Seasonal Differences in Rainfall Distribution Within the Bawku Area in the Savanna Belt of Ghana

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Abstract

Empirical evidence suggests that temperatures are continuously rising in the savannah areas of Ghana and impacting negatively on residents' livelihood activities. However, there is paucity of information on the wet and dry seasons' rate of wetness or dryness in the driest belt of Ghana. Meanwhile, residents of the area are mainly rained agriculturalists. We employed gauge station rainfall and temperature data from Ghana Meteorological Agency to assess the seasonal rainfall characteristics of the Bawku area using XLSTAT and DrinC software. Results from the rainfall anomalies show persistent dryness (-0.017) in the area during the dry season and continuous wetness in the wet season (0.021). Evapotranspiration was consistently higher in the dry season at a rate of 2.6% (0.26) yearly as well as a high rate of aridity [AI] (0.00≤AI≤0.09) in the dry season and low aridity (0.56 ≤AI ≤1.13) during the wet season. Following the reduction in the amount of rainfall, we can conclude that Bawku area is continuously drying amidst the changing climate. It is recommended that the ministry of agriculture should prioritise the construction of mechanised dams or wells and expand irrigation projects in the area to reduce the climate change effects on the livelihood of the residents especially in the dry season.

Keywords: Anomalies, Evapotranspiration, Rainfall, Savannah, Seasonal Variations

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Received on March 17th, 2023/Accepted on July 12th, 2023

Ghana Journal of Geography Vol. 15 (3), 2023 pages 196-222
Doi: https://dx.doi.org/10.4314/gjg.v15i3.7

Introduction

Rainwater is a necessity in maintaining the earth's water budget; its absence has lots of effects on the hydrological cycle (Healy et al., 2007). It is important to recognize the role rainfall plays in the earth-atmosphere system and the effect of climate change on rainfall amount and distribution worldwide. Globally, there is no doubt about the consequences of the changing climatic conditions evidenced in drought, floods, shifting rainfall patterns, rising temperatures, prolonged dry spells, and irregular rainfall patterns on human activities (IPCC, 2021). Extreme rainfall has affected many lives in many parts of the world, especially in developing countries like Ghana. The absence of rain has equally affected many agrarian economies particularly in arid and semi-arid climates (Owusu, 2018; Baffour-Ata et al., 2021). Long periods of dry spells (drought) are one of the most unprecedented destructive tools of climate, which happens to be a renowned natural hazard with an enormous effect on water systems (Tigkas et al., 2018). In Ghana, climate stress is generally predicted, with much of the shocks and stresses being paramount in the savannah agro-ecological zone. The climate of Ghana is a tropical type highly influenced by the West African Monsoon (WAM) and the rainfall regimes affected by the alternating Inter-Tropical Convergence Zone (ITCZ) (Amekudzi et al., 2015; Owusu 2018; Klutse et al., 2020; Karim et al., 2020). Generally, the migration of the ITCZ controls the rainfall pattern and distribution resulting in the unimodal and bimodal regimes in the northern and southern belts of the country, respectively (Manzanas et al., 2014; Amekudzi et al., 2015; Atiah et al., 2020; Karim et al., 2020). The alternating effects of the ITCZ makes the seasonal variability in temperature and rainfall over the country very pronounced in the northern belt than in the south (Karim et al., 2020).

Studies including Logah et al. (2013), Amekudzi et al. (2015), Issahaku et al. (2016), Owusu (2018), Incoom et al. (2020), Atiah et al. (2021) and Dankwa et al. (2021) have all researched on rainfall variability and trends in the northern part of Ghana. Results from these researchers vary from reducing rainfall amounts to upward temperature or both to affirm that rainfall variability is a canker in the savannah belt. For instance, Abbam et al. (2018) indicated that Ghana's climate in the past century has become drier making it more prone to dry spells in the cropping seasons with a resulting decline in the mean annual rainfall during the growing seasons as well as a decadal drop from 1,308 mm to 1,147 mm from 1960 to 2014. Similarly, Atiah et al. (2020) identified a decline in the total rainfall in the savannah since 1960s. These studies, however, did not focus on the wet and dry seasons characteristics. However, the seasonal rainfall is of concern since the two seasons differ in their level of wetness, especially when residents are rain-dependent for most of their livelihood activities. Meanwhile, residents in the northern part of Ghana are largely rainfed agriculturalists who farm during both the dry and wet seasons while the area has a unimodal rainfall season. Their agricultural activities require water throughout the year; crop farming and animal husbandry. The nature of climate in this region puts pressure on water resource usage and access.

This paper focuses on Bawku area which is part of the drought-prone belt and the driest areas in the country (Dietz et al., 2004). Residents in this part of the region are already suffering from long periods of dryness, whiles climate projections suggest a worsening situation to the region. The implication of this on water stress is undoubted, hence analysing local level variations in wet and dry seasons rainfall is a prudent attempt. The result will help residents to plan for water use during the long period of drought and inform decisions, policy and planning. The findings will be crucial to local adaptation planning as residents are mainly rain-fed agriculturalist. Policymakers may use it as a basis to implement plans to reduce the effect of the dry season. The study addresses the following research questions: What is the nature of rainfall in the area during the seasons?

Methods

Study Area

The study area (Bawku Area) is operationalized to refer to all the administrative districts that used to be part of Bawku Municipal prior to the demarcation of the then Bawku Municipal. The study area falls within the Upper East Region in the savanna belt of Ghana, comprising five districts: Bawku Municipal, Bawku West, Binduri, Garu, and Tempane. The area is found within latitudes 10o 30’ to 11o 11’ N and longitudes 0o 6’ E to 0o 40’ W respectively (Figure 1). It lies within the savannah agroecological belt characterized predominantly by long periods of dryness (Abbam et al., 2018). The study area has a longer dry season and a short-wet season; the dry condition impacting on livelihood activities in the area.

The dry and wet seasons of this climatic zone are influenced by the alternating North East and South West Trade Winds originating from the Sahara Desert and the Atlantic Ocean separately. The dry season dominates the area continuously for at least seven months, with a unimodal wet season of five months maximum. The presence of the Inter-Tropical Convergence Zone (ITCZ) is the main determinant of the rainfall characteristics of the area (Amekudzi et al., 2015; Owusu, 2018; Klutse et al., 2020). The fluctuating ITCZ gives rise to the effects of the WAM and the North East Trade Winds controlling the weather and climate of the savannah agro-ecological belt. The El Nino and La Nina Southern Oscillation also play significant roles in the weather and atmospheric condition of the place (Abbam et al., 2018; Atiah et al., 2021; Baffour-Ata et al., 2021). The warm and cool characteristics of El Nino and La Nina influence the sub-region leading to warm and cold winds correspondingly.

