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Effects of global warming on river Ona discharge

Abstract

Changes in weather and climate have been known to profoundly influence the availability of water resources. River Ona in Ibadan is characterized with frequent records of flooding and paucity of hydraulics records. This study determines the effect of global warming on discharge of River Ona. The rainfall (1973-2012), temperature (1973-2012) and discharge records of River Ona (1973-1986) were collected from the Nigeria Metrological Agency (NIMET), OSOT associates consulting engineer, Ibadan and their correlations were determined. The river discharge was measured at midstream and the downstream, respectively. Discharge data was simulated using normal, Log-normal, Log-Pearson and regression analysis model. The calibrated mathematical relationship between discharge, rainfall and temperature was $Q = 10.525 + 0.040R - 0.372T$. The developed regression model yielded accuracy of 73%. Sensitivity analysis based on incremental scenarios showed that a drier and warmer climate change scenario results in reduced discharge.

Keywords: weather, river ona, flooding, discharge

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Introduction

Rivers are nourished by precipitation, by direct overland runoff, through springs and seepages, or from melt water at the edges of snowfields and glaciers. The contribution of direct precipitation on the water surface is usually minute, except where much of a catchment's area is occupied by lakes.[1,2]

Ibadan, the second largest city in Africa, South of Sahara situated south west of Nigeria. It lies between longitude 3^0 50' and 3^0 73' east and latitude $7^0$28' and $7^0$29' north. It has a population of about 7 million spread over an area of 900km. Ibadan is a commercial center but in recent times it has witnessed an explosion in population and an increased tempo of economic activities. River Ona is one of the rivers in Ibadan with few flow records and frequently, yearly floods that occur within theits catchment. This has caused extensive damage and inconvenience to the community. It is located in Ibadan south west of Nigeria and receives effluent discharge from industries located in Oluyole Industrial Estate.[1,3]

Global Warming is the increase of Earth's average surface temperature due to effect of greenhouse gases, such as carbon dioxide emissions from burning fossil fuels or from deforestation, which trap heat that would otherwise escape from Earth. Global warming does not mean that our planet will turn into island. Instead, it means that the weather we are used to will become very unpredictable.[4–6]

Some places may experience droughts, while other will be flooded. Some places will become unbearably hot, while other will be covered by blizzards. As the ice cap melt, the level of the world's oceans will rise. As temperatures rise, there is a fear that the Atlantic Gulf Stream may fail, making most of Europe much colder than it is today. Even a small change in temperature can have powerful effects on species of animals that are not adaptable as humans.[7–11]

The aim of the project work is to determine the effect of global warming on River Omi discharge.

Methodology

Study area

River Omi is one of the tributes of Ona River in Ibadan, Oyo State in Nigeria. It takes its source from Alasa and Mele in Akinyele Local Government Area of Oyo State, Nigeria. And flows South West Ward through Elegunde, Apoyin, Ona etc. and joins Omi River. The discharge of River Ona was monitored at two stations Z_1 and Z_2 representing the midstream and the downstream, respectively as shown in Table 1.[12,13]

Table 1 Sampling stations and their corresponding coordinates

Stations	Name	Description	GPS location
Z_1 Upstream	Lade	4-box culverst on the river	N 07^0 23' 54"
			E 003^0 45' 38"
Z_2 Downstream	Dagilogba	3-box culvert of the 9.2m wide	N 07^0 20' 51"
			E 003^0 44' 48"

Required data collection

The following data were collected in the course of the study Rainfall data (from 1973 – 2012), Temperature data (from 1973–2012) and discharge record on River Ona (from 1973–1986). The metrological data such as rainfall, discharge was collected from the Nigeria Metrological Agency (NIMET), metrological department at old airport Samonda Ibadan and the Temperature data was also collected from OSOT associates consulting engineer Ibadan.

Measurement of river velocity

The velocity of the River was measured by using Doppler flow meter and equation 1 was used to compute the discharge.

$$Q = VA \quad (1)$$

Where:

Q = Discharge (m^3/s)

A = Wetted Perimeter (m^2)

V = Velocity (m/s)

The procedure for Doppler Flow Meter Usage are as follows:

Select a transducer mounting location at least 10 pipe diameters downstream and 5 diameters upstream of flow disturbance (i.e. elbows, tees, valves, e.t.c).

