Asian Journal of Environment & Ecology

19(1): 38-44, 2022; Article no.AJEE.86943
ISSN: 2456-690X

Water Balance Analyisis of Asa Lake Area and Environs, Ilorin, Kwara State

B. M. Gwari [a*], M. U. Jikantoro [a], Y. A. Birnin Yauri [a] and O. R. Jeminiwa [b]

[a] Environmental Studies Division, NIFFR New Bussa, Niger State, Nigeria.
[b] Forestry Research Institute of Nigeria P M B 5054, Jericho, Ibadan, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEE/2022/v19i130338

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/86943

Original Research Article

Received 06 March 2022
Accepted 11 May 2022
Published 11 August 2022

ABSTRACT

This study assessed the water availability in Ilorin for increased fisheries production. The study used rainfall 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 thare was abudant water resources in Ilorin. Therefore, more efforts should be geared towards harnesssing 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 insuficiency; and fisheries production. Further investigation is recommended on water balance and its implications for agricultural practice in the study area.

Keywords: Water resources management; water balance; evapotranspiration; rainfall pattern: fisheries.

**Corresponding author: E-mail: bitrusgwari54@gmail.com;*

1. 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” [1]. More recently [2] 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 ddition, 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” [3].

[4] 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 kwowledge of the available water in space and time is essential for efficient water resource management. Nonetheless, this is influenceed by several factors such as climatic and anthropogenic” [5,6,7]. 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 [8,9], poor flood control [10], irrigation failure [11,8] 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” [12,5].

“Four main characteristics of water balance as described by [13,14] 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.

2. 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 [15]. “Ilorin is a transition zone between the deciduous woodland of the south and dry savanna of north of Nigeria” [16]. “It is also the gateway city between the southern and northern Nigeria with an approximate land area of 100 kilometres square” [17]. The mean monthly temperatures are usually very high varying between 25.1^{0}C in August and 30.3^{0}C in March. The mean annual rainfall in the area is about 1200mm [15]. According to [18] 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

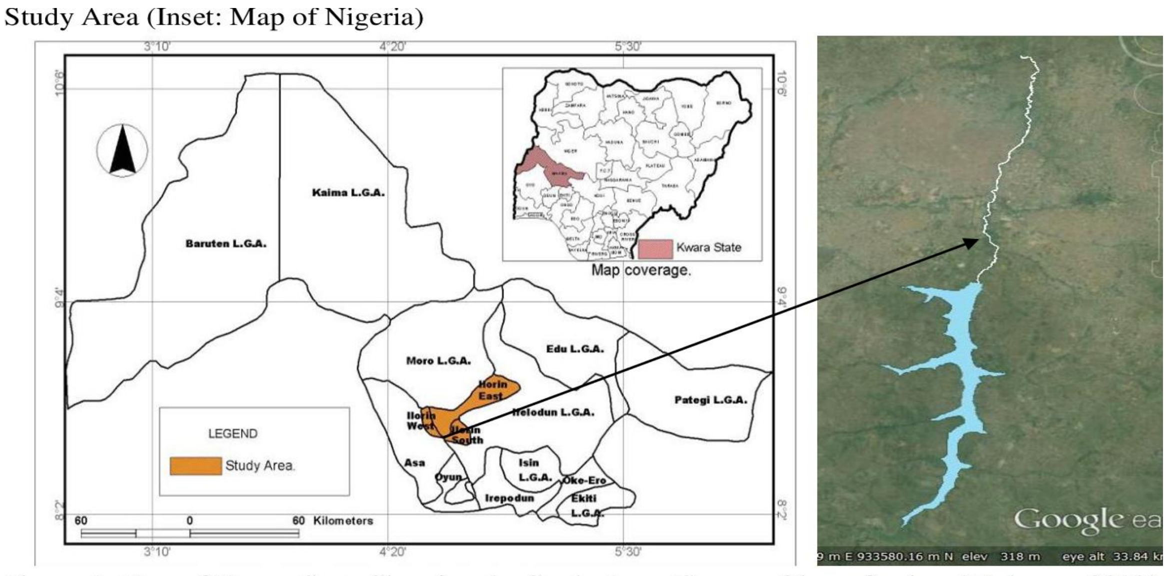

Fig. 1. Study area (Inset: Map of Nigeria showing the location of Kwara State)

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 (Fig.1).

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 [19,6]. This model replaced a comprehensive atmospheric model, in addition to some relationships determining observed temperature and precipitation [20]. Consequently, evapotranspiration values were produced using equation 1

E= 16* (10T/I)a * µN/360 ----------------------(1)

where E is monthly potential Evapotransipration (mm/month), T is mean monthly temperature (^{0}C), where E is monthly potential Evapotransipration (mm/month),T is mean monthly temperature (^{0}C), 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 -------------------------------- (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----------------------------------- (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 [21]. Thus,

AWB=TAR-AWLt--------------------------------(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. Consequently, the years were grouped into two namely wet and dry years. Years with higher rainfall value than evapotranspiration were categorised as wet years while the years with higher evapotranspiration value were categorised as dry years.

3. 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 Fig. 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.

