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Rainfall Dynamics in the Coastal Area of Ilaje, Ondo State, Nigeria (1991 – 2020)

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Abstract: Climate change and variability have become global concerns due to their wide-ranging effects on the environment, human health, agriculture, and water resources. Among the key indicators of climate change are changes in rainfall patterns. These changes are not only global but are also evident at the regional and local levels. Ondo State, located in the southwestern part of Nigeria, has a stretch of coastal land along the Atlantic Ocean. This region is particularly vulnerable to the effects of climate change due to its geographical location. Changes in rainfall and patterns in this area can have serious implications for agriculture, fishing, water availability, and general livelihood. Communities in coastal Ondo State rely heavily on rainfall for crop cultivation and productive farming seasons. Unpredictable weather conditions could therefore threaten food security and economic stability in the region. Previous studies, have observed variations in rainfall and temperature across Ondo State, highlighting signs of climate variability. However, there is still a need for more localized studies focusing specifically on the coastal areas, which may experience different climate dynamics compared to the inland parts of the state. The study area, Ilaje located in Ondo state, has a stretch of coastal land along the Atlantic Ocean. Changes in the rainfall pattern in the area can have serious implications on agriculture, fishing, and general livelihood. These changes affect crop yields, fishing patterns, access to clean water, and even the overall health of the environment. By identifying and analyzing long-term trends in these climate variables, this research can help provide useful information for farmers, fishermen, and other residents of the area who depend on predictable weather for their daily activities. The study aims to investigate the long-term changes in rainfall patterns over the coastal areas of Ondo State, to focus more specifically on the coastal region, which may experience different or more intense climate dynamics due to its location along the Atlantic coastline. The objectives of the study are to; derived equations for calculating the monthly rainfall, annual rainfall, deviations and standardized anomalies for the study area, examine the pentad and decadal changes in rainfall pattern over Ilaje, identify the long-term changes in the monthly and annual rainfall pattern, determine the deviations in the Monthly and Annual rainfall over Ilaje, determine the anomalies and standardized anomalies of rainfall over Ilaje for the study period. In this research, thirty years (1991-2020) daily historical rainfall data of Ilaje were utilized, governing equations derived, R and Python programs were used to analyzed the data and obtained the means, deviations, standard deviations, and standardized anomalies. The results were presented using charts and graphs in order to visually represent rainfall pattern and trends. Results showed that highest positive deviation from normal was 546.5mm (1994). Highest negative deviation of -39.2mm, was observed in 2015. On monthly basis, highest normal rainfall of 256.7mm (September),231.6mm (October), and 205.9mm (June), were identified. Lowest monthly normal rainfalls were observed in January (10.7mm), December (10.9mm) and February (30.0mm). Highest monthly rainfall of 508.3mm occurred in July, 1994. Change analysis showed 1991-1995 pentad had the highest mean rainfall of 1737.7mm, and 2016-2020 pentad had the lowest mean rainfall of 1400.9mm. It was generally observed that from 1991-1995, rainfall continued to decrease, but increased again in 2010, thereafter, it continued its downward trend. The decadal changes showed a downward trend as mean rainfall of 1645.7mm in the 1991-2000 decadal decreased to 1534.3mm (2001-2010) and further decreased to 1430.9mm in the 2011-2020 decade. By using statistical techniques to identify trends and variations, the study provides a better understanding of the local climate situation. The findings can help government agencies, policymakers, and communities make informed decisions on adaptation strategies and sustainable resource planning in the face of climate change.

Keywords: *Rainfall Anomalies, Deviation, Normal, Pentad, Decadal, Rainfall Pattern.*

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I. INTRODUCTION

Climate variability, especially in the context of rainfall has increasingly become a subject of academic interest due to its implications for agriculture, water supply, and ecosystem stability. In the coastal areas of Ondo State, understanding the patterns and shifts in climate elements is crucial, considering the region's dependence on seasonal rainfall and moderate temperatures for food production and livelihood. Ondo State, located in the southwestern part of Nigeria, has a stretch of coastal land along the Atlantic Ocean. This region is particularly vulnerable to the effects of climate change due to its geographical location. Changes in rainfall pattern in this area can have serious implications for agriculture, fishing, water availability, and general livelihood. Communities in coastal Ondo State rely heavily on rainfall for crop cultivation and productive farming seasons. Unpredictable weather conditions could therefore threaten food security and economic stability in the region. Previous studies, such as that by Faweya *et al.* (2023), have observed variations in rainfall and temperature across Ondo State, highlighting signs of climate variability. However, there is still a need for more localized studies focusing specifically on the coastal areas, which may experience different climate dynamics compared to the inland parts of the state.