On horizontal pipe, choose a transducer mounting location approximately 90 degrees from the top of the pipe.

Remove rust, scale and paint from the transducer mounting location. Clean to bare metal. Plastic pipes do not require preparation.

Plug the transducer plug into the transducer jack

Apply approximately 1/18th inch (3mm) silicon grease to the transducer face. Place the transducer parallel to the pipe with the capable pointing downstream of the flow direction.

Read the velocity from the meter.

However, at each location, the current meter is placed into the stream with the meter facing into the current. Where the depth of the river is less than 60cm, the velocity is measured at 0.4 × D upward from the stream bed and where the depth is greater than 60cm, measurement is taken at 0.2 × D and 0.8 × D and the main velocity is taken as the average of the two velocity. At areas where the water body for the area been measured contains large submerged object (logs, boulders, trees, etc) or is disturbed by overhanging vegetation, the velocity measurement is taken at 0.2D, 0.4D, 0.8D and the mean velocity is calculated as shown in equation 2

$$V = 0.25\left(V_{0.2} + V_{0.4} + V_{0.8}\right) \quad 2$$

Furthermore, here velocities are extremely high or flood flows exists, the velocity is measured at the surface and the mean velocity is calculated using the equation 3

$$V = KV_s \quad 3$$

Where: K = 0.85, Vs = Mean velocity m/s

The discharge for each cell (n) is calculated as shown in equation 4

$$Q_n = W_n D_n V_n \quad 4$$

Where: W_n is the width of the cell (m); D_n is the depth of the cell at the point (m); and V_n is the mean velocity of the cell at the midpoint (m/s)

The discharge (Q) for the transect is calculated using equation 5:

$$Q = sum\ of\ Q_n = W_1D_1V_1 + W_2D_2V_2 \ldots + W_nD_nV_n \quad 5$$

The measured discharge data were compared with the existed ones. Relationship between these data were noted and plotted in a graph. The relationship between temperature data and discharge was also noted.

Results and discussion

Data analysis

The field data analysis used in this study are: the Rainfall and Temperature of Ibadan. The average yearly rainfall ranges between 152.85mm to 87.0mm, for the period 1999–2012; The average yearly temperature shows a slight variation for a value of 27.4ºC – 24.5ºC for the 1973 – 2010 and it's 27.5ºC for the present year 2012 as obtained from OSOT associates consulting engineer Ibadan and BBC weather forecasting. For the discharge data, the available discharge record of River Ona from (1972–1986) was used to simulate the next years using model distribution such as normal, Log-normal, Log-Pearson and regression analysis. Discharge records of River Omi, the major tributary of River Ona was also used.

However, Figures 1–3 show the average Rainfall (mm), average discharge (m^3/s) and Temperature (ºC) per year from (1973–2012), respectively. The average discharge on River Omi, the major tributary of River Ona was also considered in this study based on the available discharge records.

Discharge modelling

The simulated discharge values using Log-Pearson, Normal, Log-Normal, Log- Pearson and Regression analysis models are presented in Figure 4. Regression models develop on the river shows a varying values due to hydrological variation at different times. The other models used has similar shape with Log-pearson model given the highest value.