Water Balance Analysis: Table 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

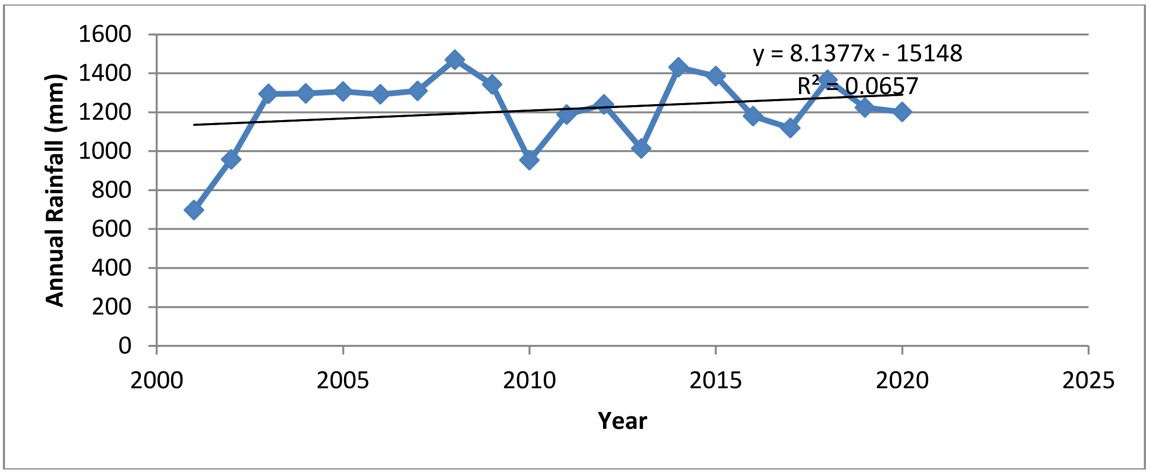

Fig. 2. Mean annual rainfall pattern of Asa Lake and environs

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	20010	1953.3	1212.1	-253.8	Dry year
11	20011	1187.4	1212.1	-24.7	Dry year
12	20012	1239.4	1212.1	-27.3	Dry year
13	20013	1013.4	1212.1	-198.7	Dry year
14	20014	1430.4	1212.1	218.3	Wet year
15	20015	1384.9	1212.1	172.8	Wet year
16	20016	1179.6	1212.1	-32.5	Dry year
17	20017	1118.4	1212.1	-93.7	Dry year
18	20018	1365.8	1212.1	153.7	Wet year
19	20019	1223.6	1212.1	11.5	Wet year
20	2020	1201	1212.1	-11.1	Dry year

Source: Nigeria Meteorological Agency (NIMET)

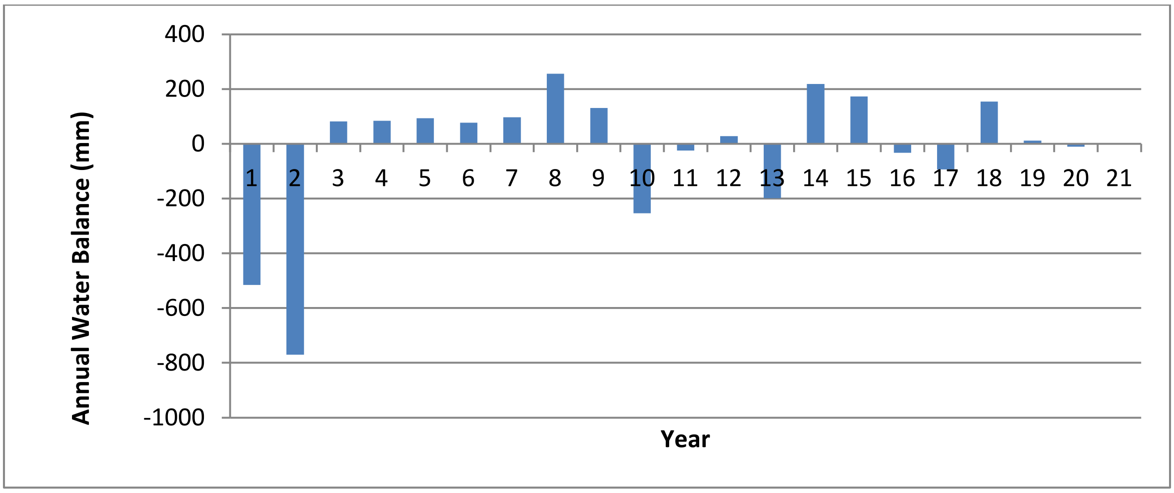

Fig. 3. Annual Water balance (mm) of Asa lake and environs (2001-2020)

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.

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.

The results generally revealed that Ilorin had more years of water surplus between 2001 and 2010 and it is consistence with other areas in the zone as noted by [22,23,24]. 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 results have further shown that water resource is generally in abundance in Ilorin and this could be the singular reason for more aquaculture activities. Thus, an improved ways of utilizing rainwater especially for Irrigation, domestic use and fisheries productoion and 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. Water resource management strategies should 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 abundant rainwater could be properly utilized for enhanced agricultural development particularly in the area of irrigation and fisheries.

