

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

ABSTRACT

This study assessed the water availability in Ilorin for increased fisheries production. The study used rainfall and temperature secondary data for the period of 20 years obtained from NIMET Office, Ilorin. Evapotranspiration data for the area was empirically generated while water balance model was computed using MATLAB R2007a version in order to ascertain the respective water availability. Regression analysis was used to ascertain rainfall trends. The findings showed that rainfall amounts vary from one year to another and also there was record of an increasing trends in the area over the period. It is also revealed that the period received more rainfall which could better be described as wet years showing that there was abundant water resources in Ilorin. Therefore, more efforts should be geared towards harnessing the excess rainwater for various purposes. This is to increase the capacity of water reservoirs and dams across the State for development of pipe borne water network, irrigation farming during insufficiency; and fisheries production. It is advised to conduct more research on water balance and its effects on agricultural practises in the study area.

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

INTRODUCTION

Water balance is the foundation of management and policy making in some critical matters related to water resources management such as design of water supply systems, flood estimation, water allocation and use, management of stormwater and wastewater in urban areas, aquatic

ecosystems management, water trading and virtual water. In all of these fields, the basin managers and policy makers need to extract information about the volumes of resources, demands and storage changes in the basin.

“The balance between the income of water from precipitation and the outflow of water by evapotranspiration is called water balance” [23]. More recently [22] termed it as “the ratio between water in flow and outflow estimated for different space and time scales. Water balance is the most important integral physiographic characteristic of any territory, determining its specific climate features, typical landscapes, possible water management and land use. This is important, because it can be used to help manage water supply and predict where there may be water shortages. In addition, it can be used in irrigation, runoff assessment, flood control and pollution control”.

“The planning, development and operation of water resources project is dependent upon the availability of water in the required quantity. Water balance study is an essential part before deciding for an irrigation project. It is therefore a means whereby hydrological understanding of the system are tested and refined” [5].

[9] 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. They were of the view that getting the knowledge of the available water in space and time is essential for efficient water resource management. Nonetheless, this is influenced by several factors such as climatic and anthropogenic” [6,7,11]. Many projects for enhanced water resources and food security have failed because of inadequate knowledge of water balance and related data among other factors. In many parts of the world including 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 [16,4], poor flood control [3], irrigation failure[10,16] among others.

“The hydrologic equation defines water balance which is read as follows: : $Inflow = Outflow + Change\ in\ storage$. But, water balance model considered the components of hydrologic cycle 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” [15,6]

“Four main characteristics of water balance as described by [21,12] include : (i) assessment of any subsystem of the hydrologic cycle, for any size of area, and for any period of time. (ii) quantitative checking of all flow and storage components involved (iii) used to calculate the one unknown of the balance equation, provided that the other components are known with accuracy; and (iv) prediction of what effect the changes imposed on certain components will have on the other components of the system or subsystem”.

This study therefore seek to analyse water balance of Asa Dam area for water resource management. The objective of this work include: (i) To determine the trend of rainfall over the period of study in Ilorin; (ii) To examine water balance 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 8° 24' and 8° 36' North of the equator and between longitudes 4° 10' and 4° 36' East of the Greenwich meridian [19]. “Ilorin is a transition zone between the deciduous woodland of the south and dry savanna of north of Nigeria” [13]. “It is also the gateway city between the southern and northern Nigeria with an approximate land area

of 100 kilometres square” [1]. The mean monthly temperatures are usually very high varying between 25.1⁰C in August and 30.3⁰C in March. The mean annual rainfall in the area is about 1200mm [19]. According to [14] few tributaries which dained into the lake includes Aluko, Alalubosa, Okun and Osere Agba. 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 km² lying within Kwara State and Oyo State of Nigeria with about one third of the basin area located in Oyo State (Fig.1)