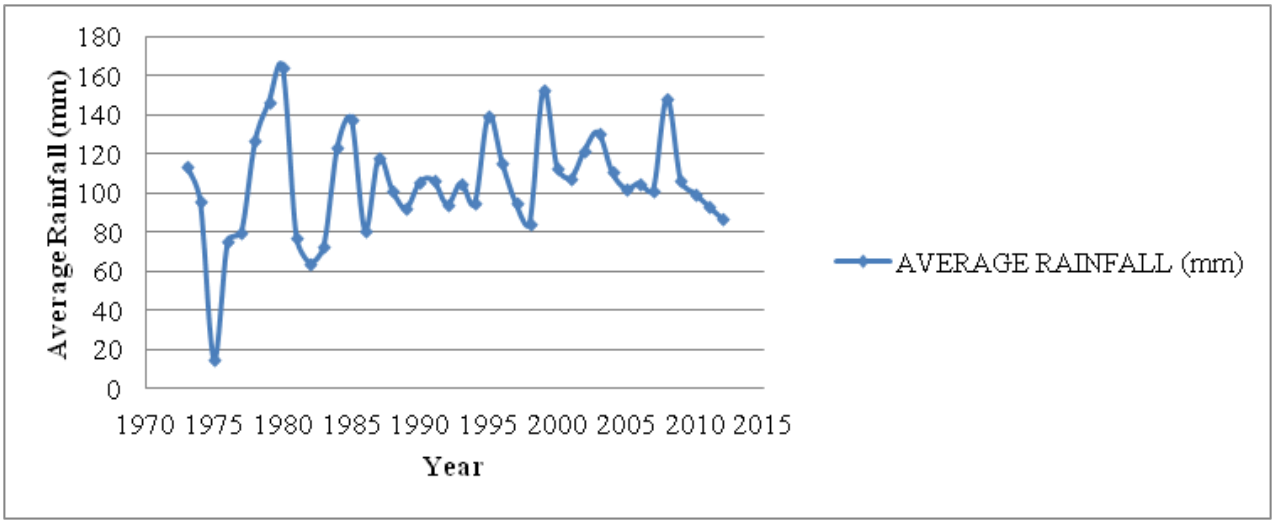

Figure 1 Graph showing average rainfall distribution in Ibadan.

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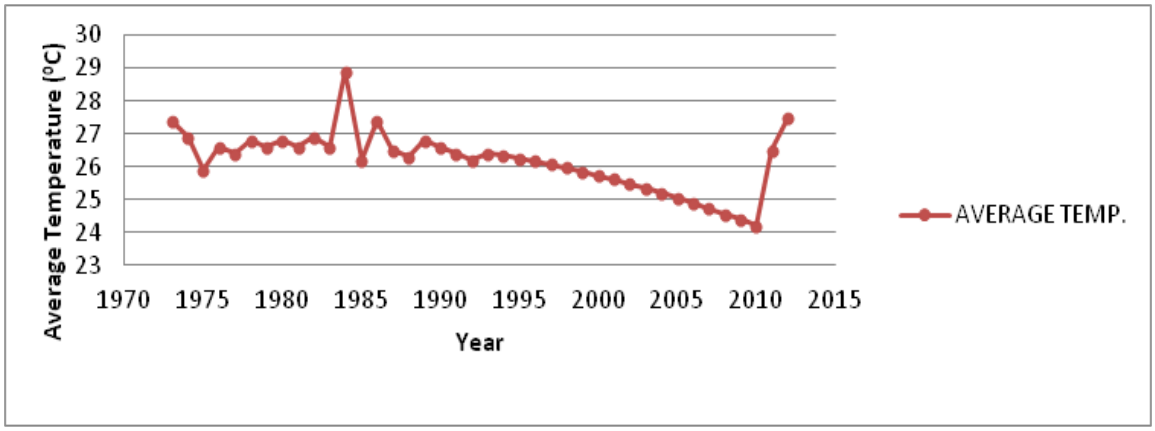

Figure 2 Graph showing temperature variation in Ibadan.

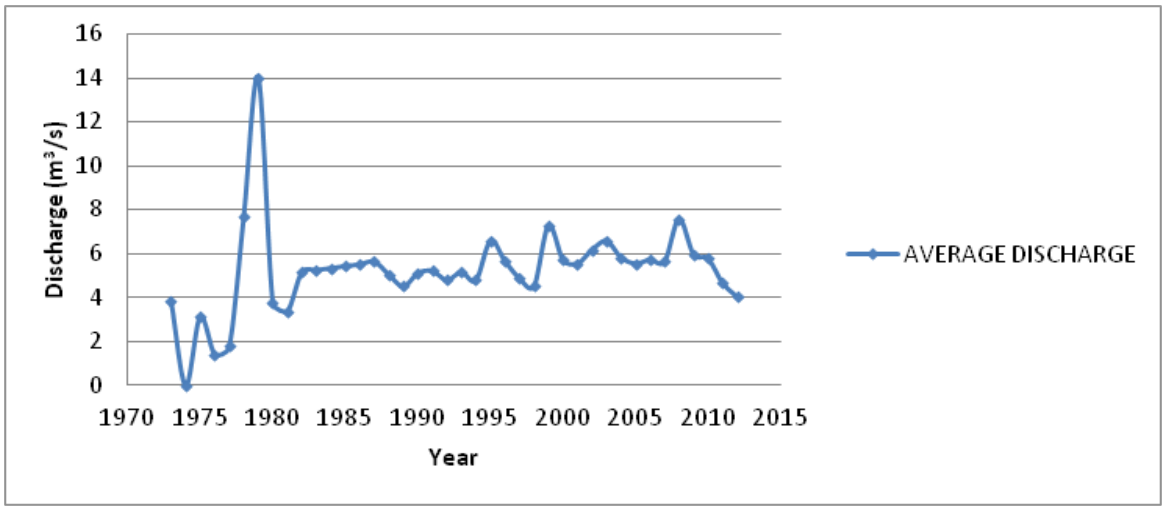

Figure 3 Graph showing average annual discharge of river Ona.

