**MINISTRY OF WATER, SANITATION AND IRRIGATION**

**KENYA WATER INSTITUTE, (KEWI)**

# ABSTRACTS BOOKLET

## Geographic Information System (GIS) and Earth Observation (EO) Symposium

## THEME:
## Supporting Water Service Provision and Water Resources Management through Utilization of GIS and Earth Observation Technologies

**Sub Themes:**

1. Innovations and Technologies in GIS & EO
2. Water Utility and Infrastructure Mapping
3. GIS in Governance and Resource Management
4. Satellite Meteorology and Global Climate
5. Application of GIS &EO tools in supporting Water Resources Assessment
6. Capacity Development in GIS & EO
7. Use of cloud facilities and big data in the EO of water.


**DATES: 24th and 25th June 2021**

**VENUE: KENYA WATER INSTITUTE (KEWI), Main Campus, Ole Shapara Avenue, South C, Nairobi**

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## WATER UTILIZATION AND MAPPING INFRASTRUCTURE

### A.The Database for The Kenyan Water Sector

***Karanjah Daniel***

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Maji Data is the pro-poor database covering all the urban low-income areas of Kenya. Maji Data contains a large amount of important information on all urban low-income areas of Kenya. This online database main objective is to assist the Water Service Providers (WSPs) and Water Services Boards (WSBs) to prepare tailor-made water supply and sanitation proposals for the urban slums and low income planned areas located within their service areas, since its data is linked to satellite imagery, it allows for the improved management and operation of these areas by WSPs.

Maji Data provides the Water Sector with the information required to measure impact and progress towards the achievement of the Millennium Development Goals and the targets set by the Kenya Vision 2030.

B.Oloolaiser Water and Sewerage Company Symposium Abstract
Utilizing mobile mapping for improved field data collection process

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Information technologies aid transformation of services as they contribute to efficiency and sustainability in terms of asset inventory and management. Open source software tools have become low cost and effective tools combining user friendly and customizable data interaction interfaces that enable utility companies to carry out satisfaction surveys, water quality surveys, mapping of systems, administration and management functions. Among the common open source mobile resource mapping tools include: Kobo collect, ODK, mWater surveyor

Kobo collect, being available and configurable on the Android platform, has proved to be a functional and effective tool in survey of the company's infrastructure as the mWater Surveyor handles the water quality aspects.

Often than not, water service providers have been faced by water deficit challenges especially during the dry times where climate change has been tagged as a causative agent. With the developments in GIS and Earth Observation technologies, use of aerial imagery in elevation modelling, conducting of time-series models on the other dependent variables of land-use change and climate variability now allow for predictions of the future climatic conditions.

Advancements in mapping have employed the web and the cloud-based solutions, where at times due to internet failure and variations in topography and landscape, mobile applications that allow for offline and decentralized working help in improving the mapping, storage and data management levels. This allows for ease of access and use by all the categories in various working capacities.

## C.Adopting new trends and approaches in the management of Non-Revenue Water

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80% to 90% of water is linked to a specific location in a utility network. According to WASREB[1] impact reports, the water utility sector experiences significant financial constraints that make it difficult to self-sustain its operations. WASREB suggests that water utilities need to invest in their self-financing potential to attract more finance. Non-revenue water (NRW) is a major contributor to the financial challenges facing water utilities. In 2019, for example, an NRW level of 43% led to a loss of approximately Kshs. 15.8 Billion.

Innovative use of GIS and EO solutions has shown great potential in reducing non-revenue-water and improving revenue collection. Among this solution is the Utility Manager (UM) and Utilis, UM is a Smart MApp application that monitors activities within a utility network and provides critical information for curbing NRW through the use of spatial analytics. The information from this App is critical in the development of revenue collection plans, Non-revenue water management strategies, and in the process of decision making to ensure that effective business strategies. Utilis is is an innovative water-leak detection solution that provides a revolutionary new way of detecting NRW leaks by analyzing images from satellites. The solution offers a fresh approach, providing a non-invasive, innovative method to the problem of water leakage detection.

In conclusion, improving revenue collection efficiency and significant reduction of NRW to sustainable levels will provide water utilities with the ability to unlock their self-financing potential.

Keywords: **Non-Revenue Water**, **Earth Observation**, **GIS**, **Utility Manager, and Utilis.**

## D.Supporting Community Water Supply Systems to Map Water Infrastructure and reduce non-revenue water using GIS open tools

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Community Water Supply Schemes are crucial entities for ensuring safe and continuous drinking water supply to millions of households in every corner of the country. In Kenya there are about 174 WSPs and numerous community water supply schemes scattered in the rural areas and urban peripheries. Even though the issue of non-revenue water is increasingly becoming a major challenge for WSP, there are few WSPs that have Implemented GIS systems to map their water Infrastructure and manage Non-revenue water. Nonetheless, the existing WSP in Kenya are have small budget and are still dependent on outdated CAD maps that are not georeferenced. This paper seeks to develop a cheaper GIS system for easier use by rural community water supply schemes

A simple geographic information system (GIS) which can create and implemented by rural community water supply schemes can be done using open source GIS software. The outdated Data sources or CAD files can be scanned, georeferenced and digitized accordingly. This will include determination of location of pipes, fittings and other water appurtenance using high accuracy GPS and digitizing feature in the water supply system using open-street map. Dataset can then be added inn QGIS and displayed over aerial photographs and other background data. An output/Map Atlas is then generated with features and potential areas for water leaks for non-revenue water management. Notably a SMART workflow taking into considering user needs assessment, source data evaluation, field data collection, implementing a GIS, and map production. This workflow can help support water management professionals for peri-urban and rural water supply systems/schemes

## E)Embracing Open-Source Packages In Mapping Out Water & Sanitation Infrastructure

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Geo-Spatial technology is ever changing in advancement from simple to sophisticated technology as its adoption in operation grows steadily. With the advancement comes the cost implication that many companies (WSP) perceive exorbitant. With proper implementation of GIS and anchoring in an organization the benefits would be limitless.

To bridge the heavy investment cost for both basic and advanced GIS implementation open source GIS packages is the way to go. With a basic workstation and cloud-space reservation at a small fee (less than 50 USD) one could setup a GIS system. A system able to capture (data collection), managing (database/storage), analyze (desktop manipulation and analysis) and dissemination of information/data (static maps & web-map/dynamic maps).

There are available softwares that can complement a simple and very powerful open-source based GIS system. These softwares range from mobile field data collection application that complements a seamless work-flow in the system integration e.g. Qfield and ODK kits. QGIS is a powerful GIS tool complemented with postGIS database, QGIS server and LIZMAP web-client give meat to Geo-Spatial Information System.

