Original Research Article

EFFECTS OF HIGH MAGNITUDE DROUGHTS ON DAGONA WATERFOWLS SANCTUARY, YOBE STATE, NORTH-EASTERN NIGERIA (1956-2015).

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Abstract

Climate change and its attendant fallouts such as drought, flood etc affect every aspects of environment including wetland ecosystem. This paper seeks to examine the effects of droughts on Dagona Waterfowl Sanctuary an important wintering area for migratory birds in Bade local government, Yobe state, Nigeria. The study used annual rainfall data collected from the archives of the Nigerian Meteorological Agency (NIMET) with respect to Nguru weather station in the area for a period of 1956-2015. Standardized Precipitation Index (SPI) in conjunction with Percentage Deviation Below Mean (PDBM) models were applied for comprehensive drought detection on a time scale of twelve (12) months. SPI anomaly graphs was plotted to depict drought of varying magnitude. The researcher went round the sanctuary and made observations with the help of binocular and telescope. Findings explicitly revealed that the study area was replete with droughts of varying intensities ranging from mild, moderate, severe and extreme ones. And high magnitude droughts led to hydrological changes causing drying up of wetland water, decreased production of seeds that provide forage opportunities, intrusion of invasive species such as typha grasses forming dense biomass that hinder birds to prey on fishes or swim freely. The result of the analysis would add to the mainstream theoretical body of knowledge about droughts effects on wetlands. The research concludes that droughts of high magnitude occurred variably and affected both native and migratory birds in the study area and hence recommend the integration of disasters like drought in the management strategies of the wetlands.
KEYWORDS: Drought, Wetland, SPI, Waterfowl, Sanctuary, Birds, Ecosystem

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1.0 Introduction

Drought in the Sahel is a recurring phenomenon seen by climate experts as one of the fall outs of climate change. It has been a matter of serious concern to man since ancient times, and even today, it is an outstanding example of man's helplessness before nature's large scale and formidable phenomenon. It is ranked as one of the foremost among earth's natural hazards representing the adverse effect due to shortage of water mainly from rainfall (Jat *et al*., 2010). An analysis by scientists at the National Centre for Atmospheric Research NCAR (2012) hinted that droughts are the second most geographically extensive hazard after flood covering 7.5 per cent and 11 per cent of the global land area each. The land area, population and GDP loss affected by drought amount to 970 million km^2, $57.3 billion and $108.6 billion US dollars respectively. The percentage of Earth's land area stricken by serious drought more than doubled from the 1970s to the early 2000s. Houghton *et al.,* (1990) observed that increase in the frequency and intensity of drought and other extreme events are due to global warming and climate change.

Droughts affect not only human population, but other organisms and their ecosystems. Hassan (2018) discovers that even with adjustment in lifestyle, human beings cannot withstand the effect of high magnitude drought events. Drought which implies a period of unusually dry weather, extensive enough to cause severe decrease of water resources, modification of the natural ecosystem, interruption of ecological function and destabilization of aquatic life (IPCC, 2012). In arid and semi-arid regions, water birds are dependent on the availability of food and water in wetlands controlled by rainfall that is unpredictable in both timing and quantity (Petrie and Rogers 1997; Zwarts *et al*. 2009), Igwenagu (2014) observed that weather conditions have continued to change, more especially rainfall in the sub-Sahara African including north-eastern Nigeria. It has been estimated that between 50% and 75% of Yobe state is affected by climate change manifesting in the form of desertification and drought (Bose *et al.,* 2018). In the state, drought is recurrent with enormous effects on the environment which keeps increasing in both magnitude and complexity (Hassan et al., 2019).

Dagona waterfowl sanctuary is part of Hadejia-Nguru wetland ecosystems situated in Yobe state Northeastern Nigeria. A sanctuary is any area of land or sea specially dedicated for the protection of biological diversity (Manu, 2000). Dagona waterfowl sanctuary serves as a habitat for waterfowls, both local and migratory wild birds that visit the area from Europe (Ringim et al., 2017, Saleh and Ahmed, 2020). It harbors a large number of breeding resident as well as exotic species of birds (Palaearctic and

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Afrotropical migrants) that came all the way from Europe for wintering purpose. Annually, about 2.1 billion birds migrate from Eurasia to Africa in search for favorable weather and food (Berthold, 2001; Hahn *et al.,* 2009). The sanctuary is well protected by fully armed rangers of the wetland sector to avoid invasion of poachers and hunters. And the conservation is for resources protection and maintenance for future prosperity (IUCN, 1988). According to Trautmann (2018) birds breed on all of the continents on Earth and have adapted to almost every habitat with high spatial density within the tropic. Due to their dependence on water, tropical aquatic birds will be particularly vulnerable to climate change (Çagan *et al.,* 2012).