Over the years, the world has witnessed significant changes in climate, and these changes are no longer distant or abstract, they are being felt in our local communities, farms, and daily lives. From rising temperatures to unpredictable rainfall patterns, the signs are clear that climate conditions are shifting, and the effects are becoming harder to ignore. This shift is not just a global issue but also a local one, especially in places like Ondo State, Nigeria. Ondo State lies in the southwestern part of Nigeria and includes a stretch of coastline that faces the Atlantic Ocean. These coastal areas are naturally more exposed to climate-related issues like sea-level rise, flooding, saltwater intrusion, and extreme weather events. However, beyond these physical risks, the people who live in these communities many of whom depend on farming, fishing, and nature-based activities are also directly affected by slight changes in rainfall and temperature. Farmers in these areas, for example, depend on the rainy season to plant and harvest their crops. If the rains come too early, too late, or not at all, it disrupts their entire season. While studies like the one by Faweya*et al.* (2023) have highlighted general climate trends in Ondo State, there's still a gap when it comes to understanding exactly how these changes are playing out in the coastal zones specifically. Coastal environments have their own unique climate behavior and might not follow the same trends as inland areas. Results from this study could go a long way in helping communities, government agencies, and policy makers make better decisions; whether it's planning for irrigation, adjusting farming calendars, or setting up early warning systems for extreme weather. In a time where climate uncertainty is growing, having reliable, localized information is more important than ever.

II. REVIEW OF LITERATURE

Climate change and variability have become global concerns due to their wide-ranging effects on the environment, human health, agriculture, and water resources. Among the key indicators of climate change are changes in rainfall patterns. These changes are not only global but are also evident at the regional and local levels. Faweya *et. al*. (2023) provided foundational insight into rainfall and temperature patterns in Ondo State. Their research basically used time series model and standardized anomaly to assess the distribution of rainfall. One of the key findings of their study was that rainfall patterns in Ondo State had become increasingly irregular. Their study revealed an observable trend of increasing temperature and unpredictable rainfall distribution, emphasizing the necessity of analyzing long-term climate changes. This aligns with broader findings by Akinsanola and Ogunjobi (2014), who examined nationwide temperature and rainfall variability and concluded that southwestern Nigeria, including Ondo, is experiencing notable climatic shifts. Akinsanola and Ogunjobi (2014) conducted a detailed study on the variability of rainfall and temperature across Nigeria, using long-term meteorological data. Their research showed a clear increasing trend in temperature across the country, while rainfall patterns were more irregular and region-specific. Some areas, especially in the North, experienced declining rainfall, while others in the South experienced slight increase. Their research pointed out the potential risks to agriculture, water resources, and human health, if these patterns continued. The study further provided a nationwide perspective on climate change in Nigeria and helps highlight the need for local adaptation strategies. Ogundahunsi *et al*. (2022), using the Walter (1967) method as modified by Olaniran (1998), examined climate variability in Ondo State, Nigeria, by analyzing rainfall features, such as; onset, cessation and duration of the rainy season. The research revealed significant shifts in these parameters, indicating increased rainfall irregularities over the years. The findings highlight the implications for agriculture and call for adaptive strategies in farming practices and planning. Akiyemi *et al* (2013), worked with long-term rainfall data using records that spanned several years to study both annual and monthly rainfall trends. The study by Akinyemi *et al* (2013) focused on understanding how rainfall behaves over time in Ekiti State, a region located within Nigeria's southwest zone. Since agriculture is a major livelihood in this part of the country, any variation in rainfall patterns can have a direct impact on farming activities, food production, and even economic stability. They mainly used descriptive statistics and trend analysis to identify patterns, fluctuations, and possible shifts in rainfall distribution over time. One of the main findings from their research was that while total annual rainfall has not drastically declined, the distribution of rainfall across months has become more uneven. This means some months receive either too much or too little rainfall. Agbonaye and Okonofua (2020) applied both statistical trend analysis and spatial mapping tools to study how climate