There are various open source solutions out there, only setback being high level of skills is needed.

**Topic:** Mapping Water Supply and Sanitation

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**Institution: Nanyuki Water and Sewerage Company**

Over the years, the use of GIS and Remote sensing technologies in the management of water infrastructure has been largely employed by water utility companies and stakeholders. This has majorly contributed to accuracy and precision in gathering, storing, analyzing and visualizing information about location, age and status of water infrastructure. The evolution of GIS and Earth observation has been greatly fast-tracked by the advancing technology, with the introduction of mobile mapping applications and web mapping. As a result, access to accurate data has been improved hence enhancing the interdependence of field personnel and geospatial data analysts.

Nanyuki water and sewerage company has intensified efforts to make GIS a super tool for designing, mapping and maintaining our water infrastructure as will be demonstrated on this presentation. The role of GIS and Earth observation in providing an insight into financial projections and determining the viability of various projects is essential to any long-term project.

GIS and Remote Sensing/Earth observation has played a vital role as a decision support system for solving GIS-based problems in the water sector. The purpose of the presentation will be to demonstrate the role of GIS and Earth Observation as a decision support system in design and management of water infrastructure.

This presentation will provide an overview of methods employed by the Nanyuki Water GIS team, how Geospatial data is stored and managed and finally dispensed as well as demonstrate the importance of spatial data in identifying land utilization patterns, management of non-revenue water (NRW) and in design of water supply and sewer system.

## F)Application of GIS Technology in Non-revenue water reduction a case study KEWASCO'

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Non-Revenue Water (NRW) is the water loss that does not earn income/revenue to a Water Service Provider(s) and is lost through physical losses for example leakages/burst in the distribution system or commercially through water theft, malfunctioned water meters, and many others. NRW has been treated as a very serious issue in Kenya, and it is one of the key performance indicators used by Water Service Regulatory Board (WASREB) to rank the performance of the Kenya Water Service Providers.

Geographic Information System (GIS) technology provides many powerful tools that allow integration of many types of data (Raster and Vector) and also analyses spatial locations. Kericho Water and Sanitation Company (KEWASCO) adopted the use of GIS technology in the year 2012 for mapping of its distribution network which has really aided in management of NRW in the company.

A well-defined small area called District Metered Area (DMA) was chosen, then the quantifiable NRW management activities were identified from the District Metered Area. Since its implementation the GIS technology has had a great impact in NRW. It is therefore critical for any Water Service Provider(s) to adopt the GIS technology to help in the management of NRW to an acceptable level set by WASREB of 25%.

## G)The urgency to address sanitation challenges in Kenya

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Kenya has a population of about 50 million people has about 48 percent of its population lacking access to basic sanitation solutions. Access to proper sanitation is critical to the health of families in Kenya so they can prepare and protect themselves from the COVID-19 pandemic and other diseases. The Challenges facing attainment of proper sanitation include inability to collect reliable data on sanitation aspects, lack of access to improved sanitation, inadequate methods in wastewater treatment, and safety by which waste is contained, emptied, transported and disposed of. For proper sanitation to be achieved, it requires a paradigm shift in policies, technologies and mindsets among individuals in the sector. The country we need to acknowledge that we have a huge challenge that calls for rethinking of strategies, efforts to implement the roadmap that aims to make the country open defecation free soonest will be key, increasing sanitation financing in counties and focus on better targeted and more inclusive interventions will also help the country reach its sanitation goals. Finally, universal sanitation cannot be achieved without strong stakeholder engagement and community consultations.

Key Words: Kenya, Sanitation, Challenges, Safety

H) Water fund Water Utility and Infrastructure Mapping Overview'

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The Water Sector Trust Fund (WSTF) is a State Corporation under the Ministry of Water and Sanitation established under the Water Act 2016 with the mandate to provide conditional and unconditional grants to the Counties and to assist in financing the development and management of water and sanitation services in the marginalized and underserved areas.

The J6P is a KES 2 billion programme co-funded by the Governments of Kenya, Finland and Sweden. The programme runs during the period of 2015-20 and is piloting new approaches to water infrastructure investments in six counties, namely Kwale, Laikipia, Migori, Nandi, Narok and Tharaka Nithi, through WSPs and WUAs. 27 water projects were financed in June, 2016 at a cost of KES 206 million, targeting to reach 151,000 people.

The J6P aims to achieve its purpose through five outcomes, namely:

- **Outcome1**: County capacity enhanced; County capacitated in fulfilling their constitutional responsibilities in establishment of an enabling environment for the provision and monitoring of Water Resources Management (WRM), Water and Sanitation services.
- **Outcome 2**: Water resources management conflicts reduced; WRM initiatives protecting water resources and ensuring equity in water access thereby reducing water related conflicts and environmental degradation.
- **Outcome 3**: Increased water service access; Water supply projects ensure improved equitable access to water services.
- **Outcome 4**: Increased sanitation service access; Sanitation investments ensure improved equitable access to sanitation.
- **Outcome 5**: WSTF capacity enhanced; The WSTF able to undertake its mandate through strengthened institutional capacity.

Under the Outcome 1 of enhancing county capacity, the first phase of Water Utility Mapping was conducted during 2017-2018 with the objective of supporting the implementing partners on mapping of their infrastructure and customer base. The mapping included 27 water projects, funded during Batch 1 of J6P. During the Water Utility Mapping, infrastructure such as intakes, storage tanks, pipelines, communal water points and treatment works, as well as customers, are mapped. WaterFund uses an open source survey-based data gathering tool, an Android Mobile Application based on Open Data Kit. The infrastructure form captures technical data and information on the condition of the structure, after which it requires the data collector to take a photo and its GPS coordinates. The customer form collects data on the potential or connected customers, the levels of current water and sanitation services as well as their health status, together with the GPS location.

Objectives of Water Utility Mapping

The objective of the Water Utility Mapping is to provide tools and support to the Counties and the Water Utilities to enable continuous mapping of the infrastructure and service levels. The mapping sets the foundation for the utility to be able to plan and monitor or track changes in service levels and coverage area and identify underserved areas.

The overall objectives of the Water Utility Self-Mapping are;

i. To build the GIS capacity of the unregulated small water utilities and to equip them with the tools and understanding of WU mapping to create a continuous self-mapping system;

ii. To assess the impact of the J6P Phase 1 investments in terms of Service levels; Coverage area and customer base; Built infrastructure network, and Utility performance

iii. To set a country-wide standard for the Water Utility Mapping concept and develop the necessary tools and materials to support it.

