Rainfall Trend and its Implications for Sustainable Crop Production and Water Resources Management: A Case Study of Iwo, Nigeria

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ABSTRACT: Studies have revealed that the pattern of rainfall will change in view of climate change scenario being experienced globally. Thus, a thirty-year (1989-2018) rainfall data analysis was conducted for Iwo in Osun State, southwestern Nigeria to determine the trend pattern of rainfall. One parameter Mann-Kendall statistic was used in the analysis of the data. The results showed that while five months (February, April, July, August and December) showed negative trend (Negative y-values) indicating declining rainfall over the period, seven months (January, March, May, June, September, October and November) revealed a positive trend (positive y-values) implying increasing rainfall over the period for those months. However, the general analysis of the 30-year data showed that there was negative trend in rainfall in the study area which means that there is general fall in the rainfall incidence over the period in Iwo. The results of monthly trend indicated that rainfall is no longer dependable for a viable agricultural practice, and so water conservation methodologies need to be embarked upon in order to salvage crops from the shortfall in the rain caused by climate change. It is therefore, recommended that shifting in the planting dates, irrigation, planting cover crops and planting heat tolerant crops and early matured crop varieties among others should be considered by farmers, especially the small scale farmers. Stakeholders in water resources management holds the responsibility on averting water scarcity and the challenge of water pollution in view of the erratic rainfall to ensure human survival.

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Investigations on the impacts of greenhouse warming had suggested that the timing and regional pattern of precipitation will change and more intense of rainfall is expected (Feng, et al., 2019; Tabari, 2020). Such regional patterns in rainfall, especially in the tropical regions is already established in literatures (Lawal and Yamusa, 2018; Woo and Tarhule, 1998; Ogunbode and Ifabiyi, 2019). This hydro-climatological parameter, however, impacts on the livelihoods of man globally because of its influence on sustainability of natural resources and especially, agricultural practices and importantly in the developing countries. Apart from this, in-depth investigation into rainfall parameter enhances a result-oriented water resource management. For instance, incidence of flood, drought, water availability for home and industrial uses among others require adequate and timely information on rainfall characteristics such has its variability, amount, intensity among others. Kumar and Kumar (2015) noted that the spatial distribution and magnitude of rainfall trends is of immense significance from agricultural and water management point of view. Also, Woo and Tarhule (1998) and Valipour (2012) in corroborating this view stated that a long term rainfall data is very crucial in arriving at decisions about agriculture, water management and
crop pattern and also to locate drought prone areas. Dutta et al. (2001) revealed that yield predictions of rice have been made by the models based on water requirement calculations and rainfall data in agro climatic zones of his study area. Rainfall pattern in Nigeria has been found to be variable over time and space that Okorie (2015) remarked that the variability in the weather and climate system of Imo State (in Nigeria) due to observed shifts in rainfall within the thirty-year climatic period which by implication showing the evidence of climate variations and change in the climate of the area. In the same vein, Ologunorisa and Tersoo (2006) noted that there was a remarkable downward trend in the annual rainfall over Makurdi, Nigeria and also attributed major floods in the metropolis to the high recurrence intervals of rainfall events. Similar observations have been made in other tropical countries in published works (Mehtal et al., 2002; Messay, 2006, Ogunbode and Ifabiyi, 2019, Ogunbode et al, 2019). Investigation into rainfall trend is demanded as it will help to optimize the use of rainwater available, identifying specific areas of high variability, knowledge of the amount of probable rainfall in the area and rainfall reliability with respect to meeting crop water requirements (also in Lawal and Yamuza (2018). Apart from the relevance of rainfall trends studies in agriculture, its relevance in water management cannot be overlooked. The incidence of flooding, water availability for home and industrial uses are intimately related to the variability feature of rainfall. Several scholars have worked on the variability of rainfall in their respective locations and its influence on water resource management (e.g. Odjugo, 2007; Muhammad, 2009; Onyenechere et al., 2011; Ifabiyi and Ashaolu, 2013). Many of these works discovered that rainfall is not static over space and time and that this feature has its influence on what is available of water for home and industrial uses. For instance Muhammad (2009) revealed that decrease in rainfall can lead to water shortages in lakes, dams, rivers for both hydroelectric generation and irrigation. Also, in the report of IPCC, it was asserted that changes in the total amount of rainfall and in its frequency and intensity directly affect the magnitude and timing of runoff and the intensity of floods and droughts. It was further stated that such variability can have major impacts on water resources, affecting both surface and subsurface water supply for human uses. Water is the lifeblood of the planet and its state in space and time influence all natural, social and economic systems (Ifabiyi and Ashaolu, 2013). In corroborating this fact, UNWater (2010) declared that water serves as the fundamental link between the climate system, human society and the environment while Ishaku and Majid (2010) also observed that variability of this hydro-climatological parameter impacts on water accessibility. Iwo, being a tropical city is also under the cycle of variation in rainfall. Thus, the objectives of this study are to determine the trend of rainfall in Iwo from 1989 to 2018 and to assess its implications for crop production and water resources management.

