	0.32	0.1	56	78	1	0.16	0	6.6	97
7067	34.85	0.4167	6.3	25	22	0.9	135	0.8	0	48	64	1	1	0	11	81
7865	34.466	0.4167	6.3	5	0.7	1.9	125	0	0	54	1	0	0.25	0	23	75
7870	34.466	0.4167	6.5	5	6.4	2.8	122	0.1	0	46	75	0	0.05	0	15	73
8557	34.75	0.4167	5.9	5	0.2	4.4	110	0	0	48	45	3	0	0	16	66
11385	34.615	0.4306	7.2	-5	0	0	1400	0	0	340	590	140	30.9	70	11	1000
7466	34.783	0.4333	6.4	5	1.2	2.2	140	0	0	51	65	7	0	0	18	84
7489	34.7	0.4333	6.3	50	12	2.53	120	0.22	0	61	57	4	0.2	0	15	72
8554	34.816	0.4333	6.4	15	31	3.2	220	0.3	0	36	112	3	0	0	18	132
9590	34.143	0.4459	6.6	5	0.98	12.4	200	0.26	0	113	0	1	0	2	0	120
7862	34.483	0.45	6.2	10	0	0	145	0.48	0	75	0	4	0	0	0	87
7859	34.416	0.4667	6.3	5	0.5	0	125	0	0	45	77	0	0	0	21	75
7859	34.416	0.4667	6.6	5	7	3.2	532	0.2	0.2	224	284	13	0.29	5.4	66	319
5712	34.315	0.4707	5.7	40	22	1.6	115	0.6	0	37	61	2	0.1	0	9.5	37
5990	34.4	0.4833	6.2	25	13	6	114	2.5	0.2	39	98	2	0.8	5	28	68.4
7070	34.883	0.4833	6.1	5	1	0.32	174	0.01	0	64	70	2	0.15	0	12	104

BH_NO	DLONG	DLAT	PH	CLR	TURB	PV	COND	FE	MN	THARD	TALK	CL	F	SO4	FCO2	TDS
7077	34.783	0.4833	6.45	10	6	20.5	370	0.05	0	74	70	50	0.75	12	10	222
7073	34.883	0.5	6.9	5	0.5	6.32	240	0.05	0	96	135	1	0.1	0	10.5	144
8803	34.15	0.5148	7.4	20	24	11.1	400	0.3	0	260	227	10	0	0	0	240
7883	34.433	0.5167	6.7	15	5.1	0	141	0.17	0.1	54	0	2	0	0	0	84.6
2798	34.55	0.5333	6.1	5	0	0	153	0	0	56	115	6	0.3	3	30	91
2798	34.55	0.5333	6.5	0	0	0	143	0.2	0	55	30	1	0.4	8	0	86
2798	34.55	0.5333	6.3	0	0	0	300	1.5	0	50	105	3	1.2	0	0	180
5950	34.433	0.5333	7.1	15	12	2.8	500	0.32	0.75	177	218	6	0.7	0	16	300
6187	34.5	0.5333	6.2	0	0.4	5.1	194	0.1	0	88	103	1	0.2	1	25	116.4
8584	34.766	0.55	8.3	6	3	0	902	0.01	0.1	4	345	1	2.2	34	0	541
8584	34.766	0.55	6.1	20	0	3.16	230	0.2	0	62	15	5	0	0	0	138
11389	34.143	0.5597	6.8	10	0	0	680	0.05	0.03	308	418	5	4	3	21.5	480
7878	34.516	0.5667	7.2	5	2.1	0.4	250	0.1	0.1	86	150	4	0.1	0.3	0	150
8565	34.533	0.5833	6.8	5	0	3.16	125	2	0	40	23	0	0	0	0	75
8814	34.257	0.5865	5.9	20	6.5	3.16	202	0.1	0	73	0	40	0	0	0	121
3004	34.633	0.6	6.7	-5	0	0	120	0	0	24	0	8	0.2	1	0	110
3004	34.633	0.6	6.7	5	0	0	120	0	0	24	68	8	0.2	1	4	72
3934	34.783	0.6	6.9	0	0	0	200	0.25	0.18	103	0	2.5	0.5	0	30.4	0
7886	34.483	0.6	6.6	10	0	0	400	0.1	0.4	228	0	2	0	0	0	240
7887	34.466	0.6	6.3	10	0	0	250	0.4	0.5	0	0	0	0	0	0	130
3004	34.633	0.6	6.7	5	0	0	120	0	0	24	68	8	0.2	1	4	72
6151	34.55	0.6167	6.27	0	0	0	160	6.4	0.4	53	0	2	0	0	0	0
8388	34.416	0.6167	6.1	5	2	12.3	200	0.2	0	74	102	6	0.3	0	26	120
5988	34.483	0.6333	7	35	15	2.5	750	1	0.5	181	319	10	0.85	0	43	450
8406	34.466	0.6333	7.6	15	0	0	530	0	0.1	269	0	1	0	0.15	0	318
1916	34.4	0.65	7	5	0	0	340	0.4	0	138	220	14	1	3	5	204
12439	34.438	0.6569	7.2	5	0	0	1200	0.1	0.04	250	600	5	0.7	4.6	12	850
6141	34.516	0.6667	6.7	5	0.8	1.9	180	0.05	1	76	76	2	0.1	0.01	7	108
6141	34.516	0.6667	6.28	0	0	0	94	0.32	0	25	0	0	0	0	0	0
12442	34.419	0.6764	6.9	-5	0	0	810	0.01	0.01	270	490	5	0.7	6	9	570