The specific objectives of the Water Utility Self-Mapping are;

i. To document all consumers for easy accessibility, following their customer satisfaction, and to ease the process of billing and revenue collection;

ii. To document the location of all the infrastructure, including intakes, tanks, pipelines, communal water points, sanitation facilities and treatment works for purposes of operation and maintenance; and

iii. To produce a map for use of future extension and improvement of services.

The expected output of Water Utility Mapping is:
1. To create **maps** on water infrastructure
2. To collect **household data** on all connected consumers
3. To assess the **performance** of utilities
4. To **monitor** and track the impact of funded projects
5. To build the **capacity** of Counties and water utilities in managing their water supply schemes and customer base
6. To strengthen **customer engagement**
7. To build capacity for **continuous** self-mapping in water utilities

Water Utility Mapping Methodology

The mapping process includes:

- Setting the mapping objectives
- Preparing the data collection tools and hosting of collected data
- Training of enumerators
- Taking inventory of existing data
- Planning of data collection
- Data collection and submission
- Data cleaning
- Post-processing of infrastructure maps and Pipeline digitization
- Production of final maps & reports
- Continued support for utilities on mapping

Data Collection Tools

The data is collected through an android app built on Open Data Kit (ODK) which is an open source survey-based application that supports pre-filled forms, multiple choice questions as well as capturing of text and digits. The app is designed to work well without network connectivity and enables capturing of images and Geo-coordinates for WaterFund investments across the country.

To use the app, one needs to download it from the Google Play store on an Android Mobile phone or Tablet. After configuration it is then possible to download the developed survey forms to conduct offline surveys and submit/upload forms once re-connected to the internet.

The following four survey forms are used for the Water Utility Mapping:

1. The **Customer** tool collects the service levels data on the water connections which could be households, institutions or commercial connections. The service level is determined by the quality, quantity and distance to water source, sanitation status as well as the health status. The Customer tool allows the utility to determine their current coverage and thus gives them a mechanism to engage with the customers and helps the utilities to assess the number of water connections and the satisfaction levels of their customers.

2. The **Infrastructure** tool is used to collect data for all the components of the infrastructure within the service network, such as intakes, distribution systems, storage tanks, treatment works, amongst others. The form requires the enumerator to fill in technical parameters on the infrastructure, its condition, operational status, and finally to take a photo of the structure.

3. The **Pipeline Infrastructure** tool captures the pipelines and the pipeline appurtenances together with their technical parameters, such as diameter and class, as well as the condition and operational status. The capturing of the pipeline data is started at the beginning of the pipeline, and the enumerator is expected to 'trace' the pipeline accurately by capturing each node, appurtenance or bend along the way until the end of the pipeline. A guide who is well informed of the route of the pipeline is required in the process.

4. The **Creditworthiness** tool is used in the assessment of the financial, technical and management performance of the utility using indicators on expenditure, income, technical aspects, governance and systems. For the assessment of creditworthiness, the water utility is requested to provide documents such as registration certificates, water permits and financial statements, amongst others. Since the survey is at the beginning of the project implementation It is mainly meant to track change in the performance of the utility and identify the areas of required improvements and targeted support in the operations of a utility.

Water Utility Mapping Work Flow

WaterFund established the work flow for Water Utility Mapping in collaboration with Kenya Water Institute. The work flow is as shown in the table below:

Continued Data Collection

In order to keep the mapping system updated, the Water Utilities should ensure together with WaterFund that the process is continuous. Whenever the utility builds new infrastructure or connects a new customer, or plans to connect to a new zone, the data should be captured promptly. This means that also the maps should be updated as new sections have been mapped to keep the entire system up-to-date.

For more information on Water Utility Self Mapping, the Water Utility Self Mapping Manual can be downloaded from www.waterfund.go.ke

**SUB-THEME**: WATER UTILITY AND INFRASTRUCTURE MAPPING
**TOPI**C: Application Of Gis In Management Of Nrw (Non-Revenue Water)

Non revenue water (NRW) refer to the difference between volume of water supplied into a water distribution system and that volume that is billed to customers.NRW can be in form physical losses, commercial losses and unbilled authorized consumption.
In the whole of the earth, according to International Energy Agency about 34% of the pumped water eventually becomes non-revenue water.
The main components of NRW include: leaking main pipes, lack of active leakage control, worn out meters, illegal connections, booster's pumps and machineries' leakage, worker' faults, unrecorded consumption, outright water theft, customer's pipe leakage, free supplies such as those used by firefighting and wastage by consumers.
NRW has major effect on the company and customers such as high physical losses resulting to intermittent supply, high leakages increase flow rates in pipe network, lead to high tariffs charges and pose significant health challenges as sewage can get into leaking pipes.
Many water companies such as Bomet Water and Sanitation Company(BOMWASCO) despite having information on loss of water through NRW means have not succeeded in managing non-revenue water.
This study aims at applying GIS in management of non-revenue water by remotely detecting bursts, leakages and other associated losses. (A case study of BOMWASCO)

GIS IN GOVERNANCE AND RESOURCE MANAGEMENT

A) Multi-Criteria based watershed prioritization for soil and water conservation planning in Gotu watershed, Awash river basin, Ethiopia

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**Background:** In Ethiopia, soil and water conservation has often been implemented through community mobilization during dry season haphazardly but the issue of "which part of the watershed should be conserved first considering different criteria? and which one should be the last?" has hardly been embedded.

**Objective:** This study was undertaken to prioritize sub-watersheds on the basis of myriad of parameters: morphometric, soil loss, socioeconomic and related criteria for soil and water conservation activities in five catchments in Gotu watershed, Awash river basin, Ethiopia.

**Materials and methods:** Advanced Spaceborne Thermal Emission and Reflection Radiometer Digital Elevation Model, Revised Universal Soil Loss Equation (RUSLE) indices (gauge rainfall data, soil data, Digital Elevation Model, and landsat-8 Operational land imager, socioeconomic and related data like population density, share of cultivated land, economic status, land pressure, potential labor force for conservation, conservation work performance, and share of unirrigated land were used for prioritization exercise.

