River Mapping and Digital Twin Project

Project Overview

This project involves mapping rivers starting from their sources (e.g., springs) and developing a digital twin model for real-time simulation and analysis. It supports applications in hydrology, urban planning, flood prediction, and environmental conservation.

Local Context: Kisii and Luo Nyanza

In Kisii County, spring water is the primary source of water for most households due to the scarcity of piped water, even in urban areas. People commonly fetch water using jerricans for drinking, cooking, cleaning, and livestock.

These springs feed rivers that flow downstream into the Luo Nyanza counties. However, the lower regions frequently experience flooding, especially after heavy rains in the Kisii highlands. Kisii experiences two long rainy seasons each year, with short dry periods in between.

The downstream communities in Nyanza also depend on these rivers for daily water use, making it critical to understand and manage the water sources effectively. Mapping the springs and modeling the river system from the source can help in flood forecasting, water resource management, and planning for resilience in both regions.

River Ecosystems, Tree Cover & Climate Impact

The Gusii highlands are rich in vegetation along both minor and major rivers, with Blue Gum (Eucalyptus spp.) being the most common tree species. These trees are vital in regulating the microclimate, supporting biodiversity, and mitigating the effects of climate change.

Tree-covered riparian zones play a significant role in:

- Absorbing carbon dioxide through photosynthesis (carbon sequestration)
- Regulating river temperatures and reducing evaporation
- Preventing soil erosion and improving water retention
- Slowing down surface runoff and reducing flood peaks

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This project aims to simulate the role of tree-covered riverbanks in contributing to climate resilience. By including layers such as NDVI vegetation indices, tree species data, and carbon absorption models, the digital twin will illustrate how natural ecosystems support both human and environmental health across Kisii and downstream regions.

Project Objectives

1. Map river systems beginning from natural springs.
2. Collect and integrate geospatial, environmental, and hydrological data.
3. Analyze changes over time and simulate river behavior.
4. Develop a digital twin model that reflects real or near-real-time river conditions.
5. Enable decision-making and awareness through interactive visualization tools.
6. Model the impact of tree cover on local climate and carbon balance.

Tools and Technologies

- GIS Tools: QGIS, ArcGIS, Google Earth Engine
- Data Sources: Sentinel-2, Landsat, HydroSHEDS, OpenStreetMap
- Programming: Python, R, MATLAB
- Visualization: Leaflet.js, Mapbox, CesiumJS, Unity
- Sensors: GPS, turbidity, temperature, pH (optional for field deployment)

Step-by-Step Implementation

Step 1: Identify the River and Spring Sources
- Choose a target river (e.g., in Kisii)
- Use satellite imagery and topographic maps to locate springs

Step 2: Field Verification (Optional)
- Visit spring sites with GPS tools
- Record parameters like pH, turbidity, temperature, and surroundings

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Step 3: Map Springs in GIS

- Use QGIS to load satellite basemaps
- Plot spring locations using GPS or manual input
- Add spring attributes (name, elevation, notes)
- Trace downstream river paths using hydrology tools and DEMs

Step 4: Organize Data

- Store in structured folders and spreadsheets
- Document spring data, images, and coordinates

Step 5: Trace River Flow from Springs

- Connect springs to river networks
- Mark tributaries, confluences, and nearby human activities

Optional Enhancements:

- Add 3D terrain or drone imagery
- Create a web map using Leaflet.js or CesiumJS

Expected Deliverables

- GIS Maps showing springs and river paths
- Structured dataset of springs and rivers
- Simulation models of river behavior
- Carbon absorption and tree coverage models
- Interactive digital twin visualizations
- Reports and documentation for sharing and presentation