4. SUMMARY AND CONCLUSION

This study investigated the availability of water resources in . 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 Ilorin. 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. It is recommended that more advance inveatigation into land use and climate change effects on water balance of the study area for more better management of water resources.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Thornthwaite CW, Mather JR. Instructions and tables for computing potential evapotranspiration and the water balance. Publ. Climatol. 1957;10(3).
2. Sposób J. Water balance in terrestrial ecosystems. In: Gliński J., Horabik J., Lipiec J. (eds) Encyclopedia of

Agrophysics. Encyclopedia of Earth Sciences Series. Springer, Dordrecht; 2011.
Available:https://doi.org/10.1007/978-90-481-3585-1_267

3. Bunt CM. Irigation water balance fundamentals. Conference on Benchmark in Irrigation System Performance Using Water Measurement and Water Balances. San Luis Obispo, CAUSCID, Denver, Colo. 2009;99,1-13.
Available:http://www.itrc.org/papers/irrwaterbalance/irrwaterbal.pdf ITRC Paper 99-0
4. Ellison DN, Futter M, Bishop K. On the forest cover–water yield debate: from demand- to supply-side thinking. Glob. Change Biol. 2012;18:806–820.
5. Chahine MT. The hydrological cycle and its influence on climate, nature. 1992;359:373–380.
6. da Rocha HR. Patterns of water and heat flux across a biome gradient from tropical forest to savanna in Brazil, J. Geophys. Res. 2009;114:G00B12.
7. Gaines MD, Tulbure MG, Perin V. Effects of climate and anthropogenic drivers on surface water area in the southeastern United States. Water Resources Research. 2022;58:e2021WR031484.
Available:https://doi.org/10.1029/2021WR031484
8. Lukman S, Otun JA, Adie DB, Ismail A, Oke IA. A brief assesment of a dam and its failure and prevention. Journal of Failure Analysis and Prevention. 2011;11; 97-109.
9. Borowicz A, Urbanski M. Hydraulic model for the Witka River and Niedow Reservoir-The niewdow dam failure during the flood in august, 2010 and the determination of flooded area. Wroclaw University of Sience and Technology Report; 2011.
10. Azeez O, Elfeki A, Kamis A, Chaabani A. Dam break analysis and flood disaster simulation in arid urban environment: The Um Al-Khair dam case study, Jeddah, Saudi Arabia. Natural Hazards. 2020;100:995–1011.
Available:https://doi.org/10.1007/s11069-019-03836-5,
11. Foster M, Fell R, Spannagle M. The statistics of embankment dam failures and accidents. Canadian Geotechnical Journal. 2000;37:1000–1024.
12. Korzun, VI' World Water Balance and Water Resources of the Earth, UNESCO; 1978.
13. Sokolov AA, Chapman TG. Methods of water balance computations: An international guide for research and practice. A contribution to the International Hydrological Decade. The UNESCO Press.1974;87-89.
14. Healy RW, Winter TC, La Baugh, Franke OL. Water budgets: Foundations for effective water-resources and environmental management: U.S. Geological Survey, Reston, Virginia, Circular. 2007;1308:90.
15. Olaniran OJ. Rainfall anomalies in Nigeria: The contemporary understanding 55th inaugural lecture, university press, Ilorin. 2002;66.
16. Jimoh HI. Erosion tolerance range of land use surfaces: Implication on land resource use and management techniques in Ilorin Nigeria. International Journal of Environmental Studies. 2003; 60:446.
17. Adediji A, Ajayi BO, Olawole MO. Assessment of land-use/cover dynamics in Ilorin and its Environs, Kwara State, Nigeria, Ilorin Journal of Business and Social Sciences. 2009;13(1):1-16.
18. Jimoh HI, Iroye KA. Managing high runoff discharge in the urbanized basin of Asa River Catchment Area of Ilorin, Nigeria. Environmental Research Journal. 2009; 6(1):19-2.
19. Pinker RT, Thompson OE, Eck TF. The energy balance of a tropical evergreen forest. Journal of Applied Meteorology. 1990;19(12):1341-1350.
20. Tremberth KE, Shea, DJ. Relationships between precipitation and surface temperature. geophysical research; letters, 2005;32(1):1-4 . 14703.
21. Mohit KB, Manish S, Nazrul I. Study on the dam & reservoir, and analysis of dam failures: A data base approach. International Research Journal of Engineering and Technology (IRJET). 2020;7(5).
22. Egbinola CN, Amobichukwu AC. Climate variation assessment based on rainfall and temperature in Ibadan, South-Western, Nigeria. Journal of Environment and Earth Science. 2013;3(11):33-45.
23. Ayeni OD, Adediran A, Ofordu, CS, Mba NC, Amoo-Onindundu ON, Arabomen O, Okumodi BO. Analysing the characteristic-sequence of rainfall amounts in Ibadan,

Nigeria Journal of Meteorology and Climate science. 2020;18(1):89-98.
24. Ogunbode TO. Pattern of domestic water utilisation and management in selected rural areas of Oyo State, Nigeria. An unpublished PhD Thesis Department of Geography & Environmental Management, University of Ilorin, Nigeria. 2015;290.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/86943