MATERIALS AND METHODS

Study Area: This research was carried out in Iwo Township (Figure 1). Iwo, located in Osun State in the southwestern Nigeria, has an area of 245km$^2$ with a population of 191,348 according to 2006 population census. It is located on the coordinate axis of 7°38’N and 4°11’E. The prevailing climatic condition is tropical with about eight months of rainfall (March to October) and about four months of dry season (November to February). Ogunbode (2015) discovered that annual rainfall in most tropical wet climate regions ranges between 1000mm and 2000mm with double maxima in July and September.

Fig 1. This research was carried out in Iwo Township

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Iwo habitants are predominantly farmers with high dependence on rainfall for agricultural practices. Apart from this the dominant vegetation is tropical forest comprising hardwoods such as obeche, walnuts, acacia, eucalyptus among others. In addition, the dominant agricultural practice is growing of permanent and annual crops such as cocoa, kolanut, oil palm, yam, maize and so on. However, the dry period in the year is often dominated with farming in the wetlands and along some river banks. Aiba Water Reservoir located within Government Forest Reservation Area in Iwo forms one of the sources of potable water for home use in the area. However, as a result of unreliable and erratic supply from this Water Works and, in view of the susceptibility of the surface to pollutants, inhabitants have resorted to the exploitation of subsurface sources. Iwo is underlain by Precambrian Basement Complex comprising mostly gneiss, granite, schist, undifferentiated met-sediment rocks and overburden that are comprised mainly of clay, sand and silt soils. These compositions are neither porous nor permeable except where they are deeply weathered or along the lines of weakness. Also, Iwo is drained by rivers such as Oba and Yanyanhun River among others.

Data collection and analysis: A thirty-year rainfall data from 1989 to 2018 which was collected from the office of Nigeria Meteorological Agency (NiMET) (1989-2008) and Forest Research Institute of Nigeria (FRIN) (2009-2018) for the purpose of this investigation while XLSTAT software was used to determine seasonal Mann-Kendall and Sen’s slope trend statistics for the period.

RESULTS AND DISCUSSION

Composite 30-Year Rainfall Trend Analysis: Table 1 shows the summary of the descriptive statistics. The Table shows that there is no month without rainfall over the 30-year period. Also the seasonal variations in rainfall manifests in the pattern of rainfall with the lowest mean rainfall in the months of January (10.207 ± 18.097mm), February (35.363 ± 18.097mm), November (32.337 ± 38.327mm) and December (6.573 ± 11.278mm). Furthermore, the raining months as observed in the Table revealed that mean rainfall were highest in the months of July (188.048 ± 96.065mm) and September (188.207 ± 63.043mm) but lowest in the month of March (81.677 ± 48.243mm).

