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Hydro-meteorological trends in the Gidabo catchment of the Rift Valley Lakes Basin of Ethiopia

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ABSTRACT

The global and regional variability and changes of climate and stream flows are likely to have significant influence on water resource availability. The magnitude and impacts of climate variability and change differs spatially and temporally. This study examines the long term hydroclimatic changes, analyses of the hydroclimate variability and detect whether there exist significant trend or not in the Gidabo catchment, rift valley lakes basin of Ethiopia. Precipitation, temperature and stream flow time series data were used in monthly, seasonal and annual time scales. The precipitation and temperature data span is between 1982 and 2014 and that of stream flow is between 1976 and 2006. To detect trends the analysis were done by using Mann Kendal (MK), Sen's graphical method and to detect change point using the Pettit test. The comparison of trend analysis between MK trend test and Sen graphical method results depict mostly similar pattern. The annual rainfall trends exhibited a significant decrease by about 12 mm per year in the upstream, which is largely driven by the significant decrease in the peak season rainfall. The Pettit test revealed that the years 1997 and 2007 were the change points. It is noted that the rise of temperature over a catchment might have decreased the availability of soil moisture which resulted in less runoff. The temperature analyses also revealed that the catchment was getting warmer; particularly in the upstream. The minimum temperature trend showed a significant increase about 0.08°c per annum. There is generally a decreasing trend in stream flow. The monthly stream flow also exhibited a decreasing trend in February, March and September. The decline in annual and seasonal rainfall and the increase in temperature lead to more evaporation and directly affecting the stream flow negatively. This trend compounded with the growth of population and increasing demand for irrigation water exacerbates the competing demand for water resources. It thus calls for prudence in devising appropriate intervention in the planning and sustainable development of the basin water resources.

1. Introduction

Ethiopia is one of the developing countries, which is adversely affected by climate variability and change. Low level of socio-economic development, inadequate infrastructure, weak institutional capacity and a higher dependency on natural resources aggravate the problem. The main causes for vulnerability of Ethiopia to climate variability and change are very highly dependent on rain fed agriculture and underdevelopment of water resources (NMSA, 2007). World Bank (2006) report also states that “Ethiopia's development is seriously constrained by a complex water resources legacy and a lack of access and management of these water resources”. The country has a substantial amount of water resources, which are found in lakes, rivers, streams, and ground water. The aggregate annual runoff from the major river basins estimated about 122 billion cubic meter excluding ground water (MoWR 2008a). The distribution and quantity of water has strong relationship with the topography and rainfall distribution. The highest mean annual rainfall (more than 2700 mm) occurs in the southwestern highlands, and then it gradually decreases in the north (to less than 200 mm), northeast (to less than 100 mm), and southeast (to less than 200 mm) (World Bank, 2006). Because of the marked seasonality of rainfall, the range of flow in the rivers within a year is extremely very large. During dry season, there is practically no surface runoff, followed by a wet season when runoff is excessive. For example, 80% of the Blue

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Table 1
Description of data and sources.

Data Type	Time interval	Source	Station	Description
Rainfall and Temperature	Monthly	National Meteorological Agency	- Hagereselam - Yirgachefe - Teferikela - Yirgalem - Aletawondo – 54 grid points	Location shown in Fig. 1
Stream flow Watershed map	Monthly Actual	Ministry of Mines and Energy	Aposto	Gidabo Catchment
DEM	Actual	USGS	Gidabo Catchment	Extracted from SRTM

Nile flow occurs between July and November (EVDSA, 1989). The seasonality of stream flow varies widely from river to river and is influenced mostly by the local seasonal cycle of precipitation, the local seasonal cycle of evaporation demand, and travel times of water from runoff source areas to surface and subsurface reservoirs and channels.

Temperature, rainfall and stream flow variability and changes in different regions of the world were addressed by many authors. For example, Degefu and Bewket (2017) in Ghibe river basin in Ethiopia, Javari (2017) in Iran and Rahman et al. (2016) in Bangladesh. Their studies focused on detecting hydrometeorological changes using Mann Kendall trend test. Degefu and Bewket (2017) analyzed the stream flow changes and found both increasing and decreasing trend at different stations but they did not observed any significant trends in annual, wet season, and the high flows. Javari (2017) in Iran and Rahman et al. (2016) in Bangladesh analyzed rainfall pattern. And Javari (2017) found that the winter and spring rainfall decreased from west to eastern part of the country significantly. Accordingly, 73% of the total rainfall stations under investigation and the monthly rainfall is decreasing at 0.05 which is at significant level. The finding of Rahman et al. (2016) revealed that except few place (Borga area which showed a decreasing trend), the annual rainfall did not show any significant trend. Whereas the monthly rainfall had a mixed pattern (decreasing/increasing) particularly from February to September. Extreme rainfall events in Yangtze river basin from 1960 to 2010 was studied by Gao and Xie (2016) and they indicated that the annual rainfall amount decreased from south eastern to north western inlands. Particularly from 1980 onward extreme precipitation showed increasing trend and this was applicable to one, seven and thirty days maximum events.

