Estimation and mapping of reservoir water quality parameters using Landsat 8 OLI: a case study of Two-Rivers Dam, Uasin-Gishu, Kenya

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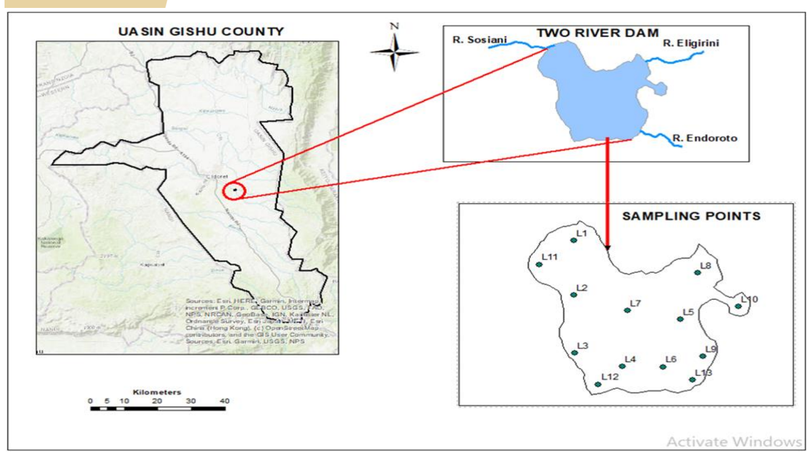
Background/Introduction

Kenya's rapid population growth rate is constantly pushing people to settle in fragile ecosystems. Increasing anthropogenic activities in these areas is a major threat to most of the world's freshwater resources. Eldoret is a fast-growing town with an estimated urban population of 475,716 based on the 2019 census data and a growth rate of 4.2% per annum (KNBS, 2019). Eldoret town relies on Chebara Water Treatment Works, Sosiani Water Treatment Works, and Kapsoya Water Treatment Works and a total of approximately 50,000 m^3/day is abstracted from Chebara Dam, Two Rivers Dam, and Ellegerini Dam for treatment (Mwaniki, 2018). Climate change, population growth, and poor agricultural practices in the catchment have negatively impacted on the water quality resulting in increased turbidity and algal blooms. Additionally, the increasing water demand among competing users has also impacted negatively on the quality of water in the water supply reservoirs. This means that there is need for continuous monitoring of watersheds and the existing water resources for sustainable water supplies to be realized (Best, 2019). Remote sensing techniques provide an avenue for water quality monitoring over larger temporal and spatial scales Optical water properties (turbidity, TSS, Chl-a) from RS used as input to Artificial Neural Network. The optimum coagulant dose for treatment can then be established based on the RS data and the ANN model developed.

Study area

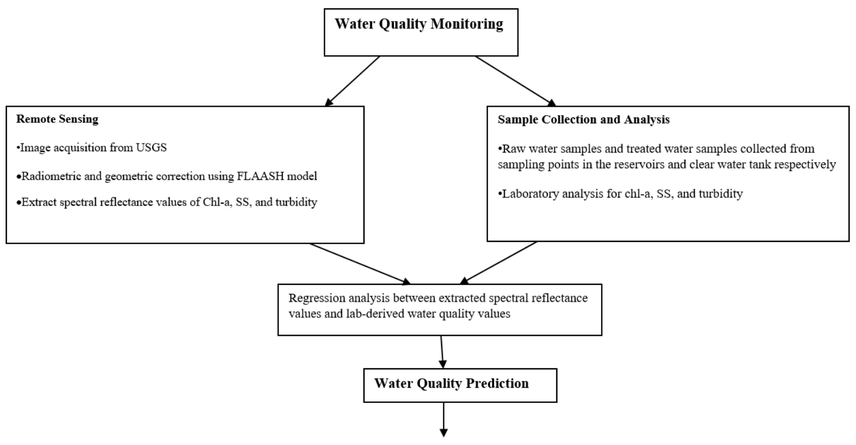


Location of Uasin-Gishu catchment in Kenya

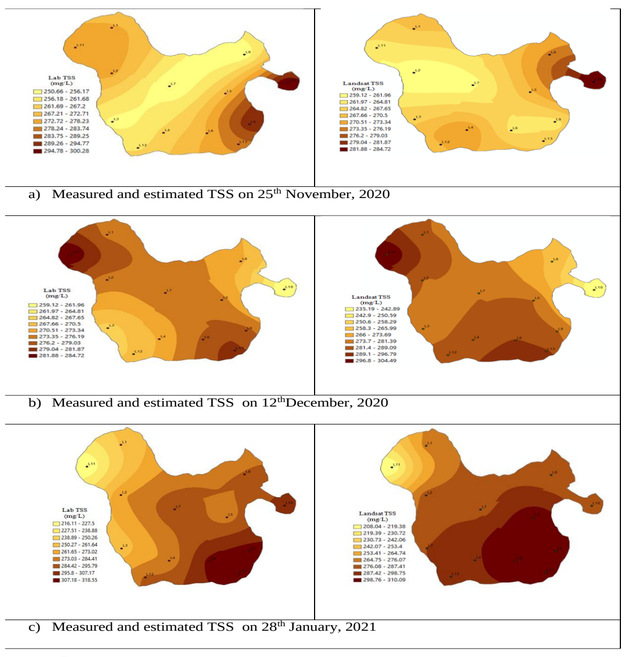
Objectives

- To compare the extracted spectral reflectance values from Landsat OLI satellite data and laboratory-derived water quality data of chlorophyll-a, suspended solids, dissolved oxygen, and turbidity.
- To estimate the spatial distribution and variability of the estimated and predicted reservoir water quality parameters (chlorophyll-a, suspended solids, dissolved oxygen, and turbidity) for the selected period between 2020-2021.