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change is playing out specifically in Nigeria's coastal regions areas that are naturally more vulnerable to environmental changes, due to their low-lying geography and proximity to the ocean. The research was considered timely, especially considering the increasing concerns over sea-level rise, coastal flooding, and shifting weather patterns in Nigeria's southern belt. The researchers focus on both trends over time and spatial variability, meaning the researchers did not just look at how climate variables like rainfall and temperature have changed, but also how those changes differ from one coastal area to another. This is important because it helps avoid generalizations and provides location-specific insights that are useful for planning and decision-making. Edokpa (2020), using trend analysis, Mann Kendall and Sen's slope, investigated the variability in long term trend of rainfall and temperature over southern Nigeria. The study identifies two distinct climatological time period over southern Nigeria. Results showed no significant increasing/decreasing trend in monthly, seasonal and annual rainfall. Odjugo (2005) analyzed rainfall patterns across Nigeria, focusing on how they have changed over time and what that means for the environment and society. The study used historical rainfall data from various parts of the country and applied descriptive statistics and trend analysis to uncover shifts in rainfall amounts and distribution. One of the key findings of the study was the fact that rainfall patterns in Nigeria have become increasingly irregular, especially since the late 1960s. It was further observed that while the southern part of the country sometimes experienced increased rainfall, the northern region has been drying up, leading to more frequent droughts. This north-south rainfall divide has significant implications for agriculture, which depends heavily on stable seasonal rainfall. The study also links changes in rainfall patterns to broader climate change effects, noting that extreme weather events, such as flooding and dry spells, have become more common. Odjugo (2005) concluded that Nigeria is already experiencing climate variability, and there is a need for proactive adaptation strategies, particularly in agriculture and water resource management. Bello (1996), investigated the increasing delay in the onset of the rainy season across Nigeria's coastal regions. The research utilized historical meteorological data from Lagos and Port Harcourt stations, and employed statistical analysis to identify long-term trends in rainfall patterns. The study links the late onset of rains to climatic factors such as shifts in the Inter-Tropical Discontinuity (ITD) and sea surface temperature anomalies. Findings indicate a consistent delay in the onset of the rainy season over the years, posing serious implications for agricultural planning and food security in rain-fed farming systems. The research underscores the importance of adaptive strategies, such as early warning systems and climate-resilient farming practices, to mitigate the risks associated with changing rainfall patterns in coastal Nigeria. Nigeria, like many developing countries, is increasingly experiencing the effects of climate change, ranging from irregular rainfall patterns to rising temperatures and extreme weather events. These changes have been observed in several regions and pose challenges for agriculture, water supply, and infrastructure (Adefolalu, 2007). The knowledge of climate variability on temporal and spatial scale, is important to understand the nature of different climate systems and their impact on the environment and society (Oguntunde *et al.* 2012). As rightly asserted by Eludoyin *et al.* (2017), farmers need help adapting to these changes to keep their crops and livelihoods safe. Audu et.al. (2023) evaluated daily empirical rainfall data covering 1979-2020 as a guide to agriculture and water resources management in Ondo, State, Nigeria, using observed rainfall data obtained from the Nigerian Meteorological Agency, Abuja. Results of their analysis showed that most areas in Ondo state observed rainfall throughout the year with March (86.4 mm) as the rainfall onset and November (56.4 mm) as the cessation. They further noted that double maximum rainfall occurred in July (254.2 mm) and September (282.1 mm) with the climatological mean of 1752.2mm. Monthly rainfall deviations were mostly negative in Igbokoda and Ilaje Local Gpvernment Areas, indicating decrease in monthly rainfall totals, while Okitipupa and Oka-Akoko showed positive monthly rainfall deviations from the climatological mean, indicating increase in monthly rainfall. Coastal areas tend to experience unique climate behavior due to the influence of large water bodies. They are more likely to be affected by sea-level rise, coastal erosion, and changes in humidity and precipitation. According to Olaniran and Summer (2016), coastal zones in Nigeria are witnessing increased rainfall intensity and higher average temperatures, which can be attributed to both global warming and localized environmental changes. In Ondo State, coastal communities such as Ilaje and Ese-Odo are particularly sensitive to climate fluctuations. Yet, most researches in the state have either taken a general or focused on inland areas. This gap leaves questions unanswered about how specific climatic elements are evolving in these coastal zones. Coastal areas, like those found in Ondo State, have their own unique weather and climate patterns. These areas lie close to large bodies of water, the Atlantic Ocean, which plays a big role in shaping how the climate behaves. On a continental level, Thompson *et al.* (2010) emphasized the connection between climate change and food security in sub-Saharan Africa. Their systematic review showed how shifts in climate patterns directly influence agricultural productivity, a concern mirrored in Salau *et al.* (2016), who analyzed the impact of temperature and rainfall changes on banana production in Ondo State, confirming that these environmental variables are affecting crop yields. Ogunrayi et.al. (2025) examines flood risk in Ilaje local government area in order to develop sustainable strategies for ecosystem conservation using satellite-derived data within a multicriteria decision-making framework. Their analysis focused on variables influencing flooding, such as land surface temperature, topographic wetness index and rainfall. Results of their research highlighted the urgent need for targeted mitigation strategies to protect ecosystems and communities. Together, these studies offer a robust conceptual framework for identifying and understanding long-term changes in rainfall and temperature. They collectively reinforce the relevance of this research, which seeks to assess climatic trends specific to the coastal parts of Ondo State and contribute meaningfully to planning, policy-making, and adaptation strategies**.** The findings of this research would not only be relevant for academics, but also for policymakers, environmental agencies, and local communities who need to start thinking about how to adapt

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to these ongoing changes. The study is further expected to strengthens the calls for more localized climate research and supports the broader narrative that climate change is not just a global issue, but deeply local too.