Dabanlı et al. (2016) applied the innovative-Şen method in comparison with the MK trend test over the Ergene drainage basin in the northwestern parts of Turkey and provided important differences. They illustrated that the former method is more advantageous due to possibilities of categorization of available data into any desired number in

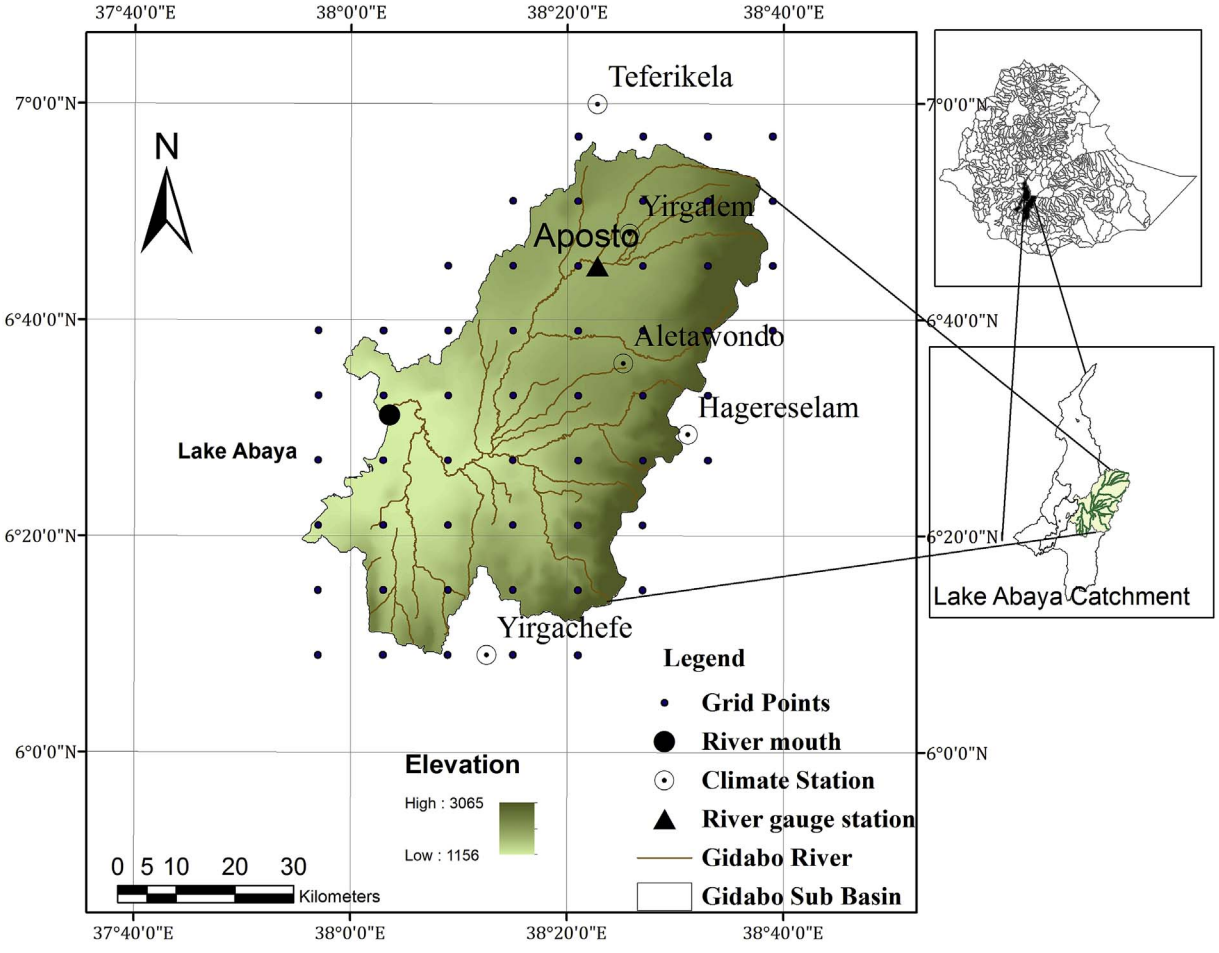

Fig. 1. Location map of the Study Area.