Table 1: Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observation</th>
<th>Obs with missing Data</th>
<th>Obs. Without missing data</th>
<th>Minimum (mm)</th>
<th>Maximum (mm)</th>
<th>Mean (mm)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>0.000</td>
<td>78.700</td>
<td>10.207</td>
<td>18.097</td>
</tr>
<tr>
<td>Feb</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>0.000</td>
<td>165.500</td>
<td>35.363</td>
<td>43.318</td>
</tr>
<tr>
<td>Mar</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>0.000</td>
<td>200.400</td>
<td>81.677</td>
<td>48.243</td>
</tr>
<tr>
<td>Apr</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>39.500</td>
<td>246.900</td>
<td>124.033</td>
<td>52.104</td>
</tr>
<tr>
<td>May</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>59.600</td>
<td>303.800</td>
<td>174.060</td>
<td>57.342</td>
</tr>
<tr>
<td>Jun</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>62.900</td>
<td>323.800</td>
<td>173.950</td>
<td>64.679</td>
</tr>
<tr>
<td>July</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>26.200</td>
<td>447.100</td>
<td>188.048</td>
<td>96.065</td>
</tr>
<tr>
<td>Aug</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>11.200</td>
<td>384.000</td>
<td>130.615</td>
<td>83.073</td>
</tr>
<tr>
<td>Sept</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>99.800</td>
<td>350.300</td>
<td>187.243</td>
<td>63.043</td>
</tr>
<tr>
<td>Oct</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>0.300</td>
<td>350.300</td>
<td>187.243</td>
<td>78.727</td>
</tr>
<tr>
<td>Nov</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>0.000</td>
<td>182.200</td>
<td>32.337</td>
<td>38.327</td>
</tr>
<tr>
<td>Dec</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>0.000</td>
<td>48.300</td>
<td>6.573</td>
<td>11.278</td>
</tr>
</tbody>
</table>

Fig. 2: Total Rainfall (1989-2018)
Rainfall Pattern over the 30-Year Period: The results of the analysis showed that rainfall in Iwo varies over the 30-year period. The results as depicted in Fig. 2 revealed that there is a negative trend, (with negative Y value) in the rainfall incidence in Iwo indicating a decreasing rainfall over the period. This finding portends the effect of climate change, which is a menace being tackled globally. Falling in the rainfall incidence over the thirty-year period calls for the attention of all relevant stakeholders in the area of agriculture and environmental/water resource management to checkmate the possible negative implication of such trend at least to ensure food security and household water accessibility.

30-Year Trend of rainfall by months: Figures 3(i-xii) shows the graphical description of the monthly trends in rainfall over the 30-year period (1989-2018).

![Fig 3(i): January Trend](image1)

![Fig. 3(ii): February Trend](image2)

![Fig 3(iii): March Trend](image3)

![Fig. 3(iv): April Trend](image4)

![Fig 3(v): May Trend](image5)

![Fig. 3(vi): June Trend](image6)
The results as presented in Table 2 shows that five (5) months of the year namely February, April, July, August and December have negative trend which implies that the rainfall event is at a decrease trend over the period of thirty years studied. On the other hand, the remaining seven (7) months namely January, March, May, June, September, October and November are observed to experience positive trend indicating increasing rainfall in the seven months and extended raining season. This observation was also made by Ogunrayi et al. (2016) in their study in Akure, Southwestern, Nigeria. The results have implications for crop farming and water resources management in the study area. For instance, the negative trend recorded in the months of December and February, which are part of dry season in the study area, revealed that dry season farming can only thrive if only water supply for plants can be augmented from other sources. Even though, the results showed that more water was received in November which marks the commencement of dry season in the study area, and also more rain in January, the intense heat often characterized the period has the tendency to aggravate evapotranspiration which could hinder water availability for good plant growth in the period, thus, the need for water supply augmentation earlier mentioned (Atedhor, 2016; Sobowale et al., 2016; Eruola, et al., 2021). Water supply augmentation may include artificial water supply to enhance plant growth as also supported by Sobowale et al., 2016). Apart from this remedial method, other water conservation method may have to be employed to ensure the
sustenance growth of plants. For instance, mulching and agroforestry may be required for moisture conservation and so preventing the plants from the intense heat that characterizes the season.

The results further revealed that the March commencement of raining season in the study area was consistent and with increasing trend. This is followed by declining rainfall in April and increasing trend in the months of May and June over the thirty-year period investigated. This finding was also corroborated by Atedhor (2016). This scenario was subsequently followed by another two months of declining rainfall in the months of July and August, rising again from the months of September through November. The rising and falling pattern in the trend of rainfall during the period of raining season could pose serious threat to agricultural yields and water resource availability in the study area. Akinniran et al. (2013) in supporting this finding discovered that production of maize and yam had suffered from erratic rainfall over a period between 1990 and 2009 in Oyo State while only cassava production was not affected by the trend, probably because of its food conservation capacity. The situation of acute shortage of rainwater in the middle of growing period of plants may result in wilting of plants and even entire death of plants, especially for plants that possess less resistance to erratic supply of soil moisture (see also Akinniran et al., 2013).