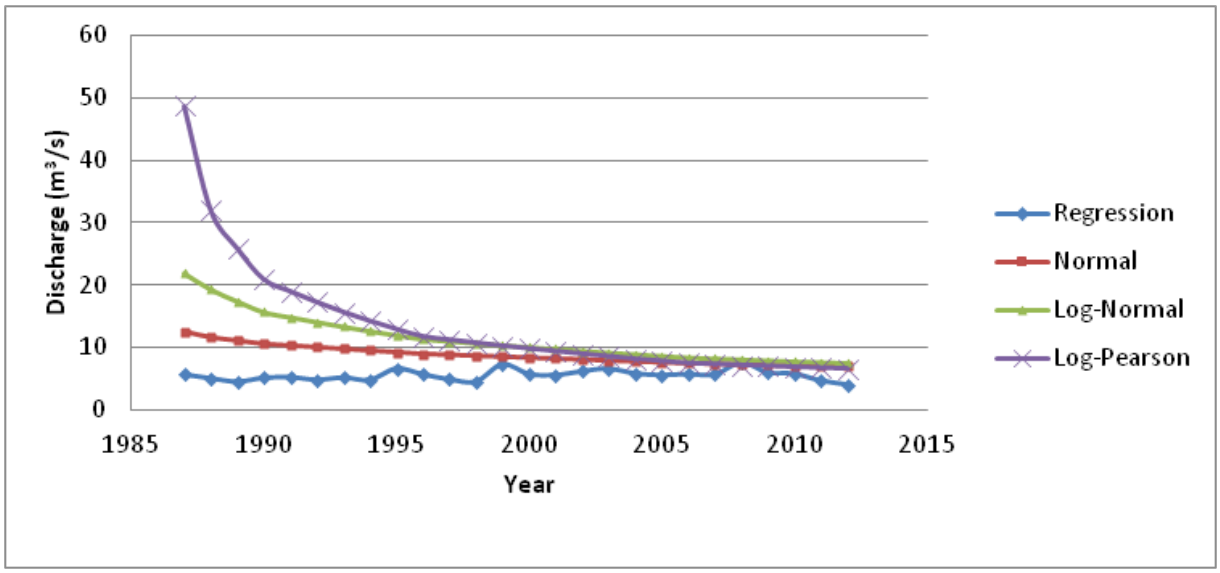

Figure 4 Graph showing the simulated discharge values on river Ona.

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Figure 5 show the results of the observed/measured versus modelled discharge for the calibration periods with monthly data from July – August, 2015 using equation 6

$$Q = 10.779 + 0.040R - 0.372T \qquad 6$$

Where: R= Rainfall intensity (mm/hr) and T= Temperature (ºC)

The Normal, Log-Normal and Log-Pearson models produced high discharge values on Rover Ona and are not reliable. Regression model of data analysis was adopted for the computation of discharge from (1987–2012) in this analysis. The variation between measured and computed is less than 5%. Take for instance; measured discharge for the year 1984 was 5.34m^3/s while the calculated discharge was 4.98m^3/s.

