ONLINE CONFERENCE IWRA 2021

COMPREHENSIVE RISK-BASED GROUNDWATER RESEARCH PROVIDES EVIDENCE FOR INFORMED WATER POLICY AND MANAGEMENT IN ASALS

Florence Tanui

University of Nairobi, Kenya

Co-Authors:

Prof. Daniel Olago

Dr. Gilbert Ouma

Dr. Zachariah Kuria

BACKGROUND

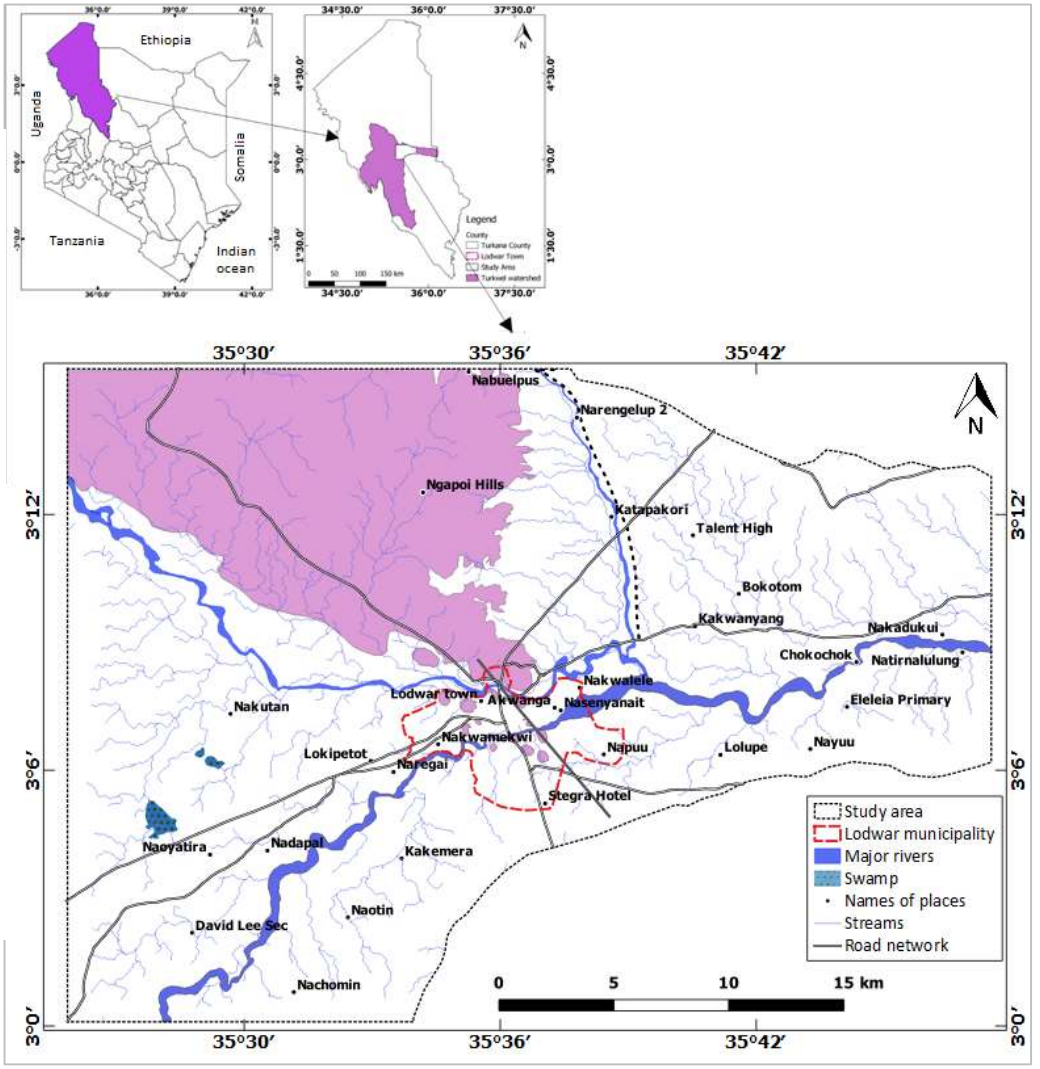
Arid Environment – Rainfall <200 mm Per year

Groundwater-dependent - highly variable water resources, lower economies of scale and increasing climate variability

Rapid Growth - Rapid population growth ~ 58,218 (2009) and 82, 970 (2019) ~ +42.5%. Attained municipality status in 2018

Emerging sectors – oil industry, expansion of irrigated agriculture upstream – effects on quantity and quality.