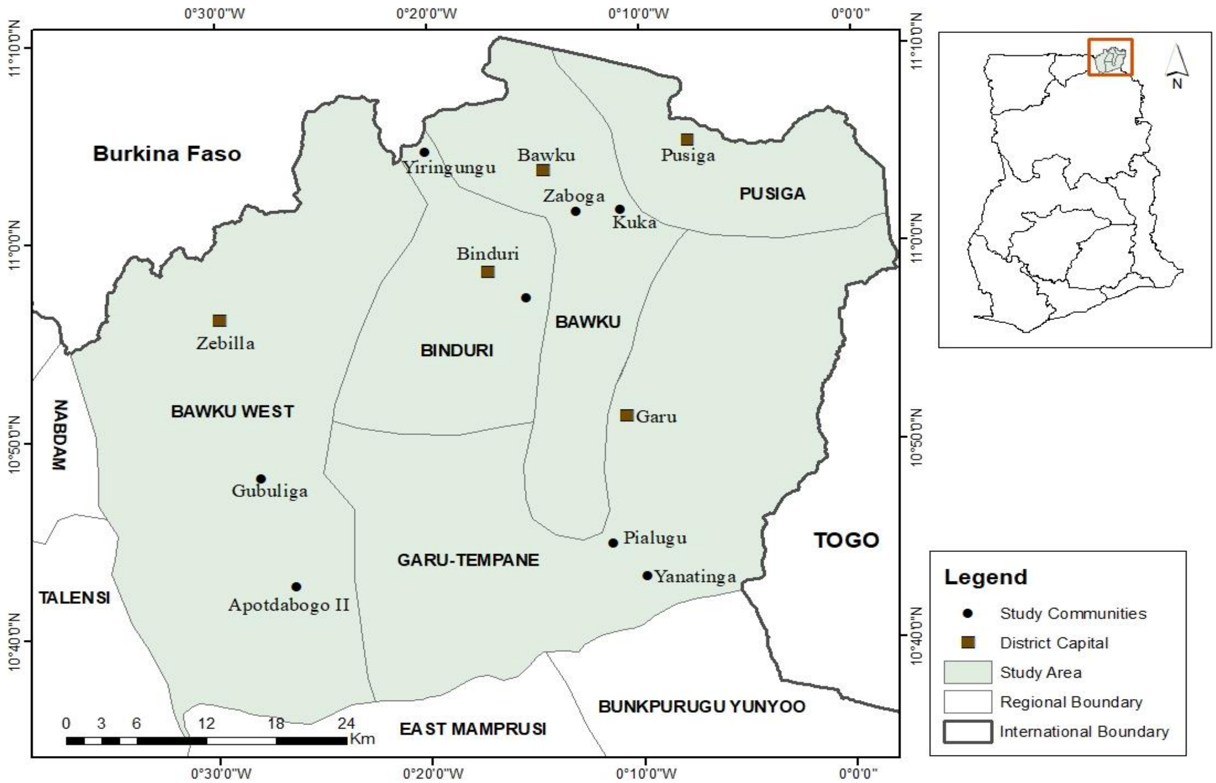


Figure 1: Study Area Map in Regional and National Context

Source: Asamoah and Ansah-Mensah (2020)

The Red and White Volta with tributaries such as Tamne and Pawnaba-Kiyinchongo are the main drainage in the area. In the wet season, there is enough rainfall to cause the rivers to overflow their banks, yet, the short-lived wet season recedes, and the rivers dry up very fast in the dry season (Incoom et al., 2020; Dankwa et al., 2021). Residents in the area resort to constructing dams and dug-out wells to survive their agriculture practices in the dry period (Leemhuis et al., 2009). Major vegetation in the area is grass interspersed with shrubs and baobab trees (Yiran et al., 2012). Their major livelihood activities are livestock rearing and crop farming even though agriculture is a stressful livelihood activity there due to the climatic characteristics and soil type (Limantol et al., 2016; Jeil et al., 2020).

Data Collection

Rainfall and temperature data were collected from the Ghana Meteorological Agency (GMet) for three (3) gauge stations (Manga, Binduri and Garu-Tempane) in the study area. The choice of the three was based on the fact that they were the only meteorological stations found in the study area at the time of the study. The choice of the forty (40) year period (1976-2015) however, was due to availability, consistency and reliability of data. Yet, to ensure that the data were in good form for analysis, it had to be cleaned by the researchers during which a few missing data were corrected using the arithmetic mean interpolation method, which uses the averages of the data before and after the missing value.

Data Analysis

As part of the data analysis processes, we computed the temperature and rainfall data from daily to monthly, annual and seasonal data. Graphs were used to show the long-term pattern and inter-annual variabilities of climate variables in the study area. Coefficients of variation (CV) was calculated to show the variability that existed in rainfall amount in the area. Here, we first calculated the means (μ) and standard deviations (δ) of the annual rainfall. CV was then found by dividing the δ by the μ values of the annual rainfall. The result was plotted using scatter plot. The interpretation of the result follows the recommendation of Hare (2003), who classified the extent of rainfall variability on the bases of less (≤20), moderate (20<CV≤30) and high (>30). The calculation of the CV followed the equation below:

$$CV = \frac{\sigma}{\mu} X\ 100$$

Where CV is coefficient of variation, δ is the standard deviation of the rainfall and μ is the mean rainfall.

Furthermore, the Standardized Precipitation Index (SPI) was used to calculate the wet and dry season's rainfall anomalies to ascertain their long-term patterns. Data from the three-gauge stations were combined for the purposes of generalisation. The SPI is the commonest drought index widely used by researchers due to its flexibility (Barker et al., 2016) and recommendation by the World Meteorological Organisation [WMO] (Van Loon, 2015). The calculation follows the use of gamma probability distribution in accordance with McKee et al., (1993). In this regard, SPI can be calculated in different timescales, including 3, 6, 12, 24, 48 months depending on the purpose of the study (McKee et al., 1993; WMO, 2012). For the purpose of comparing annual rainfall distribution of the various years understudy, the 12-months' timescale SPI was adopted. In the interpretation of the SPI output, negative SPI values indicate rainfall lower than the mean of the distribution, while positive values signify values higher than the mean rainfall (see Table 1). The analysis was performed using DrinC standalone software as used in Tsakiris et al. (2007), Nalbantis & Tsakiris (2009) and Tigkas et al. (2015: 2018). The SPI function is given by the formula:

$$I(i) = \frac{X_i - \overline{X}_m}{\sigma}$$

Where *I(i)* is the standardized index of year *I*; X_i is the value of rainfall for the year *I;* $\overline{X}_m$is the average rainfall for the year *i;* and σ is the standard deviation of the time series.