**Results:** It was found that Gotu watershed has seven order streams with a mean bifurcation ratio of 2.1; higher stream frequency = 6.4–7.9 streams km$^{-2}$; low drainage density (0.52–2.85 km km$^{-2}$) and moderate drainage texture (3.7–5.7); elongated shape (Form factor = 0.16–0.23; elongation ratio = 0.45–0.53; circulatory ratio = 0.17–0.24). Using RUSLE model, the soil loss of the study catchments ranged from 0 t ha $^{-1}$yr$^{-1}$ in the plain area up to 197.2 t ha $^{-1}$yr$^{-1}$ in the steeper, and fragile part of the watershed which made catchment two an area of severe soil erosion. Considering socioeconomic parameters, catchment five and catchment two are evidenced with low and high status, respectively. Therefore, the combined result showed that catchment five having an area of 17.77 km$^2$ out of 160.56 km$^2$ of the total area of the study watershed requires the first priority for soil and water conservation measures.

**Conclusion:** It is concluded that catchments with high soil loss may not usually guarantee primary attention for conservation unless the condition of socioeconomics, morphometry of catchments and related parameters simultaneously contribute for the decision making of conservation planners.

B) A GIS-based approach to delineating the areas of a lake that are suitable for cage fish culture

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We present a GIS-based approach to the delineation of areas that have different levels of suitability for use as tilapia cage culture sites the Kenyan part of Lake Victoria, Africa. The study area was 4,100 $km^2$. The method uses high-resolution bathymetric data, newly collected water quality data from all major fishing grounds and cage culture sites, and existing spatial information from previous studies. The parameters considered are water depth, water temperature, levels of dissolved oxygen, chlorophyll-*a* concentrations, distances to the lake shoreline and proximity to other constraints on cage culture development. The results indicated that the area most suitable for fish cages comprised about 362 $km^2$, or approximately 9% of the total area; the remaining 91% (i.e. 3,737 $km^2$) was found to be unsuitable for tilapia cage culture. We conclude that the successful implementation of this approach would need stakeholder involvement in the validation and approval of potential sites, and in the incorporation of lake zoning into spatial planning policy and the regulations that support sustainable use while minimising resource use conflicts. The results of this study have broader applicability to the whole of Lake Victoria, and other Great Lakes in the world for tilapia cage culture.

**Keywords:** GIS, Lacustrine; cage culture; wild fisheries; spatial planning; sustainability.

## C) Use of GIS technologies in data management and flood monitoring by the Water Resources Authority (WRA)

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Storage, analysis and dissemination of hydrological data has been a challenge to most institutions in Kenya. In Water Resources Authority, types of data collected include monitoring, GIS and Remote sensing data. The monitoring data is collected from stations installed at different water resources within the country. Some of the main data collected include water levels for rivers, ground water level data, water quality data, meteorological data and discharge data.

The Water Resources Authority through the Kenya Water Security and Climate Resilience Project, has developed a water information system to facilitate the handling of data collected by the institution. The main purpose of the system is to aid in data entry, storage, analysis and information dissemination to different stakeholders (Internal and External).

The Authority operationalized the MIKE IPO (INFO/Planning/operations) to provide the required decision support. MIKE IPO includes MIKE INFO, MIKE Planning and MIKE Operations. MIKE INFO is applied through MIKE INFO web, MIKE INFO desktop and MIKE Workbench. These systems incorporate the use of geodatabases such as Postgres and are available for use in all WRA offices in the countries.

**Keywords:** GIS, MIKE IPO, Geo-database

D) Gis Analysis Of Solid Waste Management System And Design Of An Engineered Sanitary Landfill For Nyeri Municipality

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Municipal Solid Waste (MSW) waste comprises waste from commercial institutions and markets, households, non-hazardous industrial waste, and street sweepings, excluding hazardous waste and medical waste. Accumulation and poor disposal of MSW is one of the largest public health and environmental issues faced in Kenya. The amount of waste generated is usually a reflection of the intensity of human activities. Due to the devolution that came with the 2010 constitution, there has been a significant increase in population and economic growth that has steered an increment in MSW production. This study was aimed to assess the existing methods of solid waste disposal and design a sanitary engineered landfill in Nyeri town to curb the problem of poor solid waste management. To determine the amount, characteristics, and composition of waste, secondary data was obtained from the county offices database, as well as administering interview questions. It was established that organic waste formed the largest percentage (51%) of the MSW. According to data collected from the County Environmental and Solid Waste Management offices, the amount of waste collected was found to be approximately 320t/week. For mapping, the collection of coordinates of waste bins was done by use of Global Positioning System (GPS) aided by *GPS-essentials* mobile application. After the collection of data, a Geospatial Information System (GIS) database was developed using the GIS software (ArcGIS and USGS) to analyze the present solid waste collection system in the area. For the landfill site selection, the USGS earth explorer module was used to acquire Landsat 8 imagery, and clipping was done for the study area boundaries. To generate a subset image of the suitable landfill location, a Vector dataset in the form of shapefiles was used, grouped, and set out to facilitate the proximity analysis. The raster dataset, the Digital elevation model (DEM), was used to derive the slope, height, and drainage patterns of the study area using the ArcMap module. These datasets were reclassified, determined, and weights assigned. The weighted overlay was then used to identify the suitable candidate locations for landfill establishment. The design of the landfill was done using EPA manual guidelines. The amount of waste produced was estimated to be 15360t/year. The target lifespan was set at approximately 30 years of operations and estimated growth of 2.3%, the total waste generation was established as 687000 t. With an MSW compacted density assumed at 0.5t/m3, the estimated waste capacity produced in 30 years was established as 1.374 x 106 m3. From the calculated landfill
capacity, a rectangular landfill of an approximate area of 400m by 200m was designed, complete with leachate management, leachate storage, and bottom liner systems