Uncertainty & Pollution - hydrogeological context, vulnerability to pollution, and long-term sustainability

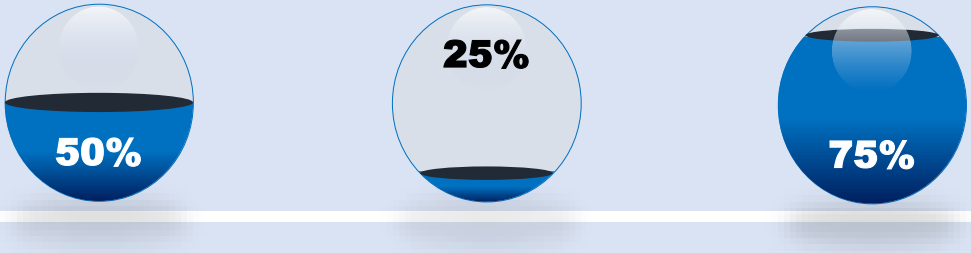


GROUNDWATER USE RISKS

Groundwater Abstraction 1

Uses 2

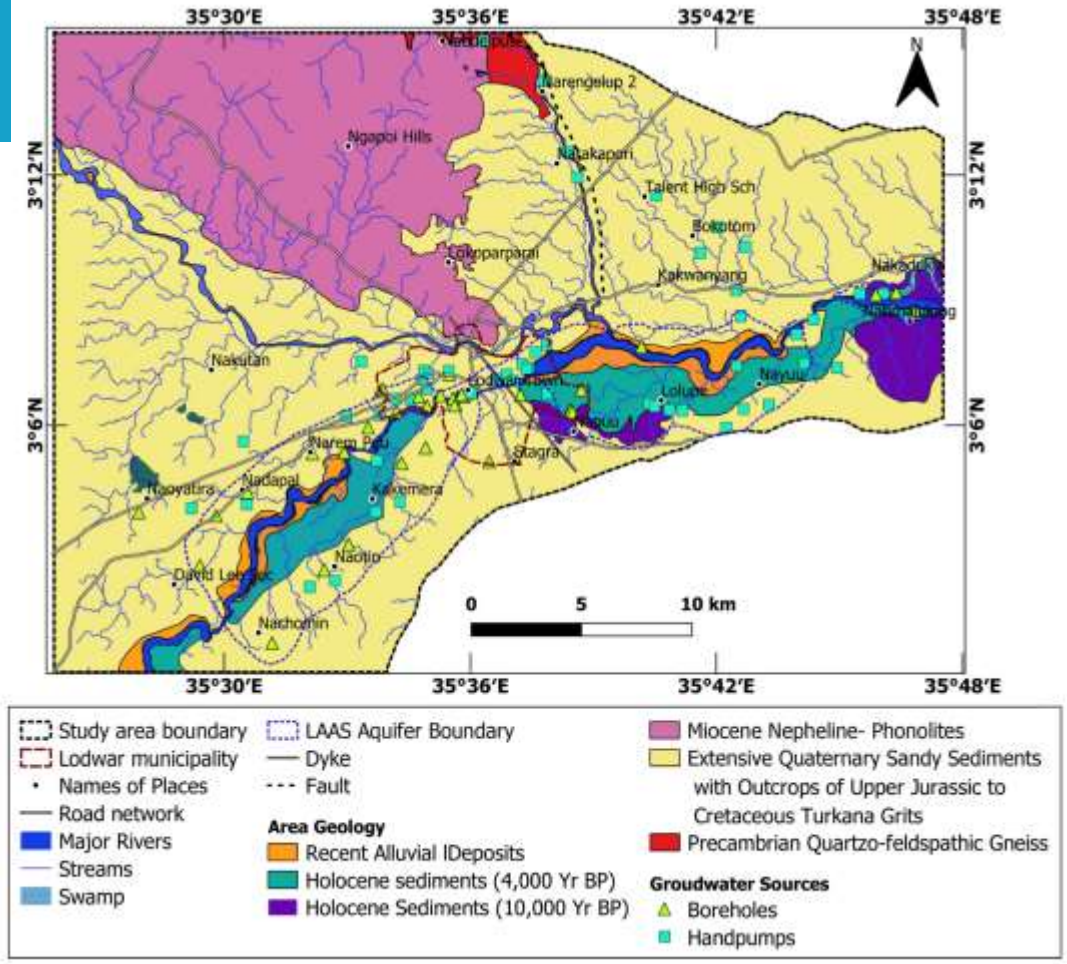
Climate and Human-induced Risks 3



Uncertainties 4

Resource allocation 5

Hydrogeology



- The geology of the area is characterized by the four rock types:

  a) Basement system rocks – mainly the quartzo-felspathic gneiss,

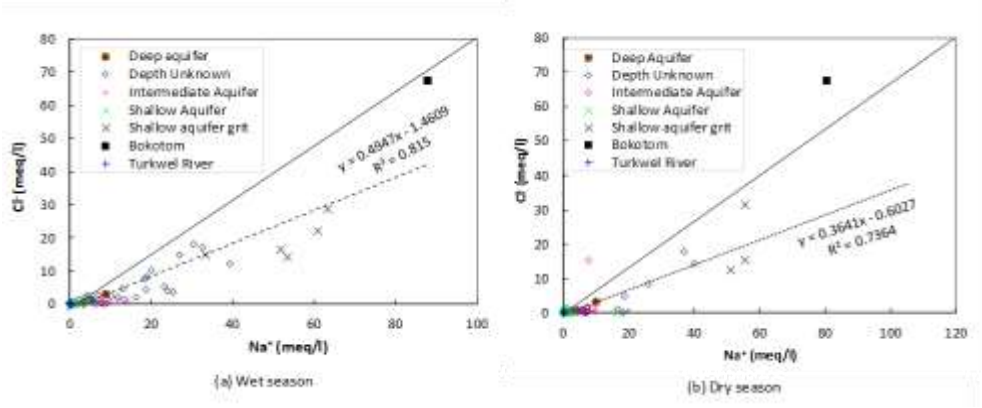
  b) sedimentary formations that comprise the Cretaceous Turkana Grits and sandstones, and the Quaternary to Holocene sediments,

  c) Tertiary Volcanics that includes the augite basalts and the nepheline-phonolite and

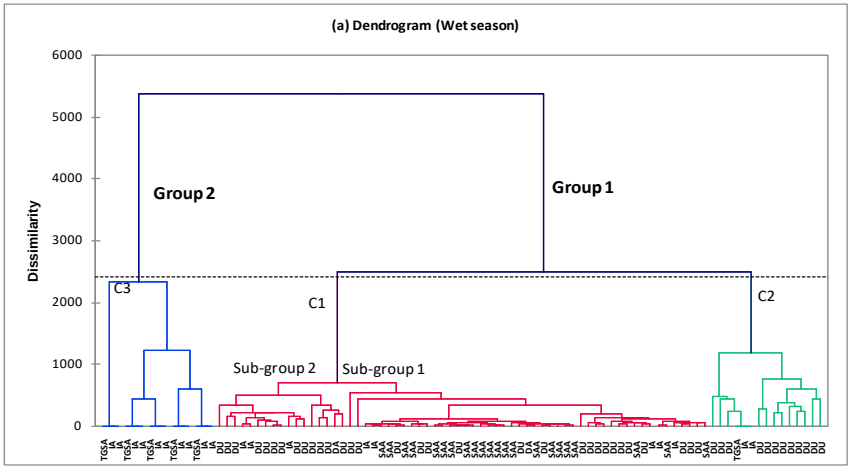
  d) the alluvial deposits.

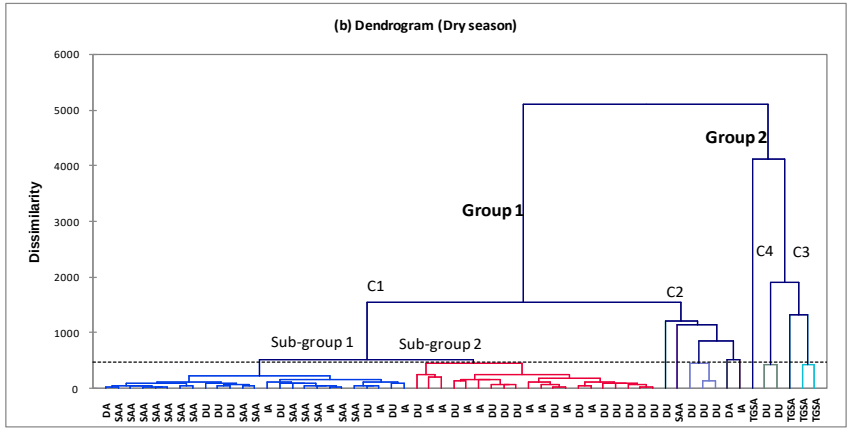
- Groundwater sources have been developed within the alluvial deposits and the Holocene sediments

