WATER BALANCE ANALYISIS OF ASA LAKE AREA AND ENVIRONS, ILORIN, KWARA STATE.

ABSTRACT

The study was conducted to examine water availability in Ilorin for Enhanced fisheries production. The data used comprised of rainfall and temperature records for the span of 20 years both collected from NIMET Office, Ilorin. Evapotranspiration data for the three zones were empirically generated while water balance model was computed using MATLAB R2007a version in order to determine the respective water availability and the regression analysis was used to determine rainfall trends. The results showed that rainfall amounts vary from year to year and also increasing trends in the area over the period examined. It was also discovered that in all the periods. It is recommended that strategies be put in place to exploit excess rainwater for various purposes especially by increasing the capacity of water reservoirs and dams across the State for development of pipe borne water network and also, for irrigation farming during dry spells. Further investigation is recommended on water balance and its implications for agricultural practice in the study area.

Key words: Water resources management; Water Balance; evapotranspiration; Rainfall pattern: fisheries

INTRODUCTION

Knowledge of the available water in space and time is a prerequisite for efficient water resource management. This, however, is under the influence of several factors including climatic and anthropogenic (see for instance, Olajuyigbe, 2010). Many failed projects in water planning are partly attributed to inadequate knowledge of water balance-related data. In Nigeria, water balance studies are still limited and this has had tremendous negative implications on many water resource development projects as many of such projects depend on crude and unreliable data. Examples of such projects include dam failures (Umaru et al., 2010), poor crop yield (Hoogeveen et al., 2015), poor flood control (Ufoegbune et al., 2011), irrigation failure (Arora, 2006) among others.

According to Ufoegbune et al. (2012), water balance refers to quantitative expression of the hydrological process and its various components over a specified area and period time. It also refers to a balance between the input of water from precipitation, snowmelt and flow of water by evapotranspiration, groundwater recharge and stream flow. Water balance also implies an accounting of the inputs and outputs of water (Ritter, 2006). Suryatmojo, et. al. (2013) observed that understanding the water balance changes in the forested area is important for managing the sustainability of water resources and anticipating potential disturbance caused by the implementation of a particular forest management system (Du et al., 2016). According to Ayoade (1983), the original source of water is precipitation, thus the water resources of a given country is related to rainfall. Furthermore, Ayoade stated that the yearly amount of rainfall incident on the land area of Nigeria is about 1400mm. Of this total, about 1070mm is lost through evapotranspiration processes leaving a balance of 330mm for surface and subsurface ruuoff. Hoogeveen et al (2015) revealed water balance analysis is generally conducted on annual basis. However, it may be carried out within any other given period for any specific purpose. Such calculation could be done for research purposes by the use of secondary data. Several approaches to the determination of water balance have been developed by scholars. These include Thornthwaite equation, Penman equation and Penman-Monteith equation. Some of these methods involve many components whose data generation could be prone to errors especially in developing nations. Thus, most of these water balance models have been modified for ease of computation in different locations and under different conditions, for instance Papadopoulou et al (2003).

Water balance is computed by the hydrologic equation which is basically a statement of the law of conservation of mass as applied to the hydrologic cycle. In its simplest form, the equation reads: *Inflow = Outflow + Change in storage*. However, a general water balance model which takes into consideration the components of hydrologic cycle is as given below:

$P = Q + E + \Delta S/\Delta t$ where P is Precipitation, Q is Runoff, E is Evapotranspiration,

$\Delta S/\Delta t$ is Change in storage (in soil or the bedrock) per unit change in time (see Sokolov and Chapman, 1974). Also, water balance can be illustrated using water balance graph which plots levels of precipitation and evapotranspiration often on a monthly scale.

Generally, water balance method has four main characteristics (Sokolov and Chapman, 1974). Firstly, it can be assessed for any subsystem of the hydrologic cycle, for any size of area, and for any period of time; secondly, it is used to check whether all flow and storage components involved have been considered quantitatively. Also, it can serve to calculate the one unknown of the balance equation, provided that the other components are known with accuracy and lastly, it can be regarded as a model of the complete hydrologic process under study which means it can be used to predict what effect the changes imposed on certain components will have on the other components of the system or subsystem.