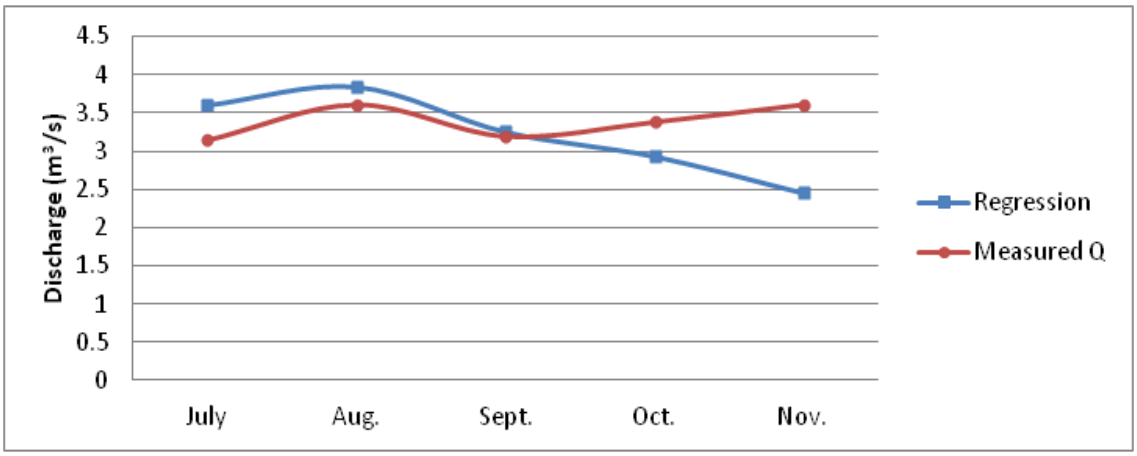

Figure 5 Graph showing measured and simulated average monthly discharge.

Thus, the model performance is assessed to be sufficient for assessing the range of uncertainty and scale of climate change. From recent research, Log-Pearson approach gives reasonable estimation of average river discharge. Although, this does not mean that it can be applicable at all instances. Therefore, regression model was 73% reliable to simulate discharge on River Ona as compared to other models.

Conclusion and recommendation

Conclusion

The following conclusions are drawn from the present study:

1) The linear regression model simulate discharge on River Onal at an accuracy of 73%.
2) Sensitivity analysis showed that a drier and warmer climate change scenario results in reduced discharge.
3) Areas and periods where rainfall does not increase sufficiently to offset the temperature increase will have significant risk of drought.

Recommendation

The following recommendations are made after the completion of this study:

1) There is need to plant trees, so as to suck up carbon dioxide, provide cleaner air and save 2,000 pounds of CO_2 a year.
2) Permanent flow recording stations should be installed along River Ona and Omi channel course to generate accurate and reliable hydrological records. This record will help River modeling as one of the input data needed for calibration and simulation.

Acknowledgments

None.

Conflicts of interest

The author declares there are no conflicts of interest.

References

1. Adegbola AA, Olaniyan OS. Temporal variation of Sediment Transport in River Omi, South western Nigeria. *International Journal of Applied Engineering Research*. 2012;7(4):421–431.
2. Subramanya K. *Engineering Hydrology*. 2nd edn. 2007.
3. Olaniyan OS. *Geometry Computation on River Omi, South western Nigeria*. 2012.
4. Gerald AM, Warren M Washington, William D Collins, et al. How much more Global Warming and Sea Level Rise. *Science*. 2005;307(5716):1769–1772.
5. Cole ST, McCarthy SL. NASA Research Finds 2010 Tied for Warmest Year on Record (Feature). *NASA*. 2010.
6. Hansen JE. Goddard Institute for Space Studies, GISS Surface Temperature Analysis. 2006.
7. Houghton JT. *Global warming, the scientific basis contribution of Group 1 to the third assessment report of the Intergovernmental Panel on Climate Changes*. 2001.
8. Jens Marott. Climate Change, Negative effects of Global Warming to Human and Environment. 2007.
9. Le Treut DO. Historical Overview of Climate Change Science. 2007. Warren Rachel. The role of interactions in a world implementing change adaptation and mitigation solution to cliimate. *Phil Trans R Soc A*. 2011;369(1934):217–241.

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DOI: 10.15406/bij.2019.03.00153

10. McCarthy JJ, Canziani OF, Leary NA, et al. *Impacts, Adaptation and Vulnerability, Assessment Report of the Intergovernmental Panel on Climate Change*. 2001.

11. Warren Rachel. The role of interactions in a world implementing change adaptation and mitigation solution to cliimate. *Phil Trans R Soc A*. 2011;369(1934):217–241.

12. Hansen JE. Climate Change: understanding global warming. In Robert lanza. *One world*: *The Health & Survival of the Human Species in the 21st century*. 2000;173–190.

13. Hansen JE, M Sato, L Nazarenko, et al. Climate forcing Goddard in Institute for Space Studies SI2000 simulation. *Journal of geophysical research.* 2002;107(D18):2–37.

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