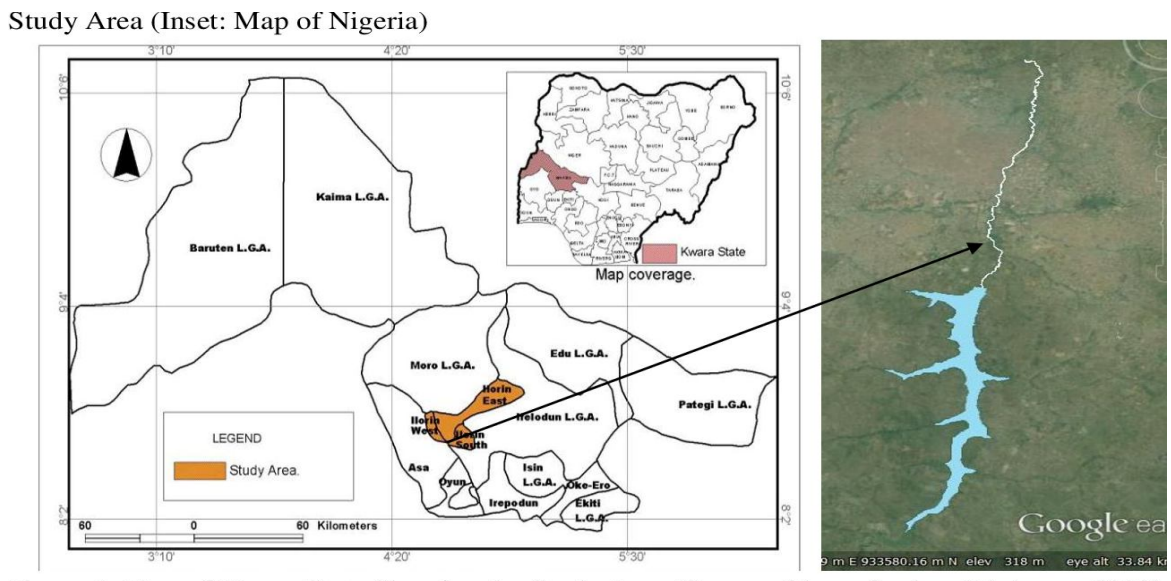


Figure 1: Study Area (Inset: Map of Nigeria showing the location of Kwara State)

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 period of 20 years (2001- 2020), while evapotranspiration values were computed from the temperature records obtained from the above named weather station

In order to generate the annual potential evapotranspiration data, empirical model developed by thortnthwaite was used to calculates potential evapotranspiration using observed air temperature and duration of sunlight data. The principle behind it is that, air temperature serve as a parameter of the net radiation [20,7]. This model replaced a comprehensive atmospheric model, in addition to some relationships determining observed temperature and precipitation [24]. Consequently, evapotranspiration values were produced using equation 1

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

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

$$ij = 0.09 * (Tj)^{1.5} \text{ -----equation 2}$$

where j is the specific month under examination,

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:

$$a = 0.016 * I + 0.5 \text{ -----equation 3}$$

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.

But model in study , water balance model considered precipitation as main input and evapotranspiration as main water loss as adopted by [17]. Thus,

$$AWB = TAR - AWL_t \text{ -----equation 4, where}$$

AWB is Annual Water Balance,

TAR is Total Annual Rainfall and

AWLt is Total Annual Water Loss via Evapotranspiration

The annual water balance for the study area was computed following equation 4. As a result, the years were divided into two categories: wet years and dry years. Years that experienced more rainfall than evapotranspiration were classified as wet years, whilst years that experienced more evapotranspiration were classified as dry years.

RESULTS AND DISCUSSION

Water Resources Characteristics : Figures 2 depict the trends of fluctuations in rainfall and the corresponding r^2 and equation over a 20-year period. The graph showed that annual rainfall varies, and the findings of the regression analysis show an upward tendency for the time period under study. In light of this, the research area's water supply and replenishment of other sources through rainfall are generally reliable.

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 the area 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
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 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)

Overall, the findings showed that Ilorin had more years of water surplus between 2001 and 2010 and it is consistent with other areas in the zone as noted by [8,2]. 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 had 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 outcomes have further demonstrated that water resource is generally in abundance in Ilorin and this could be the singular reason for more aquaculture activities. Thus, an improved way of utilizing rainwater especially for Irrigation, domestic use and fisheries production should be encouraged. There should be deliberate effort to conserve rainfall for its immediate future use especially during dry spells so as to meet the water needs of the populace. In order to reduce floods in Ilorin, water resource management techniques should include ongoing dredging and channelization of streams and rivers. Consideration for optimal use of abundant rainwater may also include its conservation for irrigation farming purposes, particularly during the dry season. The abundant rainwater could be properly utilized for enhanced agricultural development particularly in the area of irrigation and fisheries.

SUMMARY AND CONCLUSION

This study investigated the availability of water resources in . According to the findings of the regression analysis, there were positive trends in the area's rainfall, suggesting the likelihood and dependability of sufficient water resources in Ilorin. Additionally, the findings demonstrated that there were irregularities in the water balance due to years of deficit and surplus. However, the area's water balance is impacted by its geographic location. It is recommended that more advance

investigation into land use and climate change effects on water balance of the study area for more better management of water resources.

COMPETING INTEREST DISCLAIMER:

Authors have declared that no competing interests exist..

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