Aquifer Mineralization



- Increasing Na^+ and Cl^- concentrations from the SAA through the IA to the TGSA
- Generally, EC is lowest in the SAA, which has a Ca-HCO_3 water type, intermediate in the IA and DA, and highest in the TGSA, which has a Na-HCO_3 – Na-Cl water type – these transitions reflect increasing mineral content of the groundwater.
- HCA revealed the spatial characteristics of the aquifer system and enabled the classification of boreholes with unknown drilled depth in either the SAA, IA and the TGSA
- Groundwater residence times control the degree of aquifer mineralization





Water Quality Concerns

ONLINE CONFERENCE IWRA 2021

Natural Factors

SAA (0-30 m)

Increased turbidity in the wet season and high Fe^{2+} and Mn^{2+} EC < 300 (µS/cm) Rock water interactions/ dilution /oxidation

IA (31-100 m)

High Na^+ in wells adjacent to Turkana Grits ~ high HCO_3 and F^-
EC < 800 (µS/cm)
Ion exchange/dissolution /dilution

DA (> 100 m)

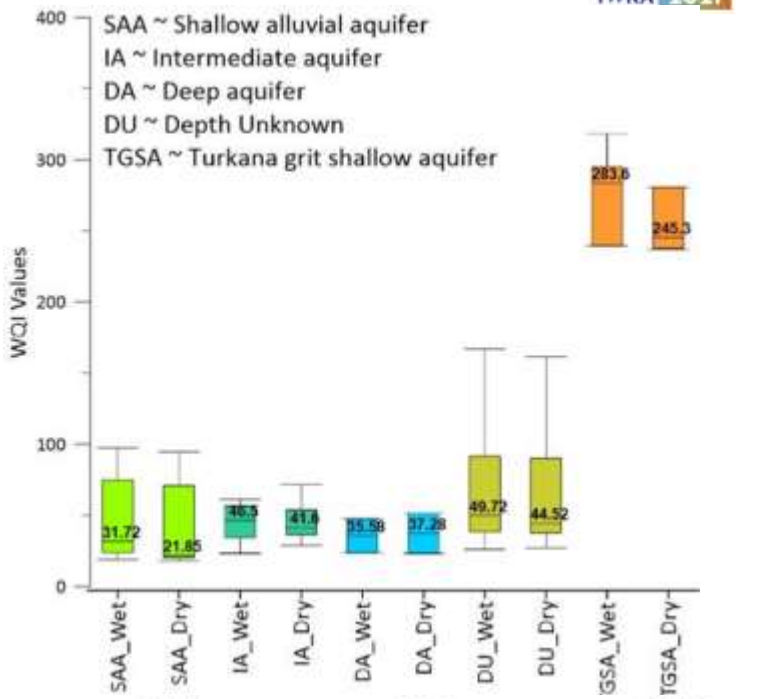
Slightly higher Na^+ in the aquifer as compared to that of SAA and IA
EC < 800 (µS/cm)
Ion exchange/dissolution

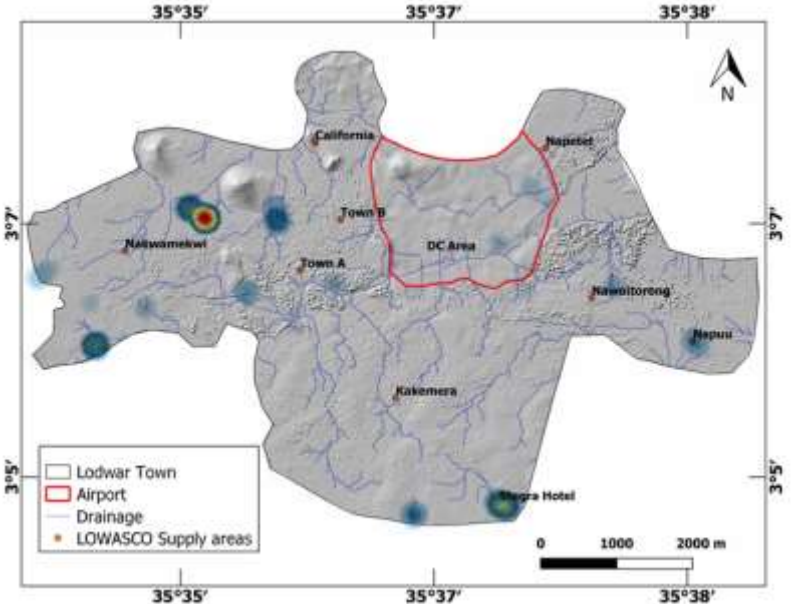
TGSA (0-30 m)