However, the objective of this work are as follow: (i) To determine the trend of rainfall over the period of study in Ilorin; (ii) To examine water in the study area; and (iii) To determine the implication of spatial water balance scenario in the study area

MATERIALS AND METHODS

The Ilorin is located between latitude 80 24’ and 80 36’ North of the equator and between longitudes 4 10’ and 40 36’ East of the Greenwish meridian (Oyegun, 1983). Ilorin is a transition zone between the deciduous woodland of the south and dry savanna of north of Nigeria (Jimoh, 2003). The mean monthly temperatures are usually very high varying between 25.1^{0}C in August and 30.3^{0}C in March. The diurnal range of temperature is also high in the area. The mean annual rainfall in the area is about 1200mm (Olaniran, 2002). It is mainly drained by River Asa and its tributaries such as Aluko, Alalubosa, Okun, Osere Agba and Atikeke (Jimoh and Iroye, 2009)

Asa Dam constructed in 1984 is a composite dam with earth embankment at its extreme ends. The dam is 597 m long and 27 m high at its deepest section and a crest width of 6 m. Its total catchment area is approximately 1037 km^2 lying within Kwara State and Oyo State of Nigeria with about one third of the basin area located in Oyo State (Fg.1)

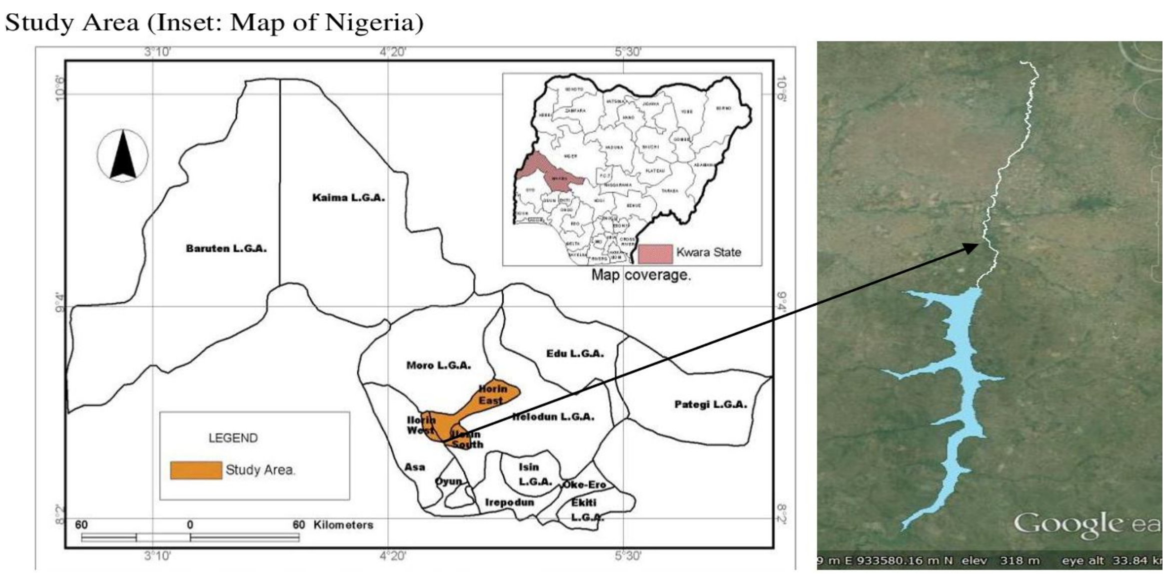

Figure 1: Study Area (Inset: Map of Nigeria showing the location of Kwara State)

Data used in this study consists of rainfall and temperature and evapotranspiration values. Rainfall and temperature data were collected from Nigerian Metrological Agency (NIMET) at Ilorin International Airport for a span of 20 years (2001- 2020), while evapotranspiration values were computed from the temperature records obtained from the above named weather station

Evapotranspiration Data: The empirical model developed by Thornthwaite was adopted to generate Annual Potential Evapotranspiration (PE) data for the three locations. The Thornthwaite’s method calculates potential evapotranspiration using observed air temperature and duration of sunlight data. The rationale, according to Papadopoulou et al.., (2003) is that air temperature does, to a considerable extent, serve as a parameter of the net radiation. According to Huang et al.., (1996), this model is a shortcut of replacing a comprehensive atmospheric model, as well as some interactions by prescribing observed temperature and precipitation. Hence, evapotranspiration values were generated using equation 1

$E= 16* (10T/I)a * \mu N/360$ -- Equation 1

where E is monthly potential Evapotransipration (mm/month), T is mean monthly temperature (0C),

where E is monthly potential Evapotransipration (mm/month), T is mean monthly temperature (0C), I is an Empirical Annual Heat Index, the sum of 12 monthly index values i, the value of i for each month is derived from mean monthly temperatures using the formula:

$ij= 0.09* (Tj)1.5$ --equation 2

where j is the specific month under investigation,

N is the mean number of daylight hours in a particular month

µ is the number of days in the month

a is an empirically derived exponent which is a function of I, and is given by the formula:

$a= 0.016*I+0.5$---equation 3

The annual water balance of the study area was computed with the use of MATLAB R20077a version.. The monthly water balance was summed up to obtain annual values.