Table 1: SPI Values

SPI Results	Interpretation	Probability of Occurrence	Severity of Event
≥ 2.0	Extremely wet	2.3	1 in 50 years
1.5 to 1.99	Very wet	4.4	1 in 20 years
1.0 to 1.49	Moderately wet	9.2	1 in 10 years
0.0 to 0.99	Mild wet (NN)	34.1	1 in 03 years
0.0 to -0.99	Mild dry (NN)	34.1	1 in 03 years
-1.0 to -1.49	Moderately dry	9.2	1 in 10 years
-1.5 to -1.99	Very dry	4.4	1 in 20 years
≤ - 2.0 and less	Extremely dry	2.3	1 in 50 years

NB: NN = Near Normal
Source: (WMO, 2012; Tsakiris et al., 2007)

Moreover, rainfall, and minimum and maximum temperatures were used to generate potential evapotranspiration (PET). Following Thornthwaite (1948), PET, which is dependent on climate characteristics, measures the degree to which evaporation would take place in an area. Results were generated separately for wet and dry seasons with the aim of providing a basis for water planning during each of the seasons. The calculation of PET was also to augment the calculation of the reconnaissance drought index (RDI). Lastly, the RDI was generated using the PET and mean annual rainfall values of the area. The RDI is used to explain the level of dryness (aridity) determined by finding the ratio of the cumulative annual rainfall and PET over a specified period. The 12-months reference period was used for easy comparison. Hence, the result was interpreted using the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and United Nation Environmental Programme (UNEP) aridity indexes (AI). The RDI might be a simple tool, but it is a very practical drought index used for the estimation of agricultural drought analysis (Tsakiris et al., 2007). Interpretation of results ranges between hyper arid (HA) and humid (H), as shown in the Table 2:

Table 2: Classification of Aridity Index

	Aridity Index		
S/N	UNESCO (Penman)	UNEP (Thornthwaite)	Interpretation
1	<0.03	<0.05	Hyper arid (HA)
2	0.03 ≤AI<0.2	0.05 – 0.20	Arid (A)
3	0.2 ≤AI<0.5	0.20 – 0.50	Semi-arid (SA)
4	0.5 ≤AI< 0.65	0.50 – 0.65	Sub-humid (SH)
5	AI < 0.65	>0.65	Humid (H)

Source: (UNESCO, 1979; UNEP, 1992)

Results

Nature of Seasonal Rainfall

Mean Annual Rainfall Distribution

The study analysed the pattern, distribution and amount of rainfall on annual and seasonal bases. The assessment was to help readers and policy makers to understand the situation on the ground in each of the seasons on one hand and generally on yearly bases on another hand. This is hoped to inform tailor-made planning and adaptation based on the period under consideration to reduce the inefficiencies in planning the same way for both seasons. From Figure 2, the result shows that there was no year without rainfall. A maximum concentration of rainfall between 60mm to 100mm across the three stations were observed. Whereas the minimum rainfall was recorded in 2008 (4.0mm) at Binduri, the maximum (130mm) was recorded at Manga in 2007. However, between these low and high rainfalls are discrepancies, which show irregularities in annual rainfall over the area. The graph also shows an irregular trend throughout the study period depicting highs and lows of per annum rainfall amount.

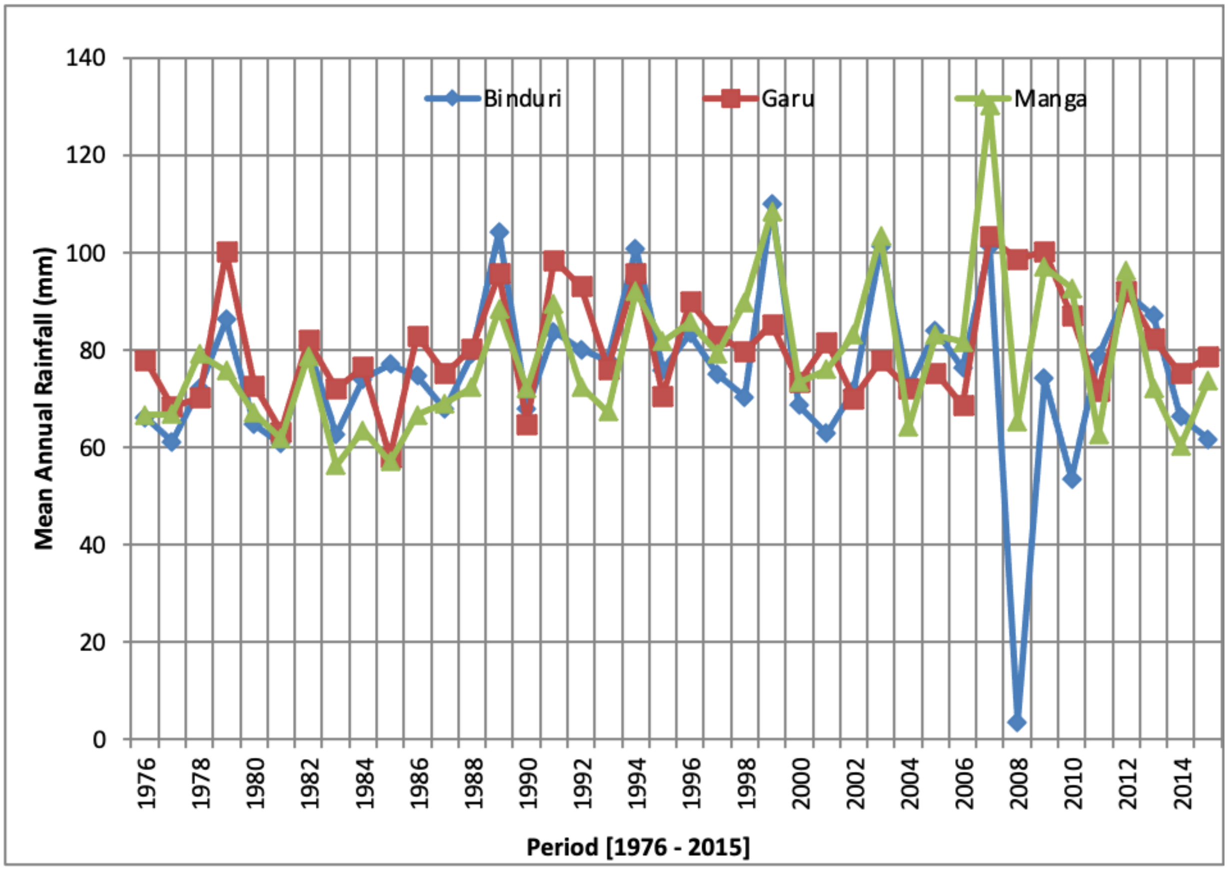


Figure 2: Mean Annual Rainfall distribution

Seasonal Rainfall Cycles

The study examined rainfall cycles on seasonal (dry and wet) bases; this was to augment the understanding of rainfall distribution on seasonal bases for proper planning on water conservation and use especially in the future. In this respect, the three-gauge stations were put together for easy description, comparison and generalizations.