However, the wetland is threatened by the phenomenon of climate change, which over the years has shown high level of variability and uncertainty in the annual water flow regime (Yahya *et al.,* 2010). And due to their dependence on water, tropical aquatic birds will be particularly vulnerable to climate change manifesting in the form of drought, flood, heat waves etc (Çagan *et al.,* 2012).

Therefore, it is on this note that this study seeks to examine the vagaries of severe and extreme droughts on flora and fauna, as well as the ecological settings of Dagona waterfowl sanctuary, with a view to provide insight on the changes in ecological character brought by the high magnitudes drought. This will help in the conservation, maintenance and protection initiatives to safeguard the site of ecological importance.

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2 MATERIALS AND METHODS

Dagona waterfowl sanctuary is situated in the Sahelian northern part of Yobe state. Geographically, it lies between 12˚ 40ʹ 00ʺ N of the equator and 10° 30ʹ 00ʺ E of the Greenwich meridian. It is within the ambit of Bade-Nguru wetlands sector of the Chad Basin National Park, it covers a total land area of about $938km^2$ with numerous species of flora and fauna. According to Lameed (2012), the sanctuary has a total population of about 135 bird species in three buffer sites namely Gastu Lake, Maram Lake and Oxbow Lake. Migratory Shikra, Ovambo sparrowhawk, Black-shouldered kite, Marsh harrier and palearctic bird species includes the Yellow Wagtail, the Warblers, Northern Shoveler, and Sandpipers etc whereas the sedentary species include Blach heron, Cattle egret, Squacco heron etc.

The hydrology of the sanctuary is derived from a confluence of two different rivers of Hadejia and Jama'are which inundate and drain the entire floodplains. However, the natural flow and the level of inundation is reduced to a greater extend due to the construction of Challawa and Tiga dams on the Hadejia river axis.

The climate of the sanctuary is characterized by short wet season of about 3 to 4 months (June to September) and long dry season from (October to May). Hamatan which is dry, cold and dusty period begins from November to March. It is during this period that migratory birds from Europe visit the sanctuary for the sole purpose of wintering. Rainfall is highly variable with annual total of less than 600mm and may fall to 250mm in some cases. The temperature is high with the monthly mean of about 29^0c (Ayoade, 1988, Bulama, 2018). According to Manu (2000), the temperature rises up to 43^oC in the hottest months of May or June, The vegetation in the sanctuary is Sahelian Savanna characterize by few and short trees, shrubs and grasses. Plant species include acacia woodlands, Baobab, Dum palm, Tamarine trees, African Mahorgany etc. There is presence of wide spread tall grasses called of typha grass which occupies significant pools, lakes and agricultural land in the basin.

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2.1 Method of Analysis

Rainfall records spanning a period of 60 climatological years (1956-2015) for Nguru station was fully obtained from Nigerian meteorological agency (NIMET). The rainfall data was subjected to the SPI and PDBM indexes for the computation of SPI and PDBM values. Table 1 below shows Nguru meteorological station and its locational characteristics.

Table 1 Meteorological station used and its geographic location

S/N	Station	Latitude	Longitude	Elevation(m)
1.	Nguru	12 º 58 ' N	10 º 28 ' E	500

Source**:** Nigerian Meteorological Agency Oshodi, Lagos, 2010.

