ANALYSIS OF LAND SURFACE PROCESSES AND IN-SITU MEASUREMENT FOR WATER MANAGEMENT IN LAKE TURKANA BASIN

Tohoku University, Student Member ○Jacqueline Muthoni Mbugua
Tohoku University, Regular Member Yoshiya Touge
Tohoku University, Regular Member So Kazama

1. INTRODUCTION

Lake Turkana is the largest permanent desert lake in the world. The arid lands of northern Kenya in East Africa surrounded the lake. Kenya and Ethiopia largely share the endorheic basin forming the lake. Due to the location of the lake, growing human activities in the basin, and climate change, the level of water in the lake is susceptible to fluctuations. Approximately 80percent of the total freshwater influx to the lake is the Omo River, which is the main inflow. Other water sources include the Turkwel and Kerio rivers, which supplement the other 20percent.

Recently, major developments are underway in this basin. There are plans to increase the area of land under irrigation in both Kenya and Ethiopia. The 2016 inauguration of the Gibe III dam in Ethiopia brought with it the possibility of the expansion of the irrigated area in the basin. The Kuraz sugar plantation project located in the downstream of the Omo River was projected to cover 175000ha, which was later scaled down to 100000ha in 2016. By February 2016, 10600ha had already been put under sugarcane irrigation while an additional 13000ha had already been cleared but not yet cultivated on (Kamski, 2016). Additionally, Kenya is planning to put 10000ha of land under irrigation in this basin to produce maize, sorghum, vegetables and fruits to ease the food crisis (Capital News, 2011). The increase in irrigation development in this basin will result in the potential increase of water abstraction from rivers draining into the lake (S. T. Avery & Tebbs, 2018). If this is left unchecked, the impending consequences to the Lake and the basin will be an environmental disaster such as the one experienced in the Aral Sea basin. One of the greatest environmental tragedies of the 20th century.

This study aims to explain how land use changes will affect the sustainability of the lake by examining the changes in water balance in the lake using numerical simulation and in situ measurement. Understanding this will help to improve water management in this water scarce basin.

2. METHODOLOGY

To consider climate change and human impact in the basin, a basin scale hydrological approach was necessary. The Simple Biosphere including Urban Canopy (SiBUC) land surface model (Tanaka, 2005) was used for this purpose. This model can consider artificial water operation in an irrigated mesh. Vertical water and heat balance in a mesh is also considered.

The Japanese 55-year Reanalysis (JRA-55) was used to provide for all forcing data except for precipitation, which was obtained from the Global Satellite Mapping of Precipitation (GSMaP) version 6. Temporal data were linearly interpolated to hourly data while spatial data were interpolated to 5km resolution using Inverse distance weighting (IDW). For land surface parameters, the European Space Agency (ESA) land cover characteristics dataset and ECOCLIMAP (http://www.cnrm.meteo.fr/gmme/PROJETS/ECOCLIMAP/page_ecoclimap.htm) was used. These datasets provide for land surface conditions such as the vegetation state, soil type, and land use.

Water balance in this basin was calculated as shown below. (1) was used to calculate water balance in the mesh while (2) was used to calculate water balance in the whole basin.

$$\text{Runoff} = prec - \text{evap} - \Delta soilm \tag{1}$$

$$\text{Qin} = \Sigma Runoff - \frac{\Sigma Win}{Y} + \Sigma Wout - \alpha \tag{2}$$

where, Runoff is the water resource, prec is the precipitation, evap is evapotranspiration, soilm is the soil moisture, Qin is inflow to the lake, Win is the irrigation water requirement, Wout is the drainage water, Y is the water conveyance efficiency and α is the water requirement outside the basin.

The in situ measurement of the water level of the lake and meteorological components is currently in progress. The data will be used to validate the water balance changes from the numerical simulation. Additionally, a collection of invaluable meteorological data can explain the effects of water level changes to the surrounding environment.