Methodology



TSS

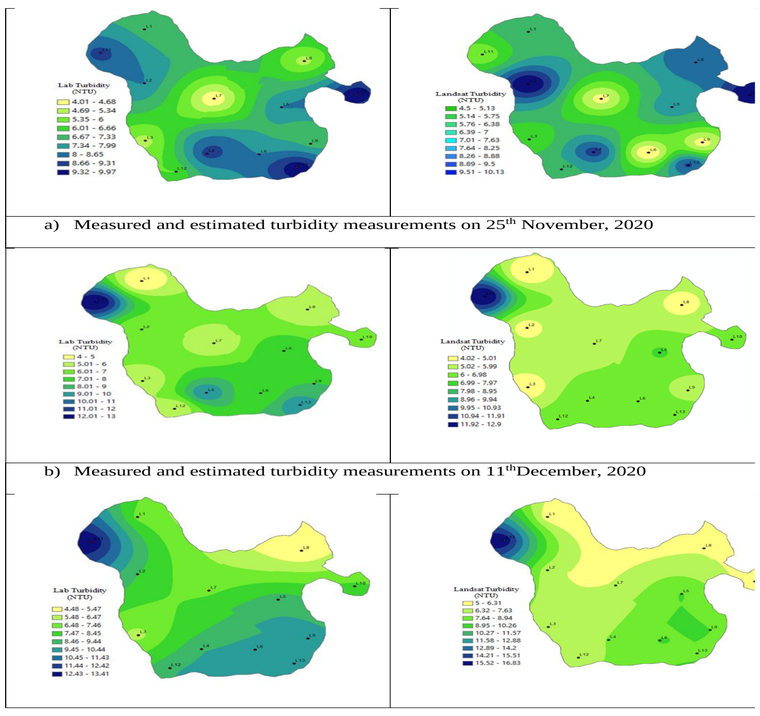


a) Measured and estimated TSS on 25th November, 2020

b) Measured and estimated TSS on 12thDecember, 2020

c) Measured and estimated TSS on 28th January, 2021

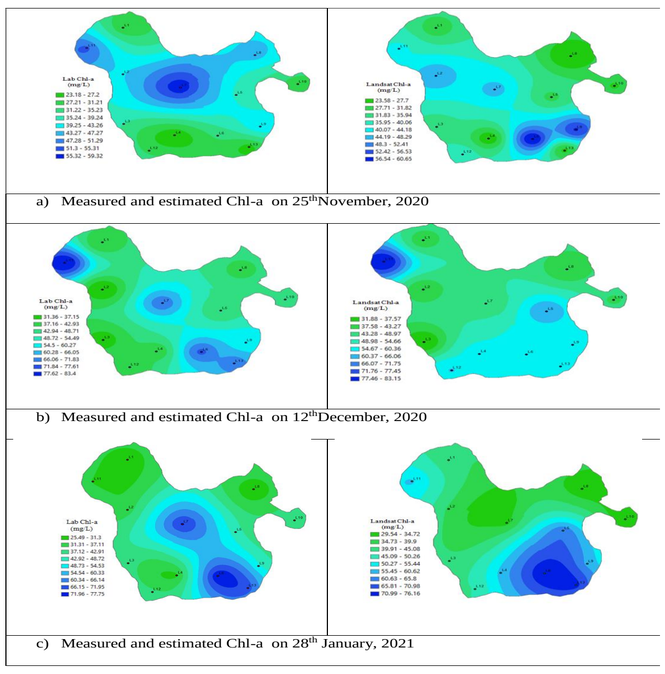
Turbidity



a) Measured and estimated turbidity measurements on 25th November, 2020

b) Measured and estimated turbidity measurements on 11thDecember, 2020

CHl-a



a) Measured and estimated Chl-a on 25thNovember, 2020

b) Measured and estimated Chl-a on 12thDecember, 2020

c) Measured and estimated Chl-a on 28th January, 2021

Results

- Low turbidity ranging from 4-17NTU.
- From the EWRM algorithm, Polynomial regression models based on the visible band combinations (blue, green, red) yielded the highest correlation coefficient between the laboratory and satellite-derived data with R^2 values of 0.797, 0.757, 0.736 and Pearson r values of 0.720, 0.886, and 0.849 for the specific data collection dates.
- TSS ranged between 247-321 mg/L.
- TSS was best estimated by logarithmic, exponential, and polynomial regression models with R^2 and Pearson r values of 0.808, 0.853, and 0.766 and 0.729, 0.723, and 0.710 respectively for the specific data collection dates.
- The visible bands (coastal aerosol, blue, green, and red) proved to be the optimal bands for the estimation of TSS.
- Chl-a ranged between 23.58-83.15 mg/L.
- The Rrs based on second order polynomial regression models for band ratios and mixed band combinations gave the best estimate of Chl-a. The visible bands B1, B3, and B4 (coastal aerosol, green, and red) yielded the highest correlation coefficient between the laboratory and satellite-derived Chl-a values

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