In the same vein, such plants like maize, yam, groundnut and the likes whose flowering and fruiting period falls within the period of falling water supply via rainfall could lose their yields (also in Abdulkadir et al., 2017). Odekunle (2004) had noticed the similar scenario when it was revealed that the rainfall distribution in his study stations remain insufficient for dependable agricultural yields and productivity, but becomes better from the month of May. Oyinbo et al. (2014) had made similar observations when it was revealed that the pattern of rainfall caused by climate change will lead to declining water resources and also, decreased agricultural productivity. Thus, it was suggested that measures should be put in place to avert the disastrous consequences of this situation. The suggested measures include use of heat-resistant crop varieties, use of early maturing crop varieties, planting of cover of crops, shift in the planting dates, minimum tillage.

The result has implications for water resources availability, accessibility and quality in the study area. The zig-zag pattern in the rainfall events as observed in the results could impact on groundwater recharge and yields.

The major source of potable water for the majority of the residents in the study area is subsurface (Ogunbode and Ifabiyi, 2017). Thus, the availability of water from this source is highly dependent on unhindered and continuous replenishment through rainfall. The trend pattern as observed in this study could pose a serious threat to that natural replenishment of subsurface water, especially, the situation that may engender poor access to water, and when accessible, may infringe on the quality of such water, the view supported by Haider (2019). Similarly, Twisa and Buchroithner (2019), in corroborating this observation, stated that in view of the declining trend in rainfall in Wami River Basin in Tanzania, it was discovered that water points were significantly affected in terms of water availability and quality.

**Conclusion:** The trend of rainfall in Iwo between 1989 and 2018 was studied in view of the prevailing global climate change scenario. The results showed that there was generally negative trend in rainfall in the study area. The monthly analysis showed that rainfall is no longer dependable for a viable agricultural practice, and so water conservation methodologies are desirable. It is recommended that shifting in the planting dates, irrigation, planting cover crops among others should be considered by farmers. Stakeholders in water resources management’s efforts on averting

<table>
<thead>
<tr>
<th>S/N</th>
<th>Month</th>
<th>Y-Value</th>
<th>R²-Value</th>
<th>Trend Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>January</td>
<td>0.3267x + 5.1432</td>
<td>0.0253</td>
<td>Positive</td>
</tr>
<tr>
<td>2.</td>
<td>February</td>
<td>-0.8355x + 48.314</td>
<td>0.0268</td>
<td>Negative</td>
</tr>
<tr>
<td>3.</td>
<td>March</td>
<td>1.3801x + 60.285</td>
<td>0.0634</td>
<td>Positive</td>
</tr>
<tr>
<td>4.</td>
<td>April</td>
<td>-0.3472x + 129.41</td>
<td>0.0034</td>
<td>Negative</td>
</tr>
<tr>
<td>5.</td>
<td>May</td>
<td>1.0435x + 157.89</td>
<td>0.0257</td>
<td>Positive</td>
</tr>
<tr>
<td>6.</td>
<td>June</td>
<td>0.08964x + 160.06</td>
<td>0.0149</td>
<td>Positive</td>
</tr>
<tr>
<td>7.</td>
<td>July</td>
<td>-0.4904x + 195.65</td>
<td>0.0002</td>
<td>Negative</td>
</tr>
<tr>
<td>8.</td>
<td>August</td>
<td>-3.4205x + 183.63</td>
<td>0.1314</td>
<td>Negative</td>
</tr>
<tr>
<td>9.</td>
<td>September</td>
<td>1.3637x + 167.07</td>
<td>0.0363</td>
<td>Positive</td>
</tr>
<tr>
<td>10.</td>
<td>October</td>
<td>2.2001x + 153.14</td>
<td>0.0605</td>
<td>Positive</td>
</tr>
<tr>
<td>11.</td>
<td>November</td>
<td>1.4835x + 9.3425</td>
<td>0.1161</td>
<td>Positive</td>
</tr>
<tr>
<td>12.</td>
<td>December</td>
<td>-0.3821x + 12.496</td>
<td>0.089</td>
<td>Negative</td>
</tr>
</tbody>
</table>

Source: Authors' work, 2021
water scarcity and the implied challenge of water pollution are required.

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