Key words: Aral Sea Basin, Irrigation, MODIS, NDWI, Remote sensing,
Contact address: Tohoku University, 6-6-06, Aza-Aoba, Aramaki, Aoba-ku, Sendai 980-8579, Japan, Tel:+81227957455

3. RESULTS AND DISCUSSION

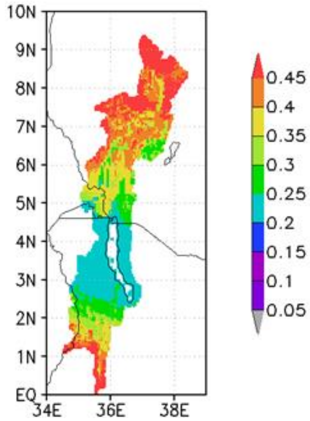

Figure 1 Soil moisture distribution in the basin.

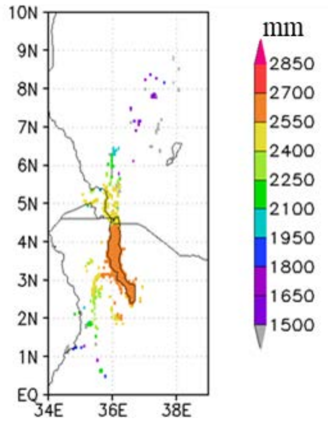

Figure 2 Evaporation from water surfaces in mm.

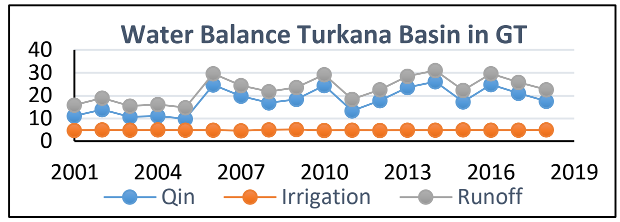

Figure 3 Water balance lake Turkana Basin

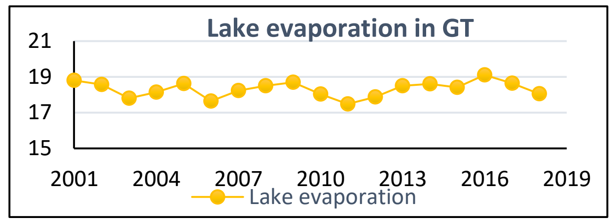

Figure 4 Evaporation Lake Turkana

Preliminary results from the numerical simulation shown in Figure 1 above shows the gradation of soil moisture in the basin. The high altitude upstream areas in the northern and southern ends of the basin which receive higher rainfall show a higher soil moisture content compared to the drier arid lands in the downstream part near the lake. The average annual cumulative evaporation from 2001 to 2018 from the water surfaces in the basin is shown in Figure 2 above. The evaporation from the lake was analysed satisfactorily when compared to the previously reported 2628mm per year (S. Avery, 2010). The annual fluctuation of cumulative evaporation from the lake surface from 2001 to 2018 is shown in Figure 4 above.

The analyzed runoff for this basin is shown in Figure 3 above. The average annual cumulative runoff from the basin from 2001 to 2018 was 22.8 GT. The runoff on the Ethiopian side of the basin which constitutes the Omo river basin was 12.8GT while that of the Kenyan side which is made up of the Turkwel and Kerio river basins was approximately 10GT. The runoff from the Omo river basin was underestimated compared to the reported value of 16.1Gt by FAO (1997). The runoff from the Kenyan side of the basin was however overestimated. Turkwel and Kerio rivers contribute only approximately 20percent of the total inflow to the lake. The analysed average annual cumulative irrigation water requirement from 2001 to 2018 was 4.9Gt. This is a slight overestimation compared to the reported 4.01Gt (FAO, 1997).

4. CONCLUSION

The preliminary results for the analysed water balance in the basin were satisfactory for evaporation from the lake surface, slightly overestimated for the irrigation water demand and overestimated for the total runoff. The slight overestimation for the cumulative irrigation water might be a result of the simulation factoring in the rate of increase of irrigated area based on the rate of land use change. The runoff will be recalibrated and improved.

5. ACKNOWLEDGEMENT

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