## E) **Erosion Risk Mapping for Sub Basins in Nzoia Watershed, Kenya**

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Degradation of Nzoia watershed is on the increase, occasioning extensive soil erosion that lead to high sediment yields and subsequent high sediment loads in River Nzoia. Sustainability of the Lower Nzoia Irrigation Scheme is therefore threatened by high silt deposition along the canals and other infrastructure, prompting this study, whose aim was to map erosion risk areas for Nzoia Watershed. The objectives of the study were to: (i) identify erosion hotspots in Nzoia Watershed (ii) generate erosion yield map for Nzoia watershed. (iii) rank and prioritize sub basins to implement soil and water conservation activities. Remote sensed vegetation cover images were processed for the Nzoia River basin and overlaid on slope map. Areas with high slopes and low vegetation cover were deemed as more vulnerable to erosion and mapped as hotspots. Revised Universal Soil Loss Equation (RUSLE) was applied for the Nzoia Watershed using remote sensed data. Rainfall Erosivity (R), Soil Erodibility (K), Slope length (L) factors were applied. TAMSAT satellite rainfall data, KENSOTER soil map for Kenya and, Normalised Difference Vegetative Index (NDVI) data obtained from MODIS were input. Sediment Risk index was calculated by multiplying the mean erosion rate per sub basin by inverse distance to the lower Nzoia Irrigation scheme, i.e Sediment Risk Index = Mean Erosion rate  1/Distance from Irrigation site. Results revealed that erosion yields in Nzoia watershed ranged from 0 to 22,7675ton/ha/yr. Areas around Mt. Elgon, Cherang'anyi hills and northern parts of Nandi escarpment have yields in excess of 800ton/ha/yr while the lower reaches generally portrayed low erosion yields of 0-500ton/ha/yr with patches of erosion hotspots around Ruambwa, Butere, Ugunja and Mumias. The study also showed that sediments yielded from sub basins in close proximity to the irrigation scheme pose more risk than those in the upper basins which are likely to settle before reaching the scheme intake. A detailed study on sediment transport is recommended to ascertain the settlement patterns of sediments generated from the Nzoia Watershed. Further, validation of the identified hotspots is encouraged before adoption of this study as a guide for activity implementation. Sub Theme 3: GIS in Governance and Resource Management- Role of GIS in planning, management and development of resources

## F) GIS based Multi criteria Analysis in Mapping potential for Irrigated Agriculture

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Agriculture in Kenya is fundamental in economic development, it contributes 35% of the gross domestic product and such remains the backbone of the economy, its growth is important for alleviation of poverty and stimulation of economic growth and development. Economic growth and development envisioned in the Kenya Vision 2030 can only be achieved by investing and transforming this sector of the economy which ensures a constant food supply and food security for the population. Through all this multiplier effects agriculture is perceived to be an engine of economic growth and development. It's the main economic activity in rural areas.
However, this sector has suffered a setback as a result of reliance to rainfall which is insufficient in most areas. Kenya's dry land areas, Arid and semi-arid makeup more than 80% of the country (Umar 1997). As a result, there has been an imbalance between food demand and supply. Increasing population numbers intensify the pressure on agricultural resources and to meet the nutritional demands of the growing population, an increased food supply is required. It's on this backdrop that irrigated agriculture should be developed in this country to complement rain fed agriculture especially in arid and semi arid areas with rivers and other Gwaetoegrr bapohdice sI.n formation Systems (GIS) based Multi criteria analysis can be employed to map areas
with potential for irrigation. Focusing on Machakos County as the case study, this research will explore how GIS can be used to identify areas with potential for irrigated agriculture thus expanding area under crop production in this County. Multi criteria analysis is concerned with the allocation of land to suit a specific objective on the basis of a variety of attributes that the selected areas should possess (JR Eastman,1999). The Research Project will focus on different variables including soil fertility (soil texture, depth and Ph), drainage (perennial rivers), land use land cover, topography and road infrastructure. GIS tools are used to analyse the data sets and result are presented using maps, tables and graphs. Google earth images, SRTM 30m are used to extract data.
The findings from the Project will help in developing strategies to address the perennial food shortage in Machakos County by among others the County Government of Machakos, Ministry of Agriculture and Non – Governmental Organisations.

# APPLICATION OF GIS AND EARTH OBSERVATION TOOLS IN SUPPORTING WATER RESOURCE ASSESSMENT

## A) Synthetic Aperture Radar (SAR) for flooded vegetation detection along Lake Nakuru riparian

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Flood inundation has become an issue of concern especially along the Rift Valley Lakes in Kenya. Most of the Land use and Land cover (LULC) have been affected by the floods hence interfering with the aquatic environments and to a larger extent the habitats and feeds for wild animals within conservation areas. Lake Nakuru National park is no exception since the riparian reserve has been affected by the swelling lake over the years. Previous studies have engaged optical based images to extract spatial information from the submerged vegetation classes but it has become difficult due to the heterogeneous nature of the landscape. It's for this reason that Sentinel 1 synthetic aperture Radar (SAR) of Single Look Complex acquisition were used in detecting the transition of the lake from the year 2014 to date. S-1 multi-date images captured between 2014-2021 was able to detect the state of the flooded riparian reserve and the extent of damage that occurred on the riparian vegetation both qualitatively and quantitatively. The results of the study can be used by the interested stakeholders for riparian reserve conservation and rehabilitation.

## B) Water Observations From Space (Wofs)

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Water monitoring and management were identified as the priority areas for Digital Earth Africa (DE Africa). To address this, a continental scale water monitoring service, known as Water Observations from Space (WOfS) has been availed. This service supports nations and stakeholders to make informed decisions, plans, and ongoing adjustments that will contribute toward achieving SDG 6 outcomes. The data helps users to understand the location and movement of water present in the African landscape and allows efficiency in identifying water resources. WOfS also helps African farmers and governments use their land and water resources more sustainably, and enables better planning which increases the availability of safe and drinkable water. Additionally, WOfS data supports the sustainable management of water and sanitation for Africa by providing information that enables the monitoring of ecosystems over time. Water information will be available through the service in near real-time and can be used for environmental monitoring, flood mapping, monitoring planned water releases, and management of water resources in highly regulated systems. Through identifying trends and changes over time, WOfS data can improve the management of water resources, providing a greater understanding of certain impacts, such as floods and droughts. The data derived from WOfS is available in the DE Africa Map and ESRI's Africa Geoportal to provide a more accessible view of spatial data in a map-based format. Through data-driven mapping, stakeholders and decision-makers can more effectively visualize and manage their water resources - dams, wetlands, and rivers.

### C) Gis As A Tool To Support Rain Water Harvesting

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Water scarcity in Kenya is a critical constraint to the country's socio-economic development. It hinders the achievement of Kenya's Vision 2030 as well as the global development agenda detailed in the Sustainable Development Goals. The situation is worsened by climate change and increasing water demand due to high population growth. Therefore, effective alternative water conservation method is needed. The construction of dams and ponds to harvest rainwater and encouraging homesteads to practice rainwater harvesting from their rooftops are among the solutions available to solve water shortage crisis in both rural and urban areas. The success of this alternative water conservation method that is, rain water harvesting [RWH] depends on technical design and identification of good and appropriate site to put the dam. For identification of suitable site for the construction of hydraulic structure, a geo information technology [GIS] and remote sensing technique can be used. This technique combines various biophysical elements: slope, runoff depth, land use, soil texture and stream order. The suitability map obtained by GIS is useful to hydrologist, cities adviser, and planners for quick identification of areas that are suitable for rain water harvesting structures.