➢ *The Study Area*

The study focused on the coastal parts of Ondo State, particularly communities in Ilaje Local Government Area (Headquartered in Igbokoda) of Ondo State, Nigeria. These areas are situated along the coastline bordering the Atlantic Ocean and are part of the Niger Delta region. The communities and are known for their fishing and farming activities. Geographically, they lie approximately between latitudes 5°50′N to 6°30′N and longitudes 4°30′E to 5°00′E. The area is heavily influenced by both marine and tropical climatic conditions, which make them prone to high levels of rainfall and relatively stable temperatures throughout the year. Rainfall in this region typically begins around March and lasts till October, with a noticeable peak between June and September. The average annual rainfall ranges from about 2,000mm to 3,000mm. Temperatures are generally warm and consistent, with monthly averages, ranging between 25°C and 31°C. Figure 1a showed the Map of Africa, with Nigeria and Ondo State incept. Figure 1b depict the Map of Ilaje Local Government Area (red boundary line) showing communities such as Igbokoda, Ugbonla and Molume. Ilaje land is bounded to the North by Ikale and Ijebu territories, to the East by the Itsekiri and Arogbo Ijaw, and to the South by the Atlantic Ocean. Their history is deeply defined by maritime adaptation, unique geopolitical structures, and rich cultural traditions. The territory is traditionally divided into four geo-political kingdoms; Ugbo Kingdom, Mahin Kingdom, Aheri Kingdom and Etikan Kingdom. The Ilaje are a prominent coastal subgroup of the Yoruba, primarily residing in the Ilaje Local Government Area with headquarter in Igbokoda, Ondo State, Nigeria. Their mastery of the intricate creeks and waterways made them exceptional fishermen, boat builders, and traders, linking them with surrounding coastal tribes.