2.1.1 Drought Detection Using SPI Index

Standardized precipitation index (SPI) is developed by McKee and his colleagues in 1993. The index is based only on precipitation and can be used to monitor conditions on a variety of timescales. It uses rainfall parameter as a sole climatological input for the computation. The nature of the SPI allows an analyst to determine the rarity of a drought or an anomalously wet event at a particular time scale for any station with precipitation records, it facilitates the identification of different drought types and known with computational simplicity and reliable results. The index is criticized for demanding long-term rainfall data and neglecting climatic variables like temperature. For instance, during drought period, the prevailing high temperatures do exacerbate the drought situation. The SPI calculation for any location is based on the long-term precipitation record for the desired period. This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero (Lucio *et al.,* 2012). Drought occurs when SPI value reads negative whereas, a positive value indicates no drought. The greater the negative deviation, the more severity is the drought (Onchiri *et al*., 2016). Following the standard procedure, the monthly rainfall totals were summed to form annual series for the station. And the annual values for the station was aggregated and totaled into a single series and the climatological long-term mean and standard deviation were arithmetically calculated within the Microsoft excel statistical software. The positive and negative anomalies from the long-term mean (normals) were calculated using the SPI formula as follows.

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A SPI value is calculated using the formula below;

$SPI = \frac{Xik - \bar{X}}{\delta i}$

Mean = $\bar{x}$ = $\frac{\sum \varkappa}{N}$

Where

$\chi ik =$ Observed rainfall for the station

$\bar{x}$ = Mean rainfall for the station

δi =Standard deviation for the station

The mean of the rainfall can be calculated using the formula as

Mean = $\bar{x}$ = $\frac{\sum i\varkappa}{N}$

Where N is the number of rainfall observed

The standard deviation for the rainfall is computed using

$\delta = \frac{\sqrt{\sum (x - x)^2}}{N}$

After the computation of the SPI values, the derived positive and negative SPI values were then compared with the threshold SPI values adopted from Mckee *et al.,* (1993) for categorization and classification of the drought intensities as shown in table 2 below.

Table 2 . Categorization of SPI values and drought severity levels

SPI VALUES	DROUGHT CATEGORIES
-1.5 to -1.99	Severe Drought
-2.00 or less	Extreme Drought

Source: McKee *et al.,* (1993).

2.1.2 Drought Detection Using PDBM Index

Percentage Deviation Below the Mean (PDBM) is applied in the assessment of drought often coupled with SPI index for comparatively performance evaluation (Umar, 2013). It is adopted from Ayoade (2008) that calculated drought conditions on the basis of percentage of departure or deviation from the normal rainfall value. It is parsimonious index with ease of calculation and generally useful and simple to understand by public. It is also challenged for demanding long-term rainfall data (Ayoade, 2008; Umar, 2013). Refer to Table 3 below for the description of categories of the various drought intensities as according to the index. The index is computed using the formula given as:

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$$\text{PDBM} = \frac{X_i - \overline{X}}{\overline{X}} \times 100\,\%$$

Where:

X_i - is the annual rainfall Series

$\overline{X}$ - is the mean of the entire series

Table 3. PDBM values and drought severity levels

PDBM Scale	Drought Category
46-60%	Severe Drought
>60%	Disastrous Drought

Source: Ayoade, (2008)

3.0 Results and Discussions

The result of the analysis revealed that Nguru where the Dagona waterfall sanctuary is situated has faced the risk of severe and extreme droughts over the period of the study. It has the severe drought of highest frequencies occurring 9 times while extreme occurred 2 times. The years include: 1969 with SPI value (-1.688), 1972 (-1.688), 1973 (-1.462), 1977 (-1.820), 1982 (-1.802), 1984(-1.525), 1987(-1.568) and 1990 (-1.547) were the severe drought years on record during the period of 1956-2015 in the area. While 2009 and 2015 were years with extreme drought magnitude. See table four (4) for details. These high magnitude droughts as pointed out by Eze (2018) have serious consequences on the vital life support systems (rivers, wetlands sanctuary and rangelands) that provide means of livelihood to the people and other organism like birds in the study area. This finding of the research is in tandem with Mortimore (1989) which discovered severe droughts that struck the Sahel region in the 1970s, leaving millions of people in famine and starvation including death of birds and their habitats. The prevalence of high magnitudes drought events is attributable to rainfall shortages or aberration that characterized the climatic behavior of the Sahelian region of which the study area is apart.