KEYWORDS
GIS; Rainwater harvesting; suitability map; stream order; hydraulic structure

D) Pollution Risk Assessment of Groundwater at Kamkuywa Market Center, Bungoma Using Geospatial Technology

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Pathogenic contamination of groundwater, due to poor sanitation, has continuously posed a significant health risk to human health. Kamkuywa market center, a peri-urban settlement, relies heavily on shallow wells for water supply and use of pit latrines as a mean of waste disposal, hence risking groundwater microbial contamination. This study used GIS-based risk mapping to establish the extent of groundwater pollution by coliforms and determine the relationship between selected risk factors, namely: depth to the water table, distance from a shallow well to the nearest pit latrine, pit latrine depth, soil permeability and ground slope for purposes of establishing the optimal well-pit latrine separation distances under different hydro-geological conditions. All shallow wells and pit latrines in the study area were mapped and the separation distances compared to the recommended standards. Water samples in 32 shallow wells were collected and analyzed for fecal content. The regression model was used to determine the relationship between coliform concentration and the selected risk factors as well as establish the extent of contamination and optimal distancing. The results indicate that 67.6% of shallow wells did not meet the World Health Organization and the Kenya safe distance criteria. In terms of relationship, pit latrine depth and soil permeability positively correlated with contamination. A negative relationship was established between groundwater contamination and water table depth and no relationship with surface slope. Out of 32 shallow wells sampled for fecal coliform analysis, 31 tested positive for fecal coliforms. Over 75% of the study area was established to be high risk for groundwater contamination. Finally, the predicted optimal distance between wells and pit latrines in the study area ranged between 31m-33m. The study concluded that Kamkuywa Market Center is water scarce as a result of extensive groundwater contamination. Lastly, safe distances can vary from area to area depending on the climatic and hydro-geological conditions of an area.

E) Application Of Gis In Investigating Groundwater Quality; Case Study Of Syokimau And Its Environs

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This project aims to identify how geological formation and depth of aquifers influences fluoride concentration in the groundwater of Syokimau and its environs. For this purpose, borehole data of several boreholes in Syokimau and Its environs and their chemical parameters was attained through secondary data. Using GIS the boreholes were mapped together with geological formation of the region, which helped relate the geology and fluoride concentration levels and the depth of the boreholes. High fluoride concentration was found to coincide with geographic location of volcanic rocks, which covered the larger parts of our area however depth was found to have no impact in the fluoride variation. Most of the boreholes in the region had fluoride ions concentration exceeding the WHO guideline of 1.5mg/l.

F) Determination Of Causes Of Reservoir Sedimentation Using Gis And Remote Sensing: A Case Study Of Kalundu Dam In Kitui County, Kenya

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In Kenya, a number of dams constructed in arid and semi-arid lands are experiencing problem of sedimentation causing severe challenges on water management, flood control and production of energy. This presentation therefore focuses on determination of causes of Kalundu dam sedimentation as influenced by land use and land cover change using GIS and remote sensing. The dam was constructed in the 1950's with a capacity of 300,000$m^3$ and silted up in 1970s. It was rehabilitated in 2013 and its capacity increased to 500,000 $m^3$. Currently the dam is silting up faster thus need to determine the causes. Therefore, Land Use/Land Cover (LULC) change for the period 1978-2020 was determined by image classification tools using Landsat images obtained from USGS website. Kalundu river sub-basin is a small catchment with an area of 24 $km^2$. The area is covered by one Landsat scene 185 x 185km, with images having spatial resolution of 30m. Thus, objects with less than 30m might not be clearly observed on Landsat imagery. Image pan sharpening procedure was used to resample the Landsat images from 30m to a higher spatial resolution of 15m. The images were taken after every 16 days. The interval was also used to determine the observable characteristics of the data captured. The catchment of Kalundu dam was delineated using QGIS hydrological processing and the Landsat images obtained on LULC were analysed. Results showed that agricultural, construction and urbanised areas were producing more sediments, which were being washed to Kalundu dam resulting to higher sedimentation rate. It was recommended that soil and water conservation methods should be employed to reduce high production of sediments.

G) Groundwater resource monitoring in Kilifi

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The presentation will focus on the rate of groundwater resource development in the Kenyan coast. A geodatabase containing various information such as ownership, depth, yield, status and the geology of the borehole location will be prepared. This information is essential in decision making for further groundwater resource development in the sense that stakeholders in the water sector will monitor the rate of deterioration in yield and water quality. Groundwater is the most reliable and affordable source of water for domestic use in the region, failure keeping proper record of the water quality and yield in the region is likely to lead to scarcity of drinking water in the region which is already an issue in the Kenyan coast. Excel data sheets and regional shapefiles have been prepared and the maps will be prepared using ArcGIS.

## H)Modelling Reservoir Chlorophyll-a, TSS, and Turbidity Using Sentinel-2A MSI and Landsat-8 OLI Satellite Sensors with Empirical Multivariate Regression

*Noor Kimtai*
*Noorkimutai*

Inland freshwater reservoirs are important resources serving both the natural and human ecosystems. Knowledge of the state of these resources is therefore important. However, the conventional assessment and monitoring systems are expensive and time-consuming creating a need for new innovative methods of monitoring their state. Studies have been conducted to assess the viability of other methods of water quality assessment for accurate and more reliable data. This study tries to assess the viability of remote sensing as a water quality assessment tool. Two sensors are assessed namely Landsat OLI mounted on the Landsat 8 satellite and ESA Multispectral Instrument (MSI) mounted on Sentinel 2A satellite. Chebara Dam in Elgeyo Marakwet was chosen for the study. The Water quality parameters assessed were Turbidity, Suspended Particulate Matter and Chlorophyll-a. For the case study, new empirical regression equations were developed to relate the water quality parameters to the reflectances from OLI and MSI. The equations developed were tested and validated using different error estimators. The accuracy of the equations showed that remote sensing has the potential for use as a monitoring tool for inland water bodies.
**Keywords:** Remote Sensing, Sentinel MSI, Landsat OLI, Reflectance, Water Quality Assessment, Empirical Regression Analysis

## Ideal Mapping Workflows for Spatial Data Preparation

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Preparation of spatial dataset can pose challenges especially where data collection is at the onset. Spatial scientists are in most cases at loss when deciding where to start, how to capture accurate and reliable information and how to fill gaps of missing information. This could pose a challenge of time, financial and resources constraints.
Official organisations' documents, resource persons, publications, non-spatial tables and sketches have information that spatial data developers tend to skip in the process of building up spatial datasets. This is amounts to failure to consider data "withing the neighborhood", that is gradually developed over time and which is data at the time of event and consequently accurate data.
We thus develop a data collection (mapping) workflow which guides the spatial scientists on where to look data in the "neighborhood" or existing data, what to do with it and considerations in case of its absence. The workflow is designed to speeds up spatial data collection activities, help generate rich and informative spatial datasets and reliable and accurate data.
By applying the workflow, we considerably reduced the time required to develop large datasets and subsequent maps for twenty-seven projects in five counties in a project funded by Water Sector Trust Fund. We also developed accurate spatial datasets for thirty-five thousand and sixteen connection for Malindi Water and Sewerage Company Limited in six Months and we were able to develop infrastructure and households' spatial datasets for four sub-counties of Baringo County under the project "Pilot baseline Survey and mapping for Monitoring and evaluation" for Central Rift Valley Works Development Agency (CRVWDA).