High values of turbidity, Na^+, HCO_3, SO_4^{2-}, Cl^-, F^- and NO_3^-
EC > 5000 (µS/cm)
Evaporation/dissolution

Anthropogenic Pollution

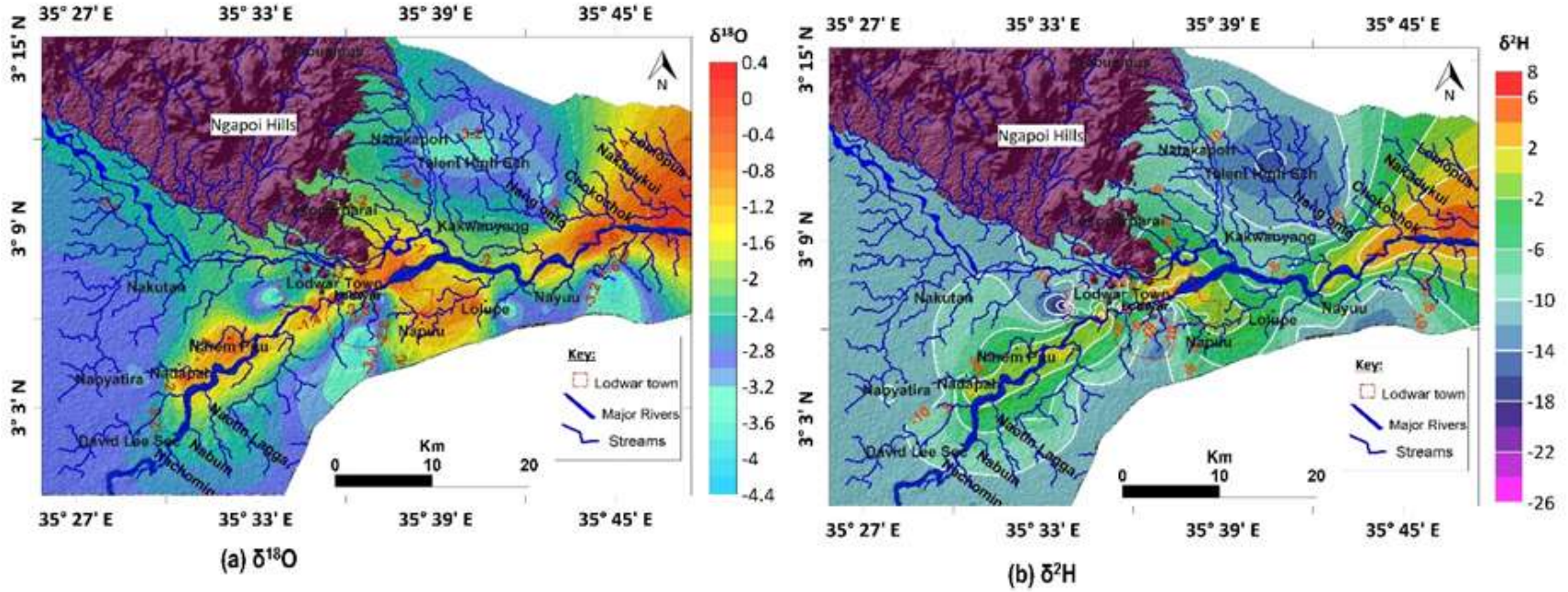
- Relatively higher NO_3^- levels during the wet season compared to dry season in the SAA and IA
- The TGSA has naturally high levels of NO_3 in both wet and dry seasons
- Elevated levels of NO_3^- in groundwater sources within Lodwar town~ link to pollution, but still safe





Oxygen-18 (^{18}O), deuterium (^{2}H), Tritium (^{3}H)

