QUANTIFICATION OF IMPACT OF CLIMATE VARIABILITY ON GAUGE WATER LEVELS OF RIVERS IN N/E NIGERIA

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Abstract

This study aimed to detect trends in the long-term hydro-climatic series using non-parametric methods. The annual and seasonal trends of rainfall, temperature, evaporation, relative humidity and, water level were analyzed for stations in north- east Rivers during 1981-2010. The non-parametric Mann-Kendall was adopted to identify if there exists an increasing or decreasing trend with their statistical significance at 5% level of confidence. The results of study indicated increasing trends for annual temperature and evaporation of 0.4 0^C and 5.3 mm. Rainfall and relative humidity revealed statistically decreasing trends annually of 10.9 mm and 8.0%. However, for the period 1981 to 2010 there were significant distinctive trends observed for climatic and hydrologic parameters at the investigated stations. It is concluded that the rivers are sensitive to climate variability, it would be necessary to make adjustments in the adaptive water-use strategies in the gauge stations.

Keywords: Quantification, Climatic Variables, Gauge water level, Rivers

Introduction

Water level crisis manifest itself in various forms. In civil engineering it causes damage in dams, water ways and shortage of water for domestic usage. Water resources have altered by climatic variability in atmospheric conditions, and their distribution in space and time. The hydrological cycle of water bodies, water quantity in more recent time has changed, creating water crisis for household needs, agriculture and industry (Abdullahi et al. 2014) Today, water resources in many river basins are fully or almost fully committed to a variety of human uses. Thus, water quality is degraded, river-dependent ecosystems are threatened, and expanding demand for water is leading to intense competition and even at times to strife. In agriculture and domestic use the challenge for water management is more with less water in river basins that are already stressed (Westerling et al., 2006). Regional changing climate and variabilities including their societal impacts over the past three decades have received a considerable concern from the scientific community. Some of the major impacts of climate change consist of changes in precipitation patterns, average and maximum temperatures, mean sea level, and altered frequencies and intensities of extreme weather (Okafor *et al*.2017). The seasonal fluctuations in lake and river levels create large land that is periodically covered and uncovered by water (Ngatcha, 2009). As the water recedes, this land stores moisture that can be exploited for agricultural production (Batello et al 2004). The deficiencies in the current water- management system include the lack of a basin-wide approach being used uniformly across landscape, available information and technology not being used and lack of flood and drought management plans in most regions. However, the size of water management organization should be based on the size of the watershed (USGCRP, 2003). Increase in global temperature is expected to increase evapotranspiration, and cause precipitation changes, and significantly affect the hydrological regimes of many river systems (Lu, 2005, Hu et al., 2013). Many studies have shown that climate change could significantly affect stream flow, soil erosion rates and sediment flux (Michael et al., 2005; Syvitski et al., 2005; O'Neal et al., 2005,Zhu et al., 2008 and Zhogshon Chen et al., 2012). Climate variability and direct water extraction from surface water can alter river stream flow. Therefore, it is important to separate and quantify the effects of climate variability so that they can be used for water extraction and water resource management. With the increasing scarcity of water resources, hydrologists, decision makers, and policy makers have paid considerable attention to how much of the observed change in annual stream flow can be attributed to climate variability and human activities (Roderick and Farquhar, 2011; Destouni et al., 2013, Chien et al., 2013; Ward et al., 2009; Chang et al., 2010). Investigations in recent years, on present and future climate change patterns and impacts on water resources have become of great interest in different parts of the world because of their serious impacts on both human society and the natural environment (Wiltshire et al 2013 and Arnell et al, 2004). Therefore, understanding the variations of rainfall, temperature and runoff at the basin scale provides opportunity to study the changing climate impact on water resources and hydrological cycle (Odunuga et al, 2015, Abdulfatai et al, 2014, Gebrekristos, 2015, Suleiman and Ifabiyi, 2014).

Methodology

Hydrologic and climatic data for Komadugu, Jamaare and Yedzaram rivers were obtained from Hadeja-Jamaare River Developmemt Authourity (HJRDA) at Kano, while those for rivers Donga, River Benue and Dadin–Kowa were sourced from Upper Benue River Development Authourity (UBRDA) for period of 30 years (1981 – 2010). Rainfall, Evaporation and Relative Humidity have been described as important indices on which water level depends (Ekpoh and Ekpenyong, 2011). Hydrologic and climatic data were subjected to statistical analysis for variations using analysis of variance. Mann Kendall rank method, was used to consider serial correlation and to check for randomness and trend in the series (Von Storch,1995 ; Modarres and Silva, 2007). To detect significant trends even when absent and otherwise autocorrelation was used as well as trend model to detect monotonic changes over decade in climatic and hydrological data of the study area.