However, water balance model in this work considered precipitation as main input and evapotranspiration as nmain water loss aadopted by Ogunbode (2015). Thus,

AWB=TAR-AWLt---equation 4, where

AWB is Annual Water Balance,

TAR is Total Annual Rainfall and

AWLt is Total Annual Water Loss via Evapotranspiration

The annual water balance for each of these zones was computed following equation 4. The years were grouped into two namely wet and dry years. The years where rainfall is higher than the evapotranspiration were categorised as wet years while the years with higher evapotranspiration (figures with negative water balance) were categorised as dry years.

RESULTS AND DISCUSSION

Water Resources Characteristics : The trends of variations in rainfall and the associated r2 and equation over the period of 20years, shown in Figures 2. The figure revealed that the amount of rainfall fluctuates from year to year while the results of regression analysis indicate increasing trend over the period investigated. Thus, in view of this, water supply and the replenishment of other sources through rainfall in the study area is generally dependable

Figure 2: Mean Annual Rainfall Pattern of Asa Lake and Environs

Water Balance Analysis: tables 1, show the annual rainfall ,annual evapotranspiration values and the annual water balance in the study area. The rainfall pattern over the period indicate that the annual totals were generally above 1000mm except few years which were incidentally found to be years of water balance deficits (dry years) in the area. The 3 dry years out of the 20years investigated in thearea zone were mostly years of rainfall totals less than 1000mm.

Table 1 : Annual Water Balance in Asa Lake area (2001-2020)

S/N	Year	Annual Total Rainfall (mm)	PE (mm)	Water balance(mm)	Water Supply Description
1.	2001	697.1	1212.1	-515	Dry year
2.	2002	957.1	1212.1	-225	Dry year
3.	2003	1293.8	1212.1	81.7	Wet year
4.	2004	1294.5	1212.1	83.8	Wet year
5.	2005	1305.9	1212.1	93.8	Wet year
6	2006	1291.7	1212.1	76.6	Wet year
7	2007	1309	1212.1	96.9	Wet year
8	2008	1469	1212.1	256	Wet year
9	2009	1342.5	1212.1	130.4	Wet year
10	2010	]953.3	1212.1	-253.8	Dry year

11	2011	1187.4	1212.1	-24.7	Dry year
12	2012	1239.4	1212.1	-27.3	Dry year
13	2013	1013.4	1212.1	-198.7	Dry year
14	2014	1430.4	1212.1	218.3	Wet year
15	2015	1384.9	1212.1	172.8	Wet year
16	2016	1179.6	1212.1	-32.5	Dry year
17	2017	1118.4	1212.1	-93.7	Dry year
18	2018	1365.8	1212.1	153.7	Wet year
19	2019	1223.6	1212.1	11.5	Wet year
20	2020	1201	1212.1	-11.1	Dry year

Source: Nigeria Meteorological Agency (NIMET)

It was observed that dryness was experienced in 2001-2002 while on the other hand, cognisance was taken of the rainfall totals of 2014, 2015 and 2018 with 1430.4mm, 1384.9 and 1365.8mm respectively. These years were also characterised with the highest record of water balance (218.3mm, 172.8mm and 157.7mm respectively) during the period indicating excess water supply.

Figure 3: Annual Water balance (mm) of Asa lake and environs (2001-2020)

The results generally revealed that Ilorin had more years of water surplus between 2001 and 2010 and is consistence with other areas in the zone as noted by Ogunbode and Ifabiyi, 2019. The increased rainfall in the areas over the study period as shown by annual water balance (see Fig 3), could be responsible for the increased erosion and consequent siltation of Asa lake. This led to the reduction of the maximum depth from 27 meters to only 17 meters. It could also be the reason for increased aquaculture activities in the Lake Asa catchment.

The results have further shown that water resource is generally in abundance in Ilorin. Thus, an improved ways of utilizing rainwater especially for Irrigation, domestic use and fisheries productoion and should be encouraged. Even though, rainy days/time may not coincide with immediate needs in homes, effort should gear towards its conservation for its immediate future utilisation especially during dry spells. Water resource management strategies should among others include continuous dredging and channelization of streams and rivers as ways of mitigating flooding in Ilorin. Consideration for optimal utilization of abundant rainwater may also include its conservation for use for irrigation farming purpose especially in the period of dry season. The advantage of abundant rainwater could be channelled towards agricultural development particularly in the area of irrigation and fisheries.

SUMMARY AND CONCLUSION

This study examined the availability of water resources in Ilorin, Kwara State. The results of regression analysis revealed that there were positive trends in rainfall in the area indicating the possibility and reliability of abundant water resources in the State. Also, the results showed that there were inconsistencies in water balance as there were years of deficit and surplus. However, the geographical location of the area have effect on its water balance.

COMPETING INTEREST DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and pedominantly used products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these product as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authurs.

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