- Enriched zones closer to Turkwel River
- Protect river buffer zones and well fields;
- Regulate upstream irrigation and catchment conservation
- Initiate surface water and groundwater quality monitoring
- The tritium analyses indicate that potable groundwater is associated with modern rainfall ~ TGSA saline groundwater
- Decreasing values of d-excess from the SAA, IA, and TGSA ~ isotope fractionation along the groundwater flow path

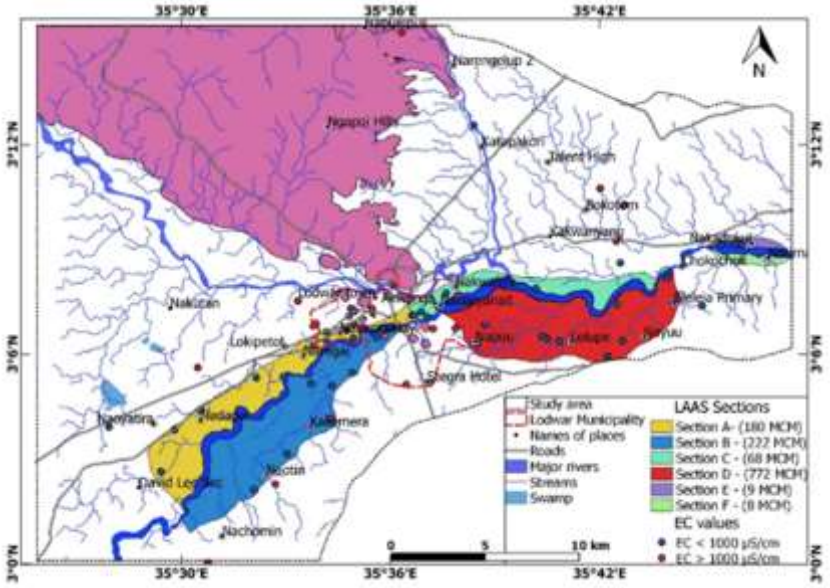


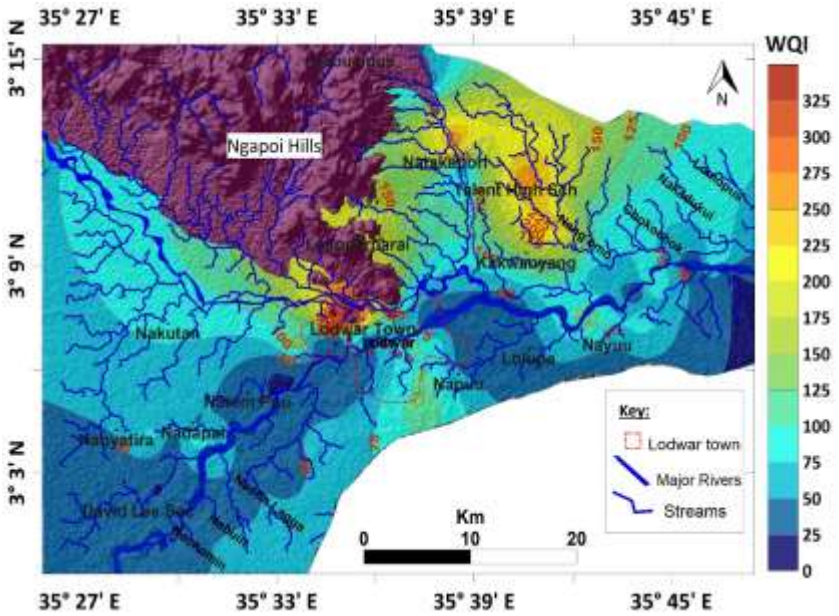
Spatial distribution of oxygen-18 and deuterium

Informed Decision-making Tools

$$WQI = \frac{\sum_{i=1}^{n} qiwi}{\sum_{i=1}^{n} wi}$$

q_i = quality rating of each water quality parameter
w_i = unit weight if each water quality parameter
n = number of parameters
i = parameters tested