BH_NO	DLONG	DLAT	PH	CLR	TURB	PV	COND	FE	MN	THARD	TALK	CL	F	SO4	FCO2	TDS
6105	34.5	0.6833	6.77	0	1.5	1.3	710	0.13	0.3	210	296	11	0.8	0	24	426
5388	34.65	0.7	7.8	70	8	25.3	123	0.46	0.3	73	99	2	0	1	0	73.8
6120	34.6	0.7333	6.8	10	5	1.26	460	0.46	0	170	246	7	0.95	0	24	276
6120	34.6	0.7333	7.15	20	12	1.9	475	1	0	198	248	2	0.98	0	25	285
6120	34.6	0.7333	6.9	5	3.2	0	450	0.3	0	196	245	7	0.6	0	0	270
6120	34.6	0.7333	7.1	10	4.5	5.69	540	0.3	0.5	248	299	41	1.1	2	32	324
6120	34.6	0.7333	7.1	25	17	1.7	445	1.35	0	176	234	5	0.8	0	19	267
6120	34.6	0.7333	6.7	20	14	2.8	450	0.4	0	78	222	9	0.9	0	24	270
7057	34.572	0.7349	8	1	1	0	145	0.03	0.1	109	94	36	0	1	0	87
7057	34.572	0.7349	6.6	5	0.5	0.9	350	0.02	0	142	174	2	0.35	0	18	210
7057	34.572	0.7349	6.6	5	0.5	0.9	350	0.02	0	142	174	2	0.35	0	18	210
8353	34.573	0.737	6.5	15	7	22.12	115	0	0	34	64	3	0	21	0	69
6192	34.559	0.7465	6.5	35	18	0.63	460	1.55	0	150	262	3	0.5	1	36	270
6192	34.559	0.7465	7.2	0	31	0	500	0.28	0	77	0	0	0	0	20	300
6192	34.559	0.7465	6.86	60	57	2.5	450	9	0	160	238	5	0.48	0	26	270
6192	34.559	0.7465	6.8	5	1.7	0	450	0.02	0	182	248	4	0.4	0	28	270
6192	34.559	0.7465	6.9	0	0	0	500	0	0	174	0	3	0	0	0	0
6192	34.559	0.7465	6.7	10	5.7	0.6	470	0.5	0	170	248	2	0	0	29	282
6192	34.559	0.7465	6.5	10	5	1.3	470	0.76	0	168	246	6	0.4	0	29	282
5391	34.533	0.75	0	39	8	0	220	0.38	1.6	0	111	3	0	0	0	132
5386	34.55	0.7667	6.6	0	0.8	2.2	620	0.1	0	204	221	8	0.35	0	30	372
6197	34.55	0.7667	7.1	0	0.2	3.5	350	0.03	2.6	120	172	8	4	0	30	210
6394	34.383	0.7667	7.1	15	8.2	2.2	520	0.2	0.4	225	291	2	0.35	3	43	312
6386	34.416	0.8	6.9	10	1.5	10.7	500	0.35	1.5	198	252	2	0.4	0	18	300
6401	34.466	0.8333	7.3	15	0.5	1.9	550	0.08	0	288	315	0.5	0.5	0	23	330
6389	34.433	0.85	6.9	100	32	5.69	520	0.6	0.5	147	253	16	0.7	0	32.5	312
6390	34.433	0.85	6.4	250	640	13.9	350	4	0	145	144	14	0	0	31	210
6398	34.45	0.85	6.6	5	1.7	6.95	500	0.1	0	223	268	0	0.9	0	39.5	300
6393	34.45	0.8667	6.8	5	6	2.2	230	0.12	0	101	118	2	0.2	5	26	138
12448	34.557	1.0569	6.3	-5	0	0	300	0	0.01	96	148	3	0.5	1	22	210

Annex 10.15: Kenya 2019 Population Census for Sub-counties in the Mt. Elgon aquifer region.

County	Sub-County (2019 Census)	Male	Female	Inter-sex	Total
West Pokot	Pokot South	78,403	75,329	5	153,736
Busia	Teso North	66,412	71,619	3	138,034
Bungoma	Cheptais	67,717	68,312	6	136,035
	Kimilili	78,560	83,475	3	162,038
	Mt. Elgon	38,977	39,893	3	78,873
	Tongaren	48,685	51,657	1	100,343
	Webuye West	74,180	78,331	4	152,515
	Mt. Elgon Forest* (indigenous community/Ogiek?)	1,862	1,759	-	3,621
	Bungoma West	58,225	61,649	1	119,875
	Bungoma South	139,705	148,055	5	289,765
	Bungoma North	58,970	62,526	1	121,317
	Bungoma East	55,775	58,771	2	114,548
	Bungoma Central	86,302	91,438	8	177,748
	Bumula	103,368	112,523	1	215,892
Trans Nzoia	Endebes	56,090	55,689	3	111,782
	Kwanza	100,234	103,584	3	203,821
	TransNzoia West (Saboti?)	101,198	101,174	5	202,377

(*Source: 2019 Kenya Population and Housing Census Volume I: Population by County and Sub-county*)

ONE RIVER
ONE PEOPLE
ONE VISION

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