## I) Showcasing the effectiveness of EO & GIS in groundwater investigations

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As a norm, Georama Engineering Services Ltd routinely integrates EO and GIS data in its groundwater resource assignments. Especially effective is Shuttle Radar Thematic Mapper (SRTM) digital elevation models.

It allows the interpretation of structural features, peeling the mask of vegetation and soil reflectance from the earth surface data. Features like faults, fracture and joints lineaments, deposition basins are readily delineated from SRTM imagery.

We present a poster(s) showing projects that have been successfully implemented with the aid of EO data and GIS applications.

The projects in in varied terrain, including volcanics and the Basement System.

Poster(s) will be in A1 and A0.

## J) An Integrated Hydrodynamic Modeling with Spatio-Temporal Changes in Land Use/Cover and Socio-Economic Factors of a River Basin

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The study seeks to plan for and/or assess the possible extent to which the current available data can help in planning and managing the natural resources within a river basin. It involves modelling water resources and integrate it with remotely sensed satellite data for land use land cover changes and socio-economic factors. Hydrologic Engineering Centre – Hydrologic Modeling System (HEC-HMS) model will be used in rainfall-runoff simulation to determine the streamflow generation. Questionnaires will be administered to a population sample size of 120 households to determine the influence of growing population on the land use land cover. Moderate Resolution Imaging Spectroradiometer (MODIS) images will be used for a period of 30 years. The basin is very significant in several socio-economic activities hence the results shall help in planning and managing the natural resources within the basin

## K)Water Observations From Space (Wofs)

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Water monitoring and management were identified as the priority areas for Digital Earth Africa (DE Africa). To address this, a continental scale water monitoring service, known as Water Observations from Space (WOfS) has been availed. This service supports nations and stakeholders to make informed decisions, plans, and ongoing adjustments that will contribute toward achieving SDG 6 outcomes. The data helps users to understand the location and movement of water present in the African landscape and allows efficiency in identifying water resources. WOfS also helps African farmers and governments use their land and water resources more sustainably, and enables better planning which increases the availability of safe and drinkable water. Additionally, WOfS data supports the sustainable management of water and sanitation for Africa by providing information that enables the monitoring of ecosystems over time. Water information will be available through the service in near real-time and can be used for environmental monitoring, flood mapping, monitoring planned water releases, and management of water resources in highly regulated systems. Through identifying trends and changes over time, WOfS data can improve the management of water resources, providing a greater understanding of certain impacts, such as floods and droughts. The data derived from WOfS is available in the DE Africa Map and ESRI's Africa Geoportal to provide a more accessible view of spatial data in a map-based format. Through data-driven mapping, stakeholders and decision-makers can more effectively visualize and manage their water resources - dams, wetlands, and rivers.

## L) Supporting water service provision and water resource management through utilization of gis and earth observation technologies

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The need to address the challenges affecting the water sector requires utilisation of large scale spatial data sets at short temporal intervals. This requires heavy investment in terms of financial, time and human capital. For these reasons organisations worldwide are resulting to use of GIS as a tool for managing their data. For water supply industry this is not an exemption. GIS skills also come in to assist in data management for the water infrastructure and customer information. Though the government of Kenya invests a lot on research, efforts need to be put in place to cut cost resulting from expenses of in data collection by providing alternative reliable and cost effective means. **Central Rift Valley Water Works Development Agency (CRVWWDA)** has for this reason found the need to change tact and use GIS to as a tool to manage their data and carry out spatial surveys. This will make the organisation to understand the extent of service levels and coverage and capture gaps. This will help them understand where to put their investments in terms of infrastructure development and operations and maintenance.

It is for this reason that **CRVWWDA** identified **Kenya Water Institute (KEWI)** was to provide consultancy service for Baseline Survey and mapping for Monitoring and evaluation of **(CRVWWDA)** in Baringo County..

# CAPACITY DEVELOPMENT IN GIS AND EARTH OBSERVATION

## **A)**: Approaches For Capacity Building In Gis And Remote Sensing Technologies In Kenya

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Capacity building can be defined as training to enhance individual knowledge, in some cases introducing new infrastructure, or quite often exposure to better environment through study tours to improve resource management skills and capabilities in regards to GIS and earth observation in this case. GIS and remote sensing are among the many geospatial technologies. These technologies aid to monitor, assess and provide information about the earth to different stakeholders through maps and other geographical outputs hence reducing costs and giving timely and accurate information. Satellite data used in earth observation is being embraced worldwide because it helps deliver information about the surface and weather changes on the planet Earth through remote sensing. With these developments it is necessary to bring the space technology close to day to day life of people through well designed and appropriate capacity building programs. The skills gained can therefore be applied to support water service provision and water resource management. Kenya like other developed and developing countries has also not been left behind. This paper is a summary of the efforts made by the different governmental and non-governmental agencies in Kenya in helping to strengthen individual capacities by specially designed training programs.
KEY WORDS: Capacity building, Remote Sensing, Geographical information systems (GIS)

## B) Competency-Based Training and Technical Capacity Development in GIS/EO- A case of Laikipia University, Kenya

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Kenya is regarded as a 'water-scarce country' hence the need for concerted and integrated efforts in the use, conservation and management of water resources for sustainable development. Research and academia are key among multiple stakeholders in water sector. Laikipia University's Mission is ***'to serve students and society through research, education, scholarship, training, innovation, outreach and consultancy services.'*** To accomplish the mission, the university has embraced and entrenched Geographical Information Systems (GIS) and Earth Observation (EO) technologies in its curriculum. The technologies ignite spatial thinking and commensurate with the country's Competency-Based Curriculum. The university offers a number of GIS/EO-oriented courses at undergraduate and postgraduate levels aimed at building and enhancing learners' technical capacities. Learners are exposed to practical fieldwork to enable them apply the acquired knowledge, skills and competencies in real-life research scenarios to solve societal problems such as of water resources. Consequently, the university works closely with relevant organizations and entities such as water, sewerage and sanitation, irrigation, natural resources conservation and management and GIS/EO among others for learners' industrial attachment and internship placements. Therefore, through education, training and research, Laikipia University is crucial in ***'Supporting Water Service Provision and Water Resources Management through Utilization of GIS and EO Technologies'***