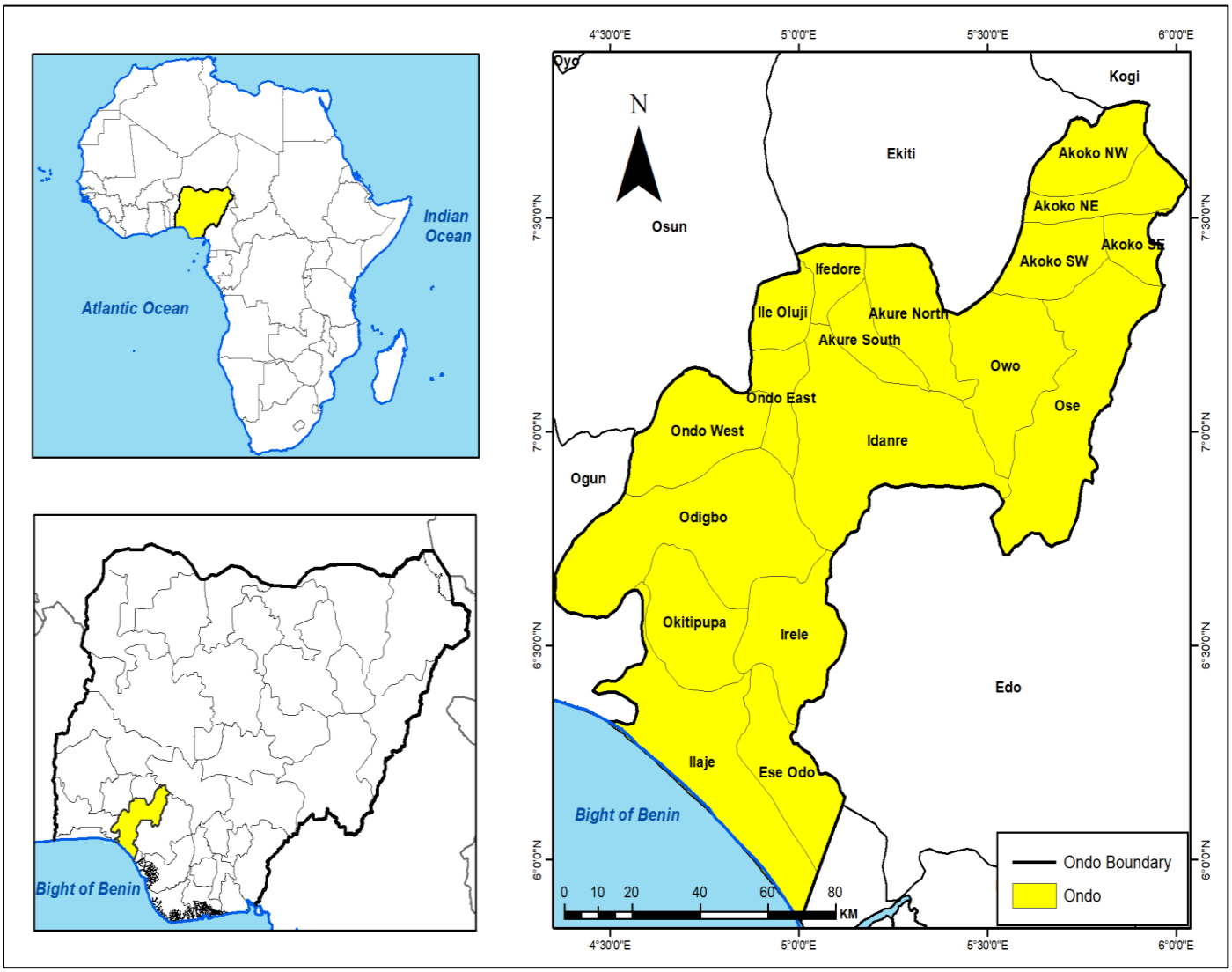


Fig 1a: Map of Ilaje Local Government Area (Red Boundary Lines).
Source: https://www.google.com. Retrieved on 18/05/2026

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Fig 1b: Map of Ilaje Local Government Area (Red Boundary Lines).
Source: https://www.google.com. Retrieved on 18/05/2026

III. METHODOLOGY

➢ *Data Collection*

The data used for this study were observed (secondary) daily rainfall data obtained from a Meteorological Station in Igbokoda, the Headquarters of Ilaje Local Government Area. The daily rainfall data covered a period of 30 years (1991-2020), which is the standard range used to study climate trends. The dataset was considered adequate for detecting long-term variability and trend in rainfall distribution.

➢ *Statistical Methods Used*

To analyze the data, several statistical techniques (Test Statistic) such as; the Monthly Mean, Annual Mean, Climatological Mean, Standard Deviation, Standardized Anomalies, Pentad Changes (Changes at five years intervals), Decadal changes (Changes at 10 years intervals) and Percentage Rainfall Changes. were derived and applied in other to assess the dynamics of rainfall distribution and patterns in the study area. The test statistic models were derived based on the categories of the data (daily, monthly, annual and climatological). The derived statistic (formulae) used are presented in Table 1, and numbered 1– 8.

Table 1 Derived Relations

S/N	Test Statistic	Derived Statistic
1.	Monthly RR Mean	$_{m_j}\bar{R} = \frac{\sum_{i=1}^{n} {}_{m_j}R_i}{n}$
2.	Annual RR Mean	$\bar{R}_y = \frac{\sum {}_{m_j}R_i}{n}$
3.	Climatological Mean	$\bar{\bar{R}} = \frac{\sum R_y}{n}$
4.	Standard Deviation	$_{m_j}Dev = {}_{m_j}R_i - {}_{m_j}\bar{R}_i$
5.	Standardize	$_{m_j}Std = \frac{{}_{m_j}R_i - {}_{m_j}\bar{R}}{\sigma_{m_j}}$
6.	Pentad Changes	$\Delta\, {}_aR_{pt} = \frac{\sum_{i=1}^{n=5} {}_aR_i}{n}$
7.	Decadal Changes	$\Delta\, {}_aR_{dk} = \frac{\sum_{i=1}^{n=10} {}_aR_i}{n}$
8.	Percentage Rainfall Changes	$\%R = \frac{{}_{m_j}R_i}{R_i} \times 100$

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From the derived Statistic in Table 1; n = number of years, m = months, $\bar{R}$ = Mean of rainfall, $\bar{\bar{R}}$ = Climatological Mean, $\bar{R}_i$=monthly rainfall Mean, ${}_mR$ = Monthly rainfall, m_j = month of each year, R_i = Rainfall for year consideration, and ${}_{m_j}R_i$ = monthly rainfall for each year, Δ = Change, $\Delta\,{}_aR_{pt}$ = Pentad Changes, $\Delta\,{}_aR_{dk}$ = Decadal Changes, $\%R$ = Percentage Rainfall Changes i = 1, 2, ..., 31 (days); j = 1, 2, …, 12(month); y = 1, 2, …, 30 (Years).

Data analysis was carried out using Microsoft Excel for descriptive statistics and graphical plots. The methods used in this study are based on what has worked in previous research. For example, Akinyemi*et al*. (2013) used descriptive analysis and regression when studying rainfall patterns in Ekiti State. These methods are appropriate because they help in identifying long-term changes, which is the core of this study.