Results and discussions

Table 1: Quantitative effect of climatic parameters on gauge water level (1981 – 2010) in N/E Nigeria

	1981 - 1990	1991 - 2000	2001 -2010	Range
RF(mm)	57.5	50.5	41.6	10.9
TP (^oC)	45.4	43.1	45.9	-0.4
EV(mm)	89.6	99.3	94.9	-5.3
RH(%)	89.1	76.3	81.1	8.0
WL(m)	29.1	32.0	47.3	18.2

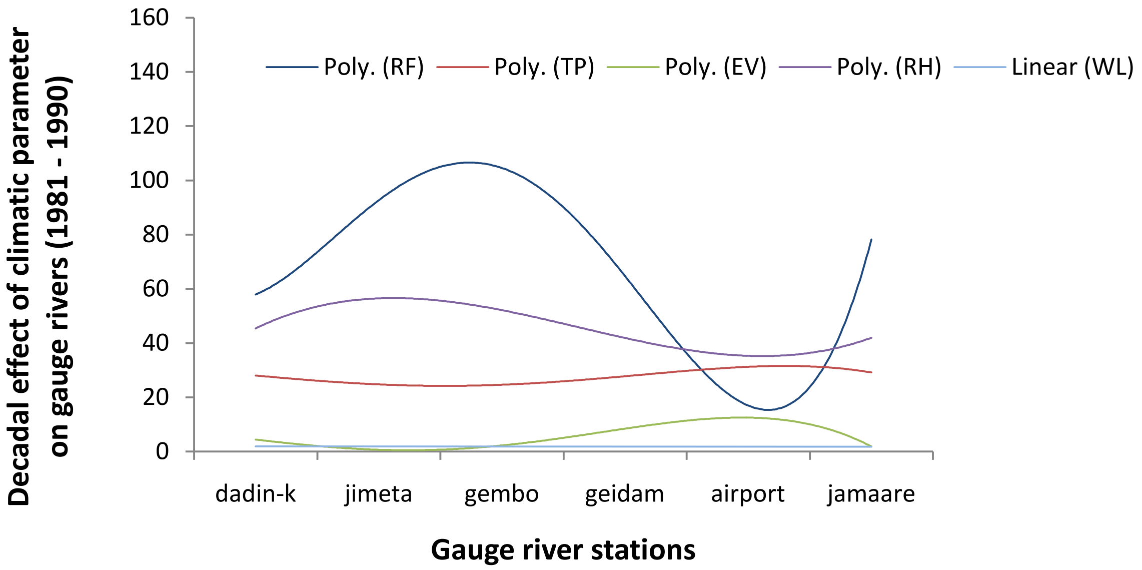

Fig 1: Effects of climatic parameters on gauge water level (1981 – 1990)

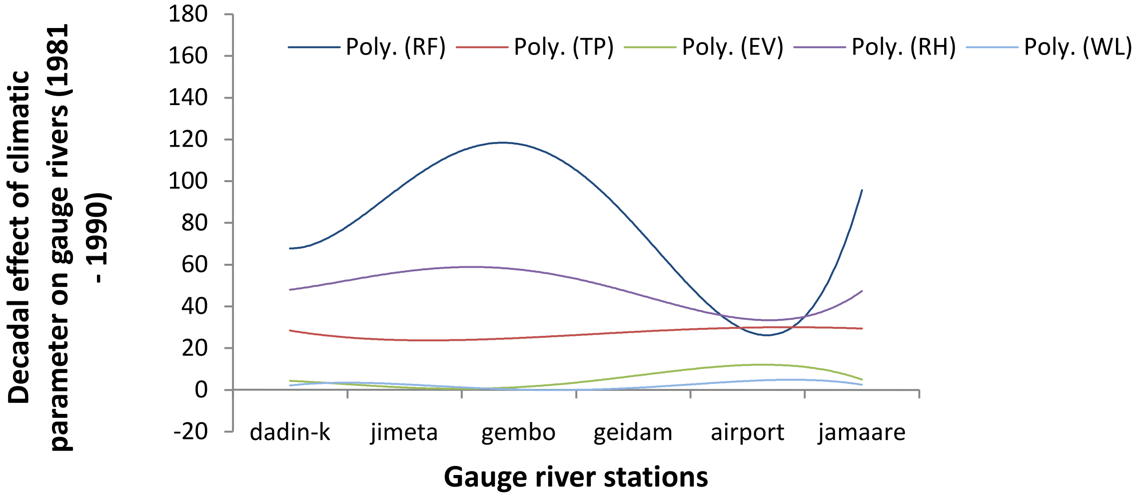

Fig 2: Effects of climatic parameters on gauge water level (1991 – 2000)