C) GIS and Earth Observation Training: Existing and Emerging Challenges

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Geographic Information Systems (GIS) and Earth Observation (EO) training, when done face to face, provide users with equitable learning environment and experiences. Over the years, training in GIS and EO has been beset by several challenges, with a lot of research done on the same, though many remain unresolved. Owing to Covid-19, abrupt paradigm shifts to virtual GIS and EO training has taken place at Higher Learning Institutions, presenting other emerging challenges that needs to be investigated and opportunities identified. This paper highlights hitherto unresolved challenges and further focuses on and unravels challenges and coping mechanisms adopted by students taking GIS and earth observation courses virtually. In addition to secondary data, a focus group discussion, with students who continued their Spatial Data Analysis course virtually after suspension of face-to-face learning, presented a good case study. Results from descriptive content analysis revealed a litany of unprecedented equity challenges. Beyond affecting GIS and EO learning outcomes by individual students, these challenges may undermine universal access to education in Kenya and perhaps globally. Opportunities needs to be explored for GIS and EO training to flourish under the new norm and support continuous capacity development.
**Key Words**: GIS, Earth Observatory, Virtual Training, Emerging Challenges, Equity, Covid-19

## INNOVATION AND TECHNOLOGIES IN GIS AND EARTH OBSERVATION

### A)Competency-Based Training and Technical Capacity Development in GIS/EO A case of Laikipia University, Kenya

The Government of Kenya is in the processing of re-alignment the country's education sector to Vision 2030 and Constitution 2010. One of the ways is by adopting the Competency-Based Curriculum (CBC) aimed at bridging the gap and disconnect between education and applicable skills and competencies. In light of that, Laikipia University has a mission of *serving students and society through research, education, scholarship, training, innovation, outreach and consultancy services*. To accomplish the mission and in line with the CBC, the university has embraced and entrenched Geographical Information Systems (GIS) and Earth Observation (EO) technologies in its curricula by offering a number of GIS/EO-oriented courses at different levels. The learners are particularly exposed to practical fieldwork for the real-life application of the acquired knowledge, skills and competencies in solving societal problems. Such problems are in water sector as Kenya is regarded as 'water-scarce' hence the need for concerted and integrated efforts for the sustainable use, conservation and management of water resources. Consequently, the university works closely with relevant organizations and entities such as in irrigation, water-supply, sewerage and sanitation for learners' industrial attachment and internship placements. The study is based on existing literature, university curricula, Constitution of Kenya 2010, government directives and policies with respect to education. It is undoubtedly evident that research and academia are key among multiple stakeholders in water sector. The need for GIS/EO training in the university is timely and necessary but with notable challenges, key being lack of funds and whose mitigations include availability of affordable hardware, free and current data and open source GIS/EO software.

**KEY WORD:** GIS/EO, University, Learners, Competency-Based Curriculum.

## .USE OF CLOUD FACILITIES AND BIG DATA IN THE EARTH OBSERVATION AND WATER

### A) Remote sensing for near-real time monitoring of floods: A case study of Lower Tana River Basin.

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Tana catchment experiences flooding in some of its areas majorly at Thiba and Lower Tana River sub-basins. This occurs during the March-April-May (MAM) and October-November-December (OND) rainfall and leads to disruption of people's livelihoods, loss of lives, infrastructure destruction and interruption of economic activities. This calls for efficient and effective methods of detecting and monitoring flooding extent and dynamics closely. Calibrated hydrological models and satellite products have proved useful in simulation of river flows, inundation depths and inundation extents on land surface areas. This study seeks to utilize satellite products in monitoring surface water flow in the near real time in the Lower Tana River Basin. A Rainfall Runoff Inundation (RRI) model was set up with Climate Hazards Group Infrared Precipitation with Station data (CHIRPS) rainfall and Famine Early Warning Systems Network (FEWSNET) Potential evapotranspiration satellite data as input and calibrated using streamflow observed data. Finally, Normalised Difference Water Index (NDWI) was applied to extract inundation from MODIS image. The satellite extracted flood events were compared to the simulated flood extent to determine the match using statistical measure of goodness of fit. The results indicated that satellite imagery is suitable for extensive flood inundation mapping especially in data limited areas.

B) NDWI change analysis of Likoni Ferry region of Mombasa as a step towards addressing the increasing accident occurrences in the area.

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The frequency of accidents in the Likoni Ferry region has been on the rise in recent years. Early in 2021, two vehicles, a tour bus and a semi-trailer, plunged into the Indian Ocean, while another vehicle belonging to a security company overturned at the mainland side ramp of the channel. According to the team that was constituted by the ministry of transport, the majority of the accidents were caused by the steep gradient and slippery ramp. Some of the reasons may be attributed to the changing morphology of the region.

The advances in satellite image acquisition and image analyses on the cloud has made it relatively easier than ever to observe temporal changes in the features of different parts of the Earth's surface. Hence, the aim of this study was to harness the power of cloud computing for assessing the changes in surface area of the Ferry region of Likoni using the Google Earth Engine (GEE). GEE is an interactive platform for scientific analysis and visualization of remote sensing data and it hosts historical and recent datasets from a wide range of sensors e.g., Landsat and SENTINEL.

Codes were written for retrieving the Normalised Difference Water Index (NDWI) data from Landsat 7 for the years 2004, 2009, 2014 and 2019. Analysis of the results on ArcGIS shows that there has been an increase in the water levels for the past years causing a shrinking of the shoreline along that region. According to the 2004 image, the waters were found to extremely cover the shoreline of the lands and this is because of the infamous Tsunami that occurred in that particular year. 2009, 2014 and 2019 images were hence used for the analysis and from the results; there is a gradual decrease of the Likoni Ferry shoreline. This increase in water levels might be brought about by relative sea-level rise. Another reason could be land subsidence due to combined factors like groundwater overexploitation from boreholes and reduced groundwater recharge due to loss of pervious surfaces to urbanization. The findings of this study, therefore, provide some technical insights for effective policy decisions on the management of the Likoni Ferry region. It also recommends more proactive steps towards mitigating the shoreline decrease in the region.