Average Rainfall in the Wet Season

We observed from Figure 3 that the highest rainfall amount was recorded in 1989 (233mm), 2007 (224mm) and 2007 (284mm) at Binduri, Garu and Manga stations, respectively. On the average, wet season rainfall was uniformly low, ranging between 120mm to 200mm across the three stations. The pattern, meanwhile, depicts an irregular rainfall distribution with a marginal upward trend at Manga and Garu immediately after 2007.

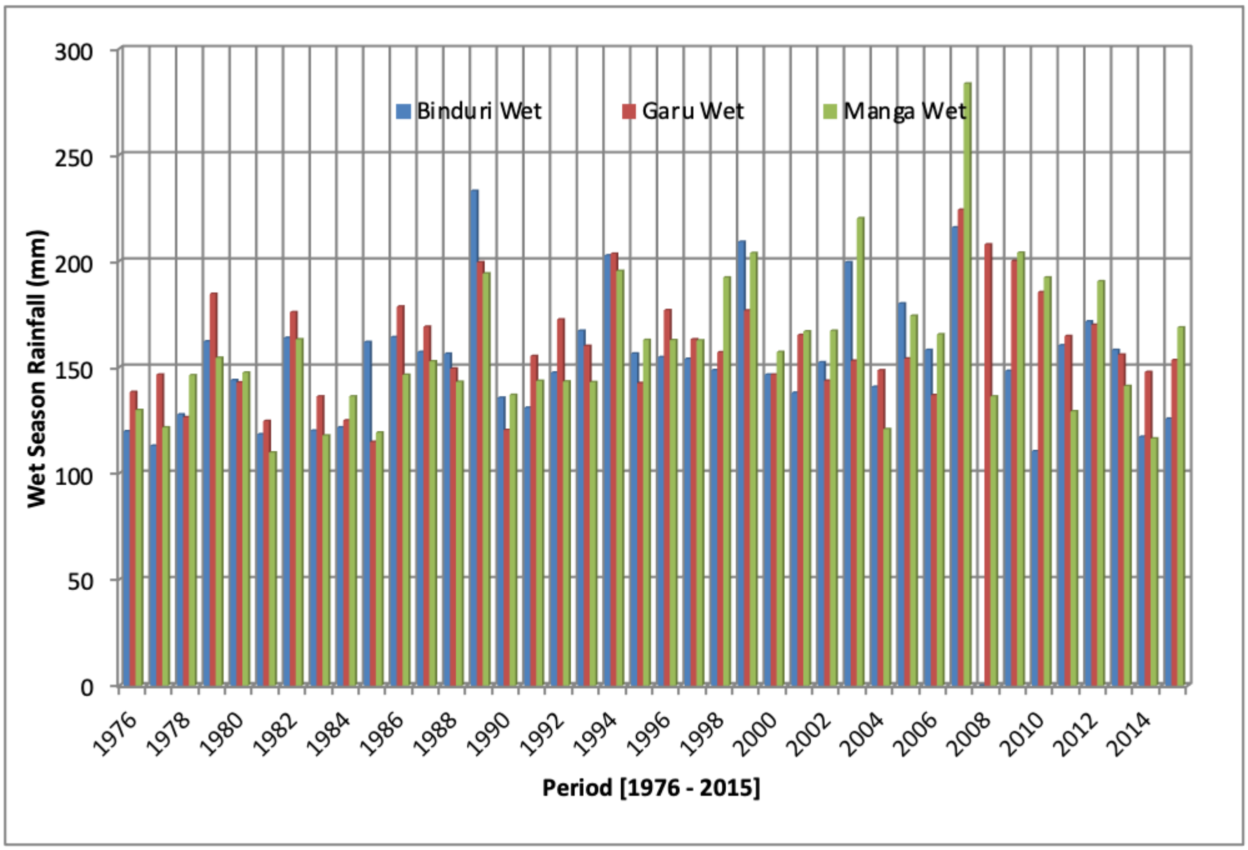


Figure 3: Mean Wet Seasonal Rainfall

Average Rainfall in the Dry Season

Generally, low rainfall was expected in the study area over the study period during the dry season. However, Figure 4 shows an uneven annual dry season rainfall distribution, with the highest (58mm) at Garu during the 1991 season and the lowest (4.0mm) at Binduri in 1987. Besides these extremes, there are various levels of disparities seemingly difficult to describe, but with majority of the years experiencing rainfall in the range of 10-30mm per annum. In Figure 4, it is also observed that there is more rainfall at Garu during dry season as compared to Manga during the same period.

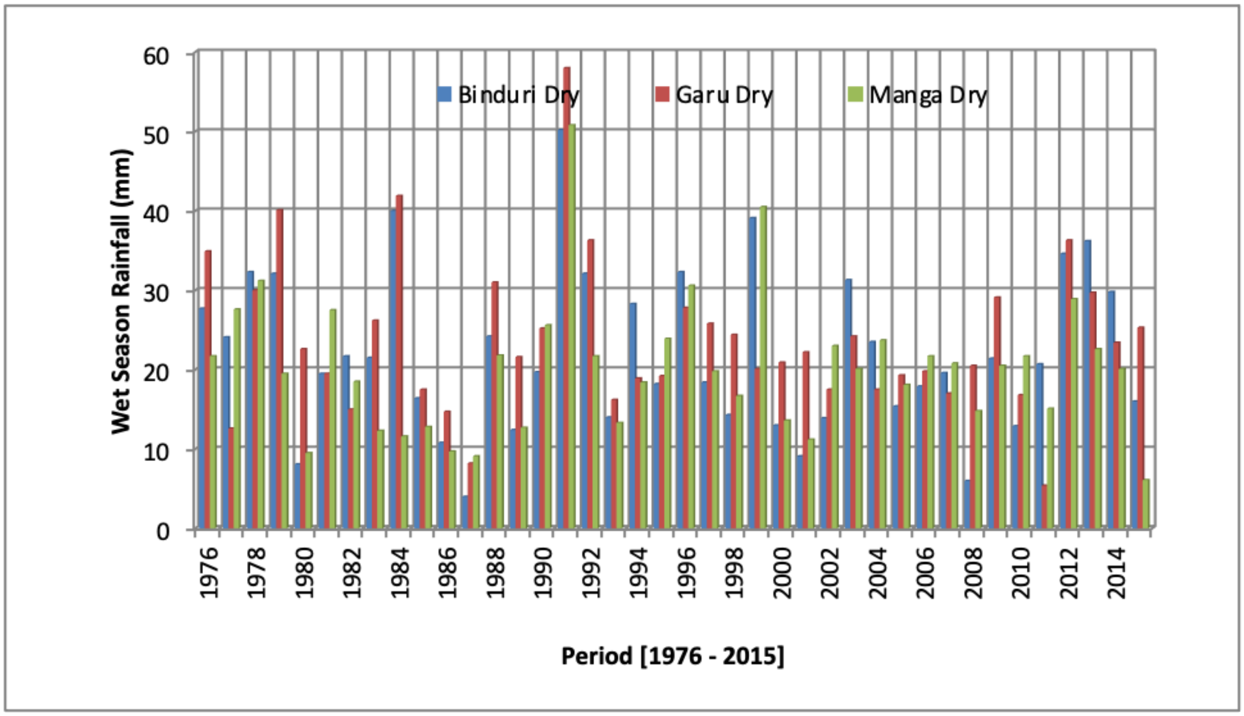


Figure 4: Mean Dry Seasonal Rainfall

Coefficient of Variation (CV)

A forty-year (40) average annual rainfall from the three (3) gauge stations was analysed to ascertain the coefficient of variations (CV) of the rainfall amount, and distribution. The results ranged from 13.9% to 22.7%. In respect of Hare's (2003) recommendations, CV forms the bases to classify the extent of rainfall variability using less (≤20), moderate (20<CV≤30) and high (>30). Figure 5 shows that most of the rainfall values in the study area fall within 15 – 20%, which depicts less variability. Three study periods had variations >20 to imply that rainfall variability was moderate in those periods compared to the others.

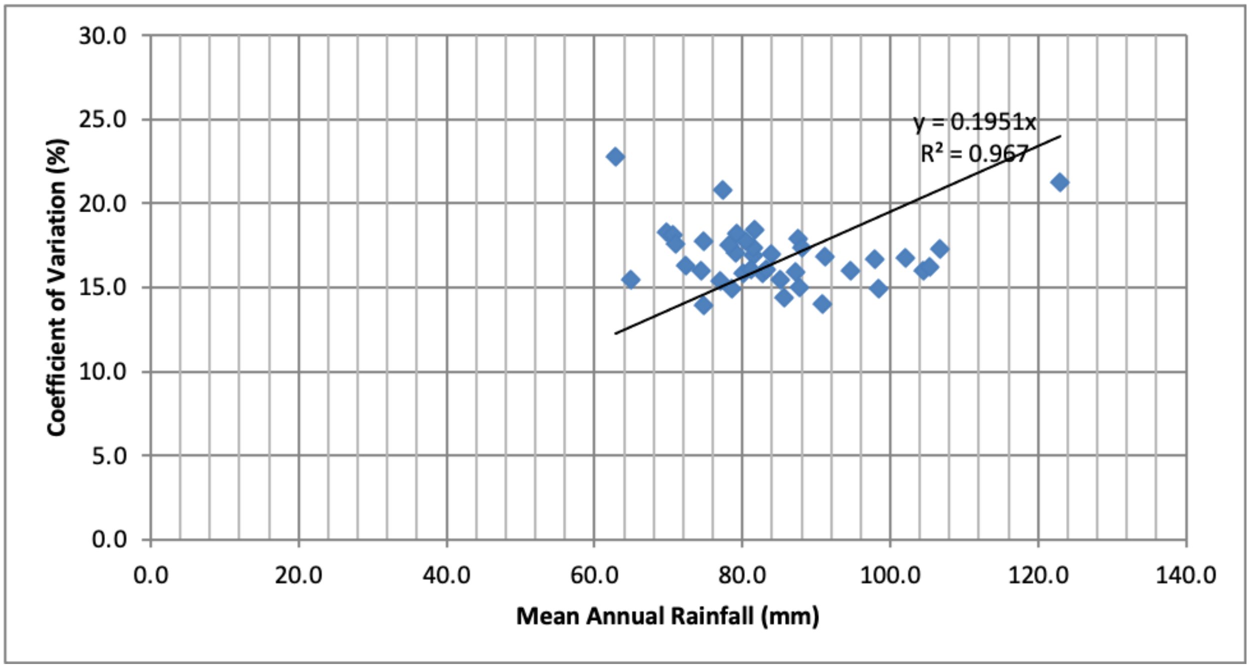


Figure 5: Coefficient of Variation

Observed Rainfall Anomalies

The study sought to describe the anomalies in rainfall in order to explain rainfall deficiency concerning wet and dry seasons in the area under study. As such, the three-gauge stations were to generate combined mean values for the wet and dry years in the period under study. The value zero (0mm) is the base value (mean), above which is described as wet and below which is dry. Thus, wet and dry periods would have a positive (+) or negative (-) anomaly, respectively. This analysis is based on a 12-month timescale SPI analysis comparing the first year (1976-1977) to all other remaining years. Following these interpretations, years with negative signs imply dry or drought-affected periods (McKee et al. 1993).

The situation in the dry season is not significantly different from the wet season except for the amount of rainfall. Figure 6 generally shows more years experiencing dryness (negative anomalies) than wetness (positive anomalies). A continuous dryness is recorded during the dry season, as shown by the downward slope -0.017x, and a constant wetness is observed in the wet season with a 0.021x slope. From Figure 6, we also observe that only in 2007-2008 that the SPI value was ≥2.0, which indicates an extreme wet year. This condition, however, has a 2.3% probability rate of likely recurrence once every 50 years with a probability of 2.3%. For 1995-1996 and 1999-2000, the SPI values ranged between ≥1.5 and ≤1.99. This result suggests a very wet condition and a 4.4% likelihood of recurring once every 20 years. The SPI values for 1989-1990, 2003-2004, 2009-2011 and 2012-2014 are ≥1.0 – ≤ 1.49mm. The finding suggests that those years recorded moderately wet conditions with a return period of once in 10 years at a 9.2% probability. Moreover, during the same wet season, some years recorded rainfall amounts below the average mean value depicted in Figure 6 with a negative (-) value. The year 2008-2009, with a recorded anomaly of 2.22mm, is the driest. The dryness, however, is only likely to reappear once in the next 50 years at a likelihood rate of 2.3%, very rare indeed. Anomalies ≥1.0 – ≤ 1.49 were observed in 1977-1978, 1981-1982, 1983-1986, 1990-1991, and 2014-2015. Moreover, the linear trend line equation suggests an upward trend with an intercept and R-square of 0.005 and 1.4% (0.014), respectively. Thus, an indication that despite the anomalies and irregularities, there is a marginal rise in wet season rainfall from 1976 to 2015.

On the other hand, during the dry season, it is shown in Figure 6 that 1984-1985 and 1991-1992 were the only years that recorded extreme wet rainfall (≥2.0). The 1989-1990 period is the only year that recorded a very wet condition with an SPI value of ≥1.5-≤ 1.99. For moderately wet periods, the 1988-1989, 1990-1991 and 1995-1996 recorded anomaly values of ≥1.0-≤1.49, which is likely to recur once in 10 years.

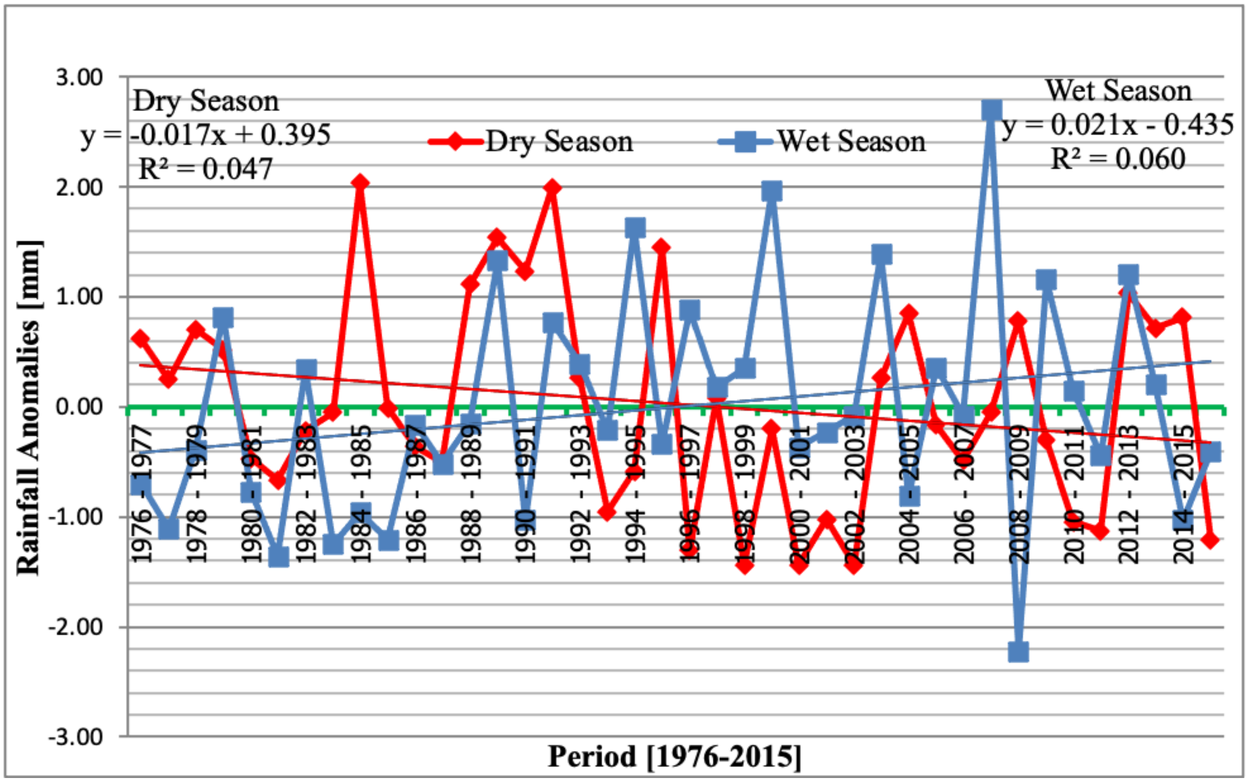


Figure 6: Rainfall Anomalies during the Wet Season

Yet, during the dry season, we observed negative anomalies below the base value (mean), indicating dryness. Years ranging from ≥0.99 – ≤ -0.99mm are considered as mildly wet period (near normal). These may reappear at least once every three years at a 34.1% certainty. These periods include 1976-1984, 1985-1988, 1992-1993, 1994-1995, 1997-1998, 1999-2000, 2003-2010 and 2012-2015. Moreover, other years including 1996-1997, 1998-2001, 2001-2003, 2010-2012 and 2015-2016 experienced moderately dry (≥1.0-≤1.49) spells. These periods have 9.2% rate of recurrence once in every 10 years.

Seasonal Potential Evapotranspiration

The study used rainfall, maximum and minimum temperatures to establish annual rate of potential evapotranspiration (PET) in wet and dry seasons. Evapotranspiration is an important process in the hydrological cycle as such knowing the potential rate is significant to the local area. According to Sahin (2012), PET is an important indicator often used in characterising drought following Thornthwaite 1948 estimations. PET estimation was necessary to understand how much water was lost to the air during each of the seasons to improve season-specific planning. During the wet season, there was significant rainfall and lower temperatures comparatively, so PET was generally lower throughout. The range of PET was between 151–178 mm and 170-186mm in the wet and dry season respectively. We also observed an irregular pattern of PET both in the dry and wet seasons throughout the 40-year. The highest PET rate in the wet season occurred in the 2014-2015 (178mm) whereas the highest in the dry season occurred in 2011 (186mm). Lowest rate of PET however, was 151mm in 1977 and 1991 for the wet season, while it was 170mm in 1976 during the dry season (Figure 7). The trendline equation of both the wet and dry seasons show increasing trend in rainfall amount with R2 of 5% (0.5269) and 0.6% (0.0612), respectively.

Level of Aridity

The annual drought characterisation provides a picture of the wetness or dryness of a specified area however, seasonal drought classification (wet and dry) will best help in industrial and domestic water usage (Tigkas et al., 2015). The Reconnaissance Drought Indicator (RDI) was used to describe the arid nature of the wet and dry seasons to augment the result of the anomalies and PET.

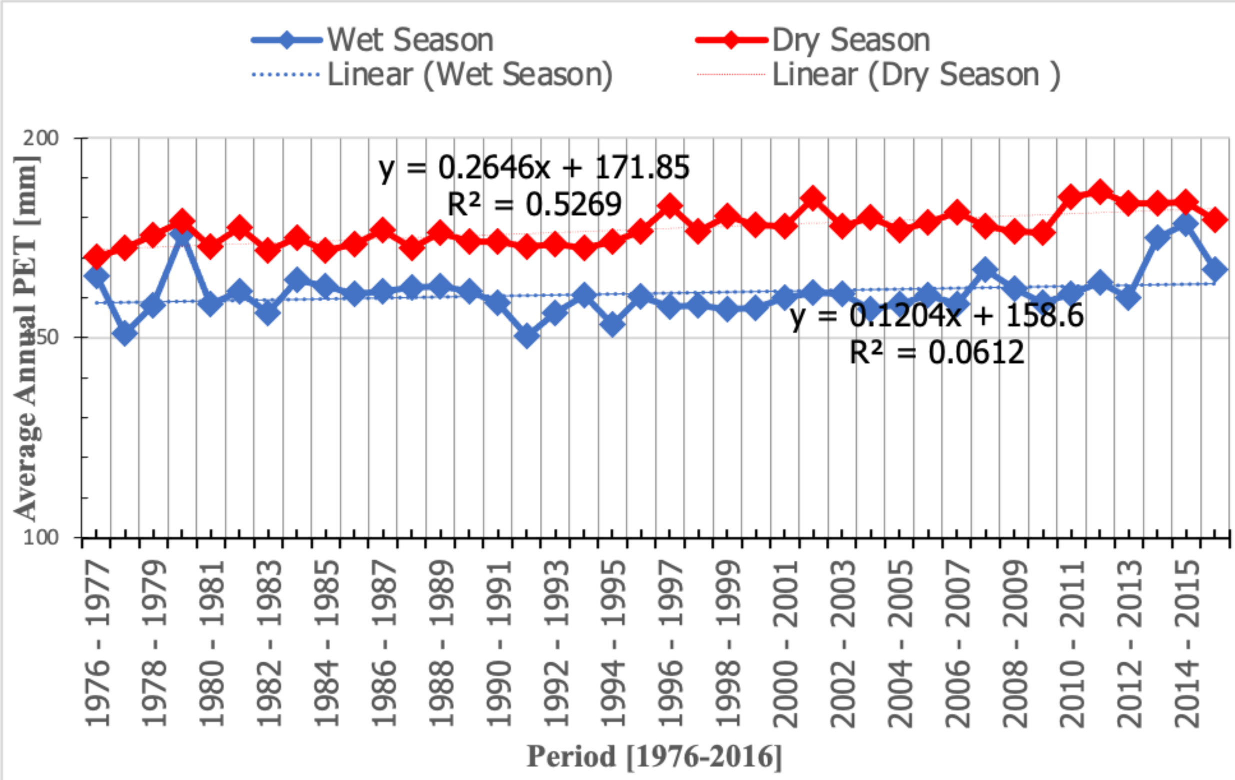


Figure 7: Potential Evapotranspiration in Wet and Dry Seasons

Dry Season

The result of the RDI is interpreted using the aridity index (AI) of UNESCO and UNEP (see Table 2). The result of this analysis is premised on the aridity calculation using precipitation and PET. In situations where there is low precipitation and the PET is high, AI will be higher (obtain a lower value). Contrarily, where precipitation is high, but PET is lower, AI will be lower (obtain a higher value). We observed from Figure 8 that AI values ranged from 0.00 ≤ AI ≤ 0.09mm over the study area during the dry season. Hence, in the dry season, the study area falls within the hyper arid climatic characteristics (AI = 0.2mm) based on both the UNESCO and UNEP classification. Specifically, all periods with AI values ≤ 0.05mm are classified as hyper arid (HA) environment, which includes all other years except 1984-1985, 1989-1990, 1991-1992 and 1995-1996.

Furthermore, in descending order; 1996-1997, 1998-1999, 2000-20001, 2002-2003, 2010-2011 and 2011-2012 were the driest years among the hyper arid climate belt in this study with AIs lower than 0.01mm. The longest and severest drought/dry spell occurred within 1996 to 2003 with an AI range of 0.00 to 0.02mm. Similarly, among the arid (A) years, 1984-1985 (AI=0.08mm) followed by 1991-1992 (AI=0.08mm) were the least arid as their AI values were above those of the other years.

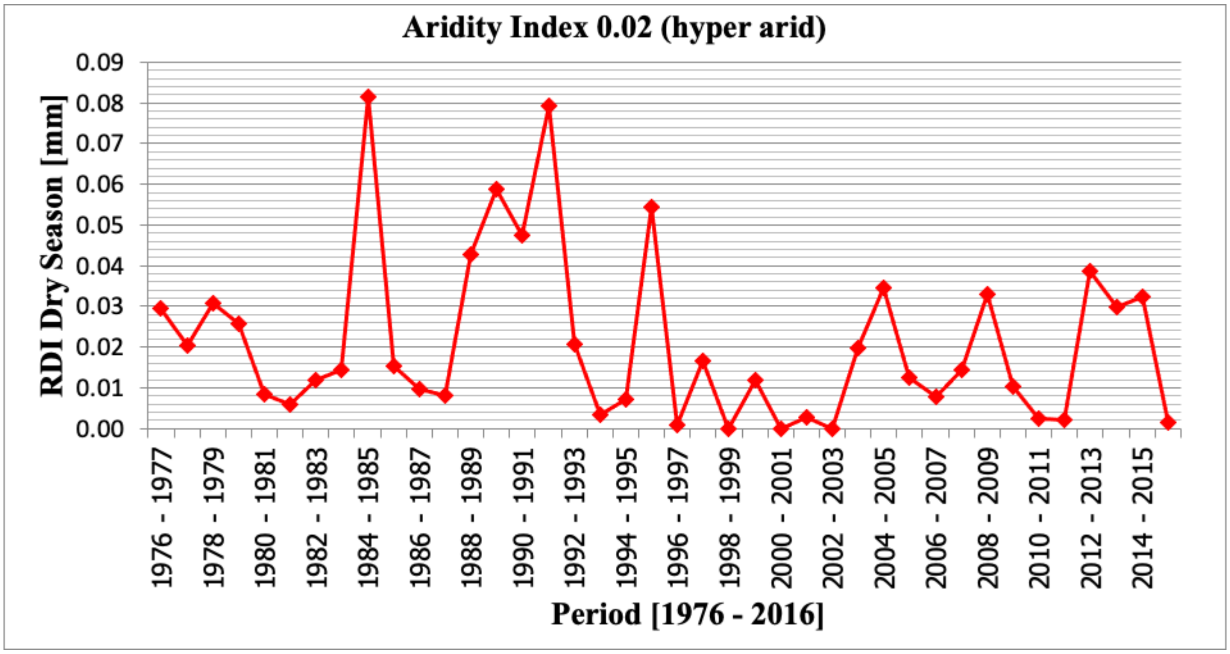
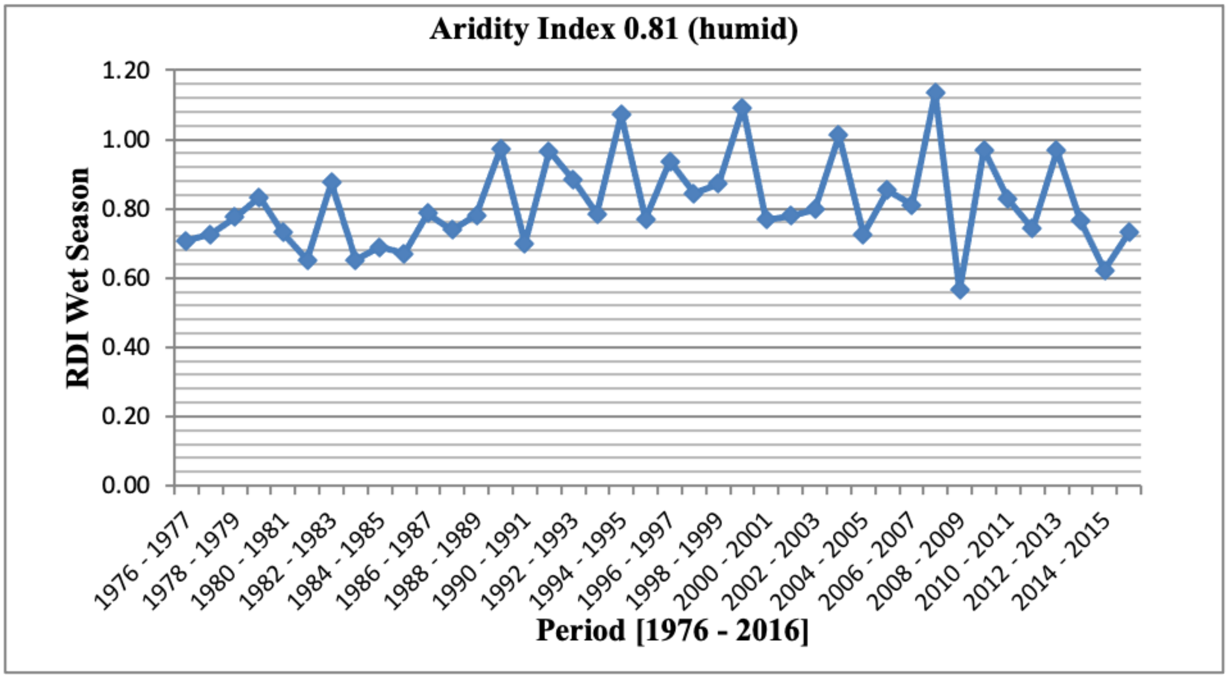