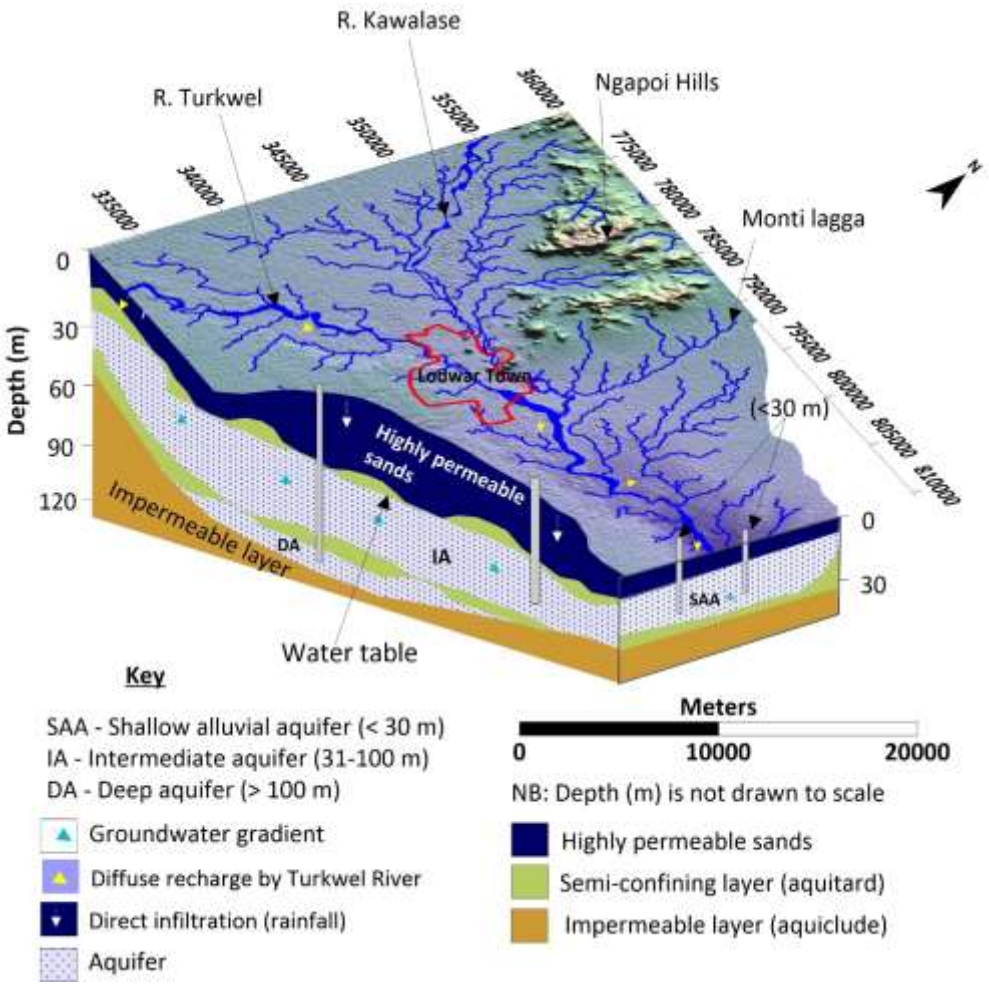


- A very tentative estimate of the storage volume is 1.3 BCM (billion cubic metres)
- The LAAS underlies parts of the – city planning required to prevent anthropogenic pollution.

- Generally, the water quality index deteriorates in the aquifers during the wet season
- Irrigated agriculture is not practised in areas with saline groundwater

Aquifer Conceptual Model

- SAA- Unconfined, while IA and DA are both semi-confined with the highly permeable semi-confining layer.
- Recharge: SAA - Diffuse recharge by the Turkwel River and from the surface water of the Kawalase River during the wet season. Direct recharge from rainfall infiltration in the study area is expected to contribute aquifer recharge during rainfall events.
- The average yield in the SAA is 16.87 m^3/h, 8.28 m^3/hr in the IA, and 6.25 m^3/h in the deep aquifer with one outlier of 100 m^3/hr in the Napuu.
- Groundwater discharge mechanisms in the study area are mainly through groundwater abstraction and evaporation.



Policy Impacts - Research Into Action

To harness and conserve water resources in the County

01 **County Climate Change Policy (2020)**

- Support research to map water resources in the County
- Protect the LAAS from human-induced pollution.
- Implement Turkana County Water, Sanitation Services Sector Strategic Plan 2017-2021.

02 **County Integrated Development Plan (CIDP) 2018/2022**

- Integrated and intersectoral approaches to the management of water catchment areas

03 **Annual Development Plan (ADP) 2020/2021**

- Real-time borehole and underground water monitoring tools procured, installed and functional in support to Water Resource Authority (WRA)