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Table 4 High magnitude drought detected using SPI

SPI	SEVERE DROUGHTS WITH THEIR VALUES		EXTREME DROUGHTS WITH THEIR VALUES	
	YEAR	SPI VALUES	YEAR	SPI VALUES
1	1969	-1.688	2009	-3.198
2	1972	-1.688	2015	-2.534
3	1973	-1.462		
4	1977	-1.820		
5	1982	-1.802		

Source: Compiled by the Author, 2021

3.1 Drought Occurrences in Nguru Station Based on PDBM Index.

Results obtained from analysis indicated that the study area has one incidence of severe and disastrous drought which struck in 2003 and 1988, the worst magnitude drought. The Nguru station has six (6) number of severe and four (4) disastrous droughts. Moreover, the disastrous drought over Nguru occurred in 1985 (66%, PDBM scale), 1965 (73% PDBM scale) and 1996 (138 % PDBM scale). This finding conformed to the results obtained by Hassan et al., (2019) that drought is a recurrent event in the state. However, severe drought episode was detected in 2012 (47% PDBM scale) and 2014 (59% PDBM scale) respectively. See table 5 below for detail

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Table 5 High magnitude drought detected using PDBM Index

PDBM	SEVERE DROUGHT WITH THEIR SCALES		DISASTROUS DROUGHT WITH THEIR SCALES	
	YEAR	PDBM SCALE (%)	YEAR	PDBM SCALE (%)
1	1982	49	1983	71
2	1987	57	1988	68
3	1984	59	2009	62
4	2003	55	2011	61
5	2012	47		
6	2014	59		

Source: Compiled by the Authors, 2021

3.2 EFFECTS OF HIGH MAGNITUDE DROUGHTS ON DAGONA WATERFOWLS SANCTUARY,

The frequent occurrence of droughts in Yobe state has impacted negatively on the environment including Nguru⁄Hadejia wetlands where Dagoana wetland sanctuary is situated (Eze, 2018). High magnitude droughts affect the ecological conditions of the sanctuary. It caused dried up of river and its floodplain that made up the basin leading to the death of aquatic organism that serve as feed to the avian population in the sanctuary. This result is in line with the findings of Eze (2018) which discovered that drought has negative consequences on the vital life support systems (rivers, wetlands and rangelands) that provide means of livelihood to the man as well as animals like birds. This finding is in congruent with Chamanpira et al., (2014) that opined high magnitude drought leads to decline in river, water table and aquifer discharge falls. The altered hydrology led to decline in species diversity and richness of both sedentary and palearctic migratory birds. This finding is in tandem with the results of Oyebande (1999) and Polet (2000) that discovered the number of waterfowl depends on the level of water draining and inundating over the floodplains of the wetland.

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High magnitude drought led to the death of plants especially grasses that provide grain food to the avian population in the sanctuary. This reduction of food availability made foraging and breeding difficult leading to migration of the birds to relatively areas with foraging opportunities. This consistently corroborates the results of Polet (2000) that discovered deteriorating food availability may cause the migratory birds to leave early from their wintering site.

During the period of high magnitude drought, the prevailing temperature becomes high thereby exacerbating the drought and temperature conditions thereby reducing the wintering period and eventually early return of the migratory birds. This agrees with the findings of Polet (2000) wherein he reported that good condition attracts high concentrations of waterfowl stay in the wetlands. Moreover, the findings of the study is in agreement with Hafner and Fasola (1997), Deerenberg and Hafner (1999) that revealed that conditions at breeding or wintering sites also influence population fluctuations of the water birds.

High magnitude drought caused intrusion of invasive plant species such as typha grasses forming dense biomass on open-water, pools and lakes in the sanctuary. That slowed the flow of water, reduced the perimeter and hindered prey on fishes, breeding, free swimming, roosting and wintering of migratory birds.

4 CONCLUSION AND RECOMMENDATIONS

The study concludes that the effects of high magnitude droughts on the waterbirds and the ecological settings during the baseline period of 1956 to 2015 in the study area are glaring. And hence the paper recommends that agencies such federal ministry of water resources, Chad Basin Authority and NGOs to come to the rescue of the sanctuary by clearing the areas taken over by invasive water weeds like Typha grasses that reduced the perimeter and hindered aquatic breeding and wintering of local as well as migratory birds. It also recommends that experts in climate science

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should tailor their researches and investigations using computer models on drought to ascertain more climatic forces that caused quality deterioration of the habitat or sanctuary. The study further recommends additional studies to be conducted using GIS and remote sensing tools to ascertain the threat posed by high magnitude droughts in the sanctuary.

Also more research can be conducted on non−climatic stressors and other anthropogenic perturbation that threaten the sanctuary ecosystem

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