IV. RESULTS AND DISCUSSION

➢ *Standardized Monthly Rainfall*

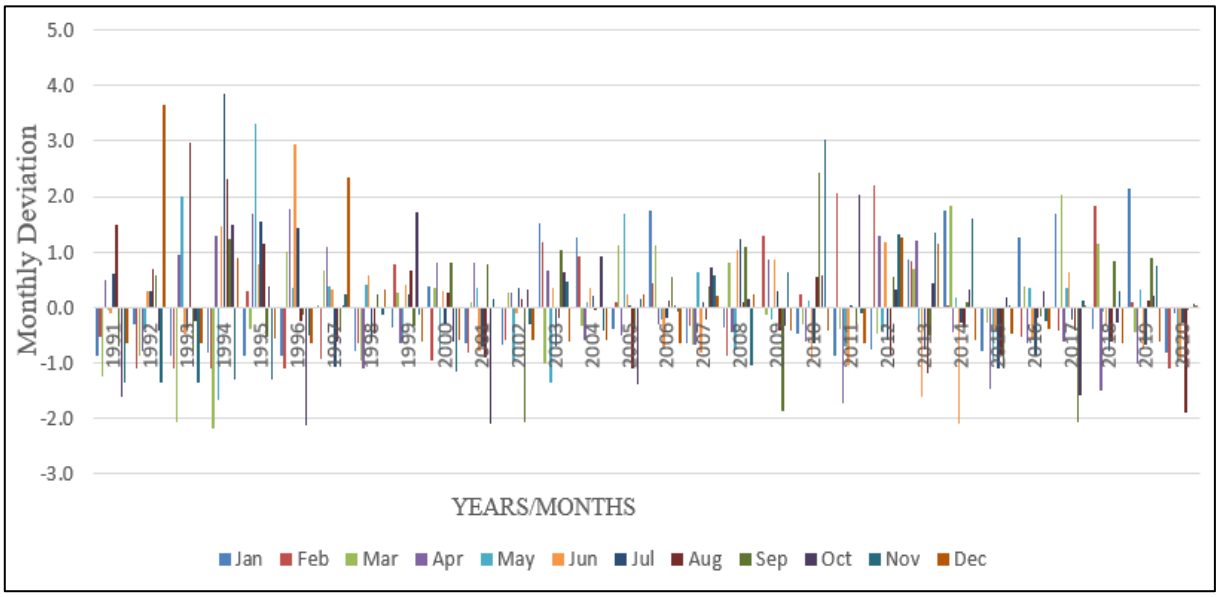


Fig 2 Standardized Monthly Rainfall Anomalies Over Ilaje for Period 1991-2020

The standardized monthly rainfall anomalies table and chart showed high fluctuations in rainfall throughout the study period. Although all months experienced variability, extreme deviations were more pronounced in the rainy season months (June–September). This suggests that while the rainy season still dominates, its intensity and regularity have been disrupted, with some years recording unusually high peaks and others significant deficits. The monthly anomaly analysis (1991–2020) provides insights into intra-annual variations. During the late 1990s, many core rainy season months (April–July and September) recorded strong positive deviations, indicating wetter-than-normal conditions and a well-established double rainfall peak, typical of southern Nigeria. By the 2000s, rainfall anomalies began clustering around the mean, with fewer positive spikes and more frequent small negatives. The August dry spell became more pronounced, while the late-season peak in September–October weakened. From the 2010s onward, negative deviations dominated, particularly in the onset months (March–April) and retreat months (September–October). This suggests a shorter rainy season, delayed onset, earlier cessation, and overall reduction in rainfall. The monthly results thus, point to both a weaker rainy season and a lengthy dry season, with significant implications for agriculture and water resources in the region.

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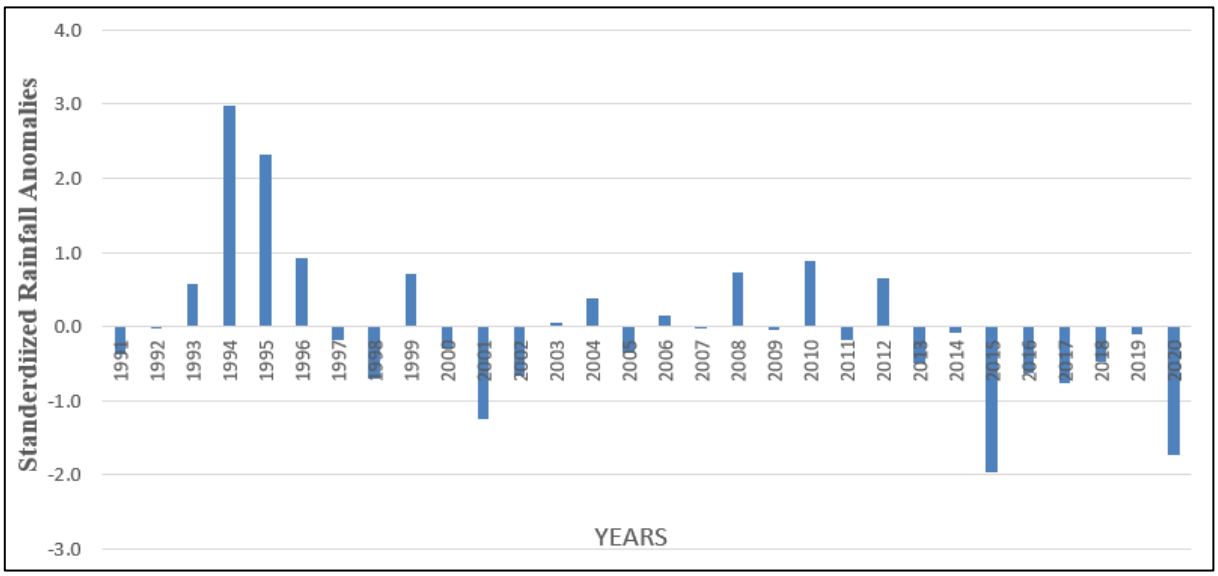