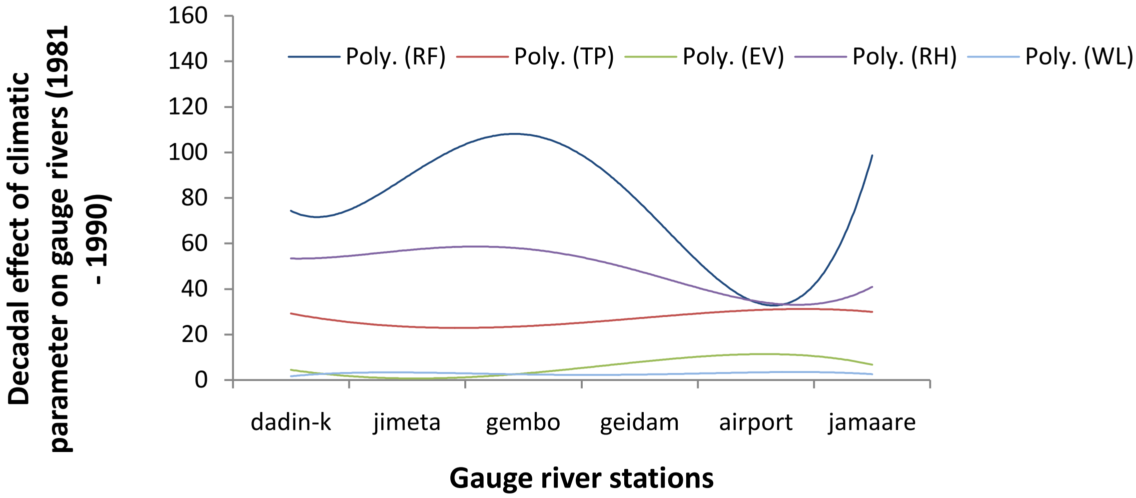

Fig 3: Effects of climatic parameters on gauge water level (2001 – 2010)

Effects of rainfall on water level were positive over the 3 decade with variations over each decade (Table 1). The rainfall in these specific sites contributed to increase in water levels in the rivers, in which each millimetre increase in rainfall resulted in increase in water level by 10.9, across the decades. This observation is similar to Oladipo and Salahu (1992); Ghahraman and Taghvaeian (2008) and Olatunde (2012). In contrast, there was decrease in rainfall in the last decade of study period implying that inflow of rain water from other areas into the river also contributed to increase in water levels in addition to specific rainfall of the area. In general, the 3 decade data in this study show downward trend in rainfall (Table 1) similar to earlier study of Hess et al (1995) which used data set of 1961 – 1990, and Ati et al, (2008) who analysed 87 years (1916 – 2002) rainfall data in Kano. The positive and negative effects of other climate variables observed from the correlation analysis may be related to global warming. Temperature impacted negatively on water level. Each rise in temperature of 45.4, 43.1 and 45.9 ^{0}C led to a reduction in water level by 0.4 m in the respective sites for the 3 decades. This may be attributed to the changes in climate variables which has the capacity to trigger large-scale climatic disturbances which ultimately may have significant impact on rainfall, evaporation and relative humidity (Igweze et al., 2014). The effects of evaporation were very high across the region and over the 3 decades. Each millimetre rise of evaporated by 94.9, 99.3 and 89.6 respectively, resulted in river water level decrease in all the gauge stations by 5.3m respectively. This indicates that evaporation was a major factor in water level reduction of rivers in all the stations. The data on relative humidity revealed each percent increase in relative humidity of 81.00, 76.3 and 80.1 %, resulted in increased water level by 8.0 m, respectively. This agrees with Nwaogazie and Olaghadien (2014) of a rise in relative humidity of 9% per decade increase water level. Fig 1 indicated no increase in gauge water levels even though there were variations in all climatic parameters over the 3 decades with significant impacts effects of negative temperature and evaporation and positive rainfall and relative humidity revealed by Mann-Kendall test, the changes observed in the indices of rainfall, temperature, evaporation and relative humidity showed the possibility of the occurrence of drier climate and flood events as observed by Okafor (2017). However, figs 2 and 3 showed increase in gauge water level of rivers in the region for the last 2 decades, implying an upward trend of climatic parameters in this present decade.

Conclusion

The results clearly revealed variability in hydro-climatic parameters, which, may have impacted negatively on the gauge water levels of rivers in the study area. However, there was an indication of upward increase in the climatic and hydrologic parameters in the last decade. The study recommends adequate water resources management and strategies as an adaptive measure in safe guarding water resources management to the changing climate.

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