Figure 8: Dry season aridity

Wet Season

During the wet season, the climatic condition exhibited by the study area depicted a humid climate characteristic with an average AI of 0.81 as shown in Figure 9. However, the range of AI in the wet season is between 0.56 ≤AI ≤1.13mm, suggesting that each of the annual values of AI in the wet season exhibit a humid climate characteristic on the average. The most humid year meanwhile was 2007-2008 (AI=1.13mm) period followed by 1999-2000 (AI=1.09mm) and 1994-1995

(AI=1.07mm) whereas the least humid years were 2008-2009 (AI=0.56mm), followed by 2014-2015 (AI=62mm) and 1981-1982/1983-1984 (AI=0.65mm); all the others revolve around an AI of 0.65-1.00mm. It is evident from Figure 9, however, that irrespective of the declining rainfall in the study area, wet season portrays a humid climatic characteristic.



Discussion

The study assessed the seasonal rainfall characteristics in the Bawku area considering the increasing temperatures and declining rainfall in the arid regions. In this study, there was no year without rain though the amount received was low and declining especially during the dry season. The above finding aligns with Amekudzi et al. (2015), Abbam et al. (2018), Atiah et al. (2021) and Baffour-Ata et al., (2021), who have also reported low and declining amount of rainfall in the savannah. The authors outlined a number of reasons, among them being the effect of the alternating ITCZ and the El Nino. In addition, is the influence of the North east trade winds (harmattan winds) over Ghana within October to April. During this period, high rate of temperature coupled with high sunshine and low or no amount of rainfall characterises the area. The harmattan period brings to the region cool, dry and dusty winds to the region. The reverse occurs from April to September when the South west trade winds control the region with its attendant rainfall to influence the entire sub-region.

Declining rainfall distribution in the dry season is consistent with the findings of Dankwa et al. (2021) whose findings included declining rainfall in the Manga-Bawku area. The implication is that rainfall is persistently low and can significantly affect agricultural output. Climate models continue to project drying conditions in the Northern part of Ghana (Klutse et al., 2020) and the arid and semi-arid regions of the world (IPCC, 2021), it is very crucial to address such development retardation because of the rain-fed agricultural activities in the region.

Observing continuous dryness in the dry season and continuous wetness in the wet season suggests that residents may lack water during the dry period, water will be available in the wet season. The dry season is a period of prolong drought (lasting about seven months), which affects residents livelihood activities such as domestic chores, farm and animal husbandry as is also reported in the works of Kabo-Bah et al. (2016), Darko et al. (2018) and Incoom et al. (2020).

This notwithstanding, residents are better off with rain water for their daily activities during the wet season. This finding supports the report of Atiah et al. (2020; 2021) and Dankwa et al. (2021), where continuous rainfall was reported in the savannah belt at a decreasing rate. Jeil et al. (2020) also indicated that residents in the savannah area attest to having enough water for their livelihood activities during the wet season. Bawku rainfall is erratic in nature, whereas there was excessive rainfall in 2007-2008, drought occurred in 2008-2009 (Figure 6).

Sadick et al. (2014) found high evapotranspiration rate in the northern region when they studied the Bolgatanga irrigation scheme project. In the current study, the rate of PET was lower during the wet season but higher in the dry season. Similarly, the RDI result shows a higher rate of aridity in the dry season as against a lower rate in the wet season. The finding is in tandem with Limantol et al. (2016), who reported an increasing trend in temperature leading to rising levels of evapotranspiration in the Upper East Region. The study area has the character of a hyper-arid environment in the dry season and humid character the wet season (see Table 2).

This suggests that the study area experiences inadequate moisture in the dry season, whereas, in the wet season, there is some significant amount of moisture. The high evapotranspiration rate may be attributed to the high temperatures and low rainfall. The low temperatures and high atmospheric moisture in the air may be the reason for low values of aridity in the wet season. It is not surprising that the wet season mimics a humid environment in the savannah belt. Perhaps, the humid nature of the area during the wet season is because of the marginal increasing rainfall amount.

Since aridity is calculated using rainfall and PET, when rainfall is low and PET is high, as is in the dry season, aridity will be high. But when rainfall is high and PET is lower, like in the wet season, aridity will be reduced. The prolonged dryness characterised by high rate of evaporation and short-lived rainfall period is what causes the water scarcity in the area, which is evident in the drying up of rivers, dams, wells, and dug-outs in the area (Issahaku et al., 2016). This situation has serious implications on local communities' climate-sensitive livelihood sources such as agriculture. As noted by Dietz et al. (2004), since the region is already dry, water supply intervention is needed in order to help the residents to cope with the situation during the dry season.

Conclusion

The climate change analysis points to continuous rising of temperatures and declining rainfall in the entire Savannah region, there is the anticipation of the rise in evapotranspiration rate. The current study found declining but erratic rainfall patterns during both the wet and dry seasons. We also observed a continuous decline in dry season rainfall while wet season rainfall shows an insignificant rise in amount per annum. The study established a rising evapotranspiration rate in both seasons especially in the dry season, and high aridity characteristics to suggest water deficiency in the area. The study area is undergoing continuous dryness. The high aridity has long-lasting effects on the livelihoods of the residents in this region as rain-fed agriculturalists. Practically, the results of this study will beef up residents' knowledge and awareness to increase their individual efforts at water resource management towards their agricultural activities especially in the dry season. Again, residents will learn of this and focus on growing crops that are resistant to drought during the long dry season and in the process enhance climate-smart agriculture. Moreover, residents may learn of these results to explore other alternative livelihood options to their agricultural activities. We suggest that the ministry of agriculture in collaboration with non-governmental organisations and civil society organisations prioritise the construction of mechanised dams or wells and expand irrigation projects in the area to reduce the climate change effects on the livelihood of the residents especially in the dry season. Furthermore, development partners may target alternative livelihood activities in the study area to ease residents stress of agriculture dependency amidst the global climate change as the area.

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