Fig 3 Standardized Rainfall Anomalies Over Ilaje for the Period 1991-2020

The Standardized anomalies analysis provides insights into the inter-annual variability of rainfall in Ilaje. Results showed that the period under study was marked by alternating wet and dry years, with some years experiencing extreme anomalies. The highest positive deviation was recorded in the early 1990s. In particular, 1994 (3.0) and 1995(2.3) stood out with Standardized Deviation values above +2.0, indicating exceptionally wet years. These years represent periods of abundant rainfall, which could have supported agricultural activities and replenished water resources in the coastal region. In contrast, the lowest negative deviations were observed in the early 2000s. Specifically, 2015 (-2.0) and 2020(-1.7) recorded significant Standardized deviation values, reflecting extremely dry years. These years signify severe rainfall shortages that could have adversely affected farming, fishing, and other rainfall-dependent livelihoods in Ilaje. The years 1997–1998 also experienced moderate negative deviations, showing another spell of reduced rainfall. Between 1997 and 2000, the deviations fluctuated around the mean, suggesting relatively stable but still variable conditions. However, after 2001, negative anomalies became more persistent, showing a gradual shift towards drier conditions in the coastal area.

➢ *Decadal Changes in Rainfall*

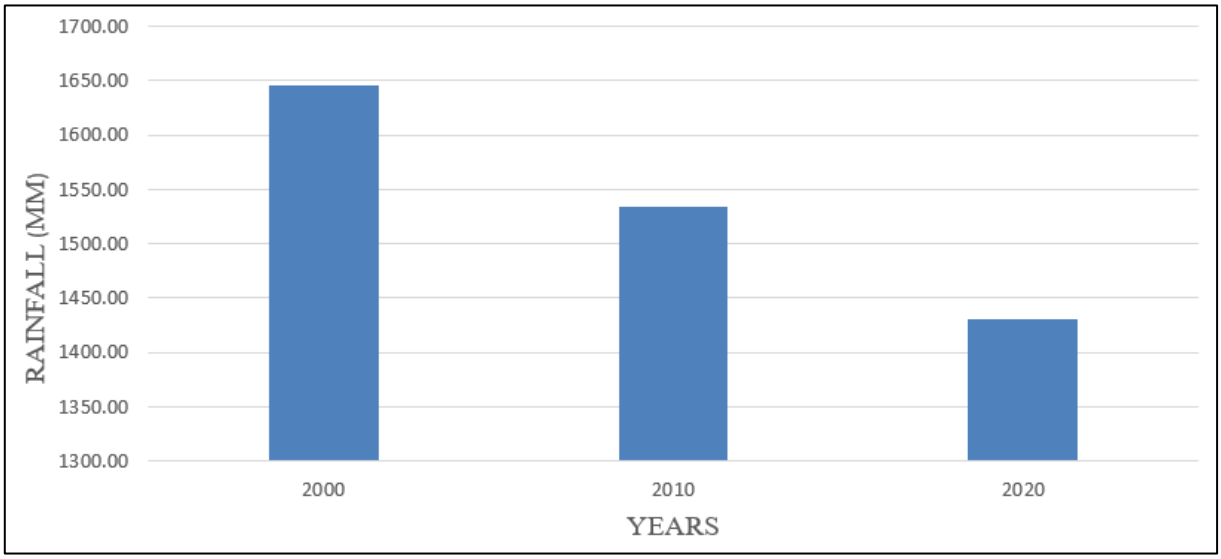


Fig 4 Decadal Changes in Rainfall Over Ilaje for the Period 1991-2020

The decadal rainfall analysis reveals a clear picture of long-term changes in rainfall distribution in Ilaje, Ondo State. By grouping rainfall into ten-year intervals, short-term fluctuations are smoothed out, allowing us to focus on broader climatic patterns.

- (2000–2009): Peak Rainfall Decade. The 2000s recorded the highest rainfall average within the study area. It stands out as the wettest decade, with average rainfall of 1645.67mm. This decade benefitted from several above-average years of rainfall that raised the mean rainfall. It

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represents the peak of rainfall availability in the study area.

- (2010–2019): The Decline Sets In. By the year 2010, rainfall had dropped to about 1534,27mm, marking a clear reduction from the 2000s. This decade is characterized by a gradual but persistent decline in rainfall.
- (2020–2022): Lowest Average Rainfall. Although the 2020s are still ongoing, the trend so far shows a further decline to about 1430.87mm. This is the lowest decadal mean rainfall recorded in the study area, confirming that the area is entering a much drier climatic phase. If this trend persists for the rest of the decade, Ilaje may face record-low rainfall conditions compared to previous decades.

➢ *Pentad Mean Changes*

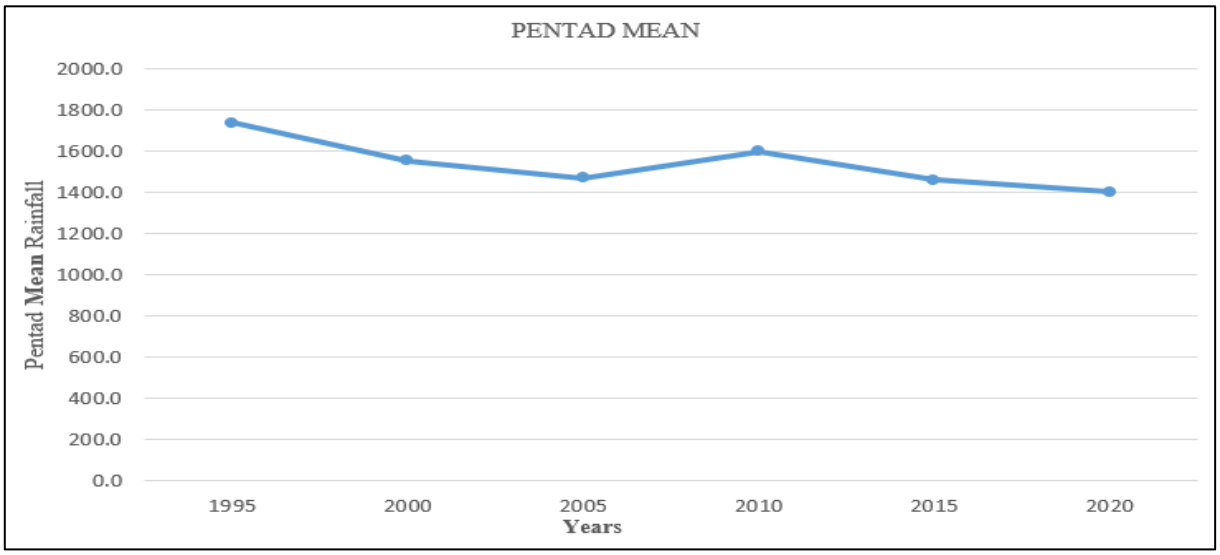


Fig 5 Pentad Mean Changes Over Ilaje for the Period 1991-2020

The pentad mean rainfall (1995–2020) confirms decline in rainfall pattern in Ilaje. The graph indicates that rainfall has been decreasing across the periods. Although, there was a slight recovery around 2010, the overall direction remains downward. This decline suggests a long-term reduction in rainfall. The Pentad Mean Rainfall chart provides a clearer long-term perspective by smoothing annual fluctuations into five-year averages. The trend indicates a consistent decline in rainfall over the study period, highlighting a possible long-term shift in rainfall pattern. In the early 1990s (around the 1990–1995) pentad, rainfall totals were relatively high, averaging close to 1800mm. This represents one of the wettest periods in the record. However, a notable decline followed immediately after, with rainfall decreasing to 1553.6mm in the early 2000s pentad.A brief recovery was observed around the 2010 pentad, when rainfall totals increased again to about 1599.6mm. Despite this short-term increase, the overall trend did not sustain, as rainfall dropped significantly afterwards in year 2015–2020 pentad, where the mean annual rainfall had reduced to nearly 1460.9mm-1400.9mm, representing one of the lowest averages across the entire period of study. The consistent downward trend, apart from the temporary rise around 2010, suggests that rainfall in Ilaje is undergoing a long-term reduction.

➢ *Annual Rainfall Variation*

The annual rainfall distribution chart reveals a general downward trend in rainfall totals over the 30-year period. This indicates a long-term decline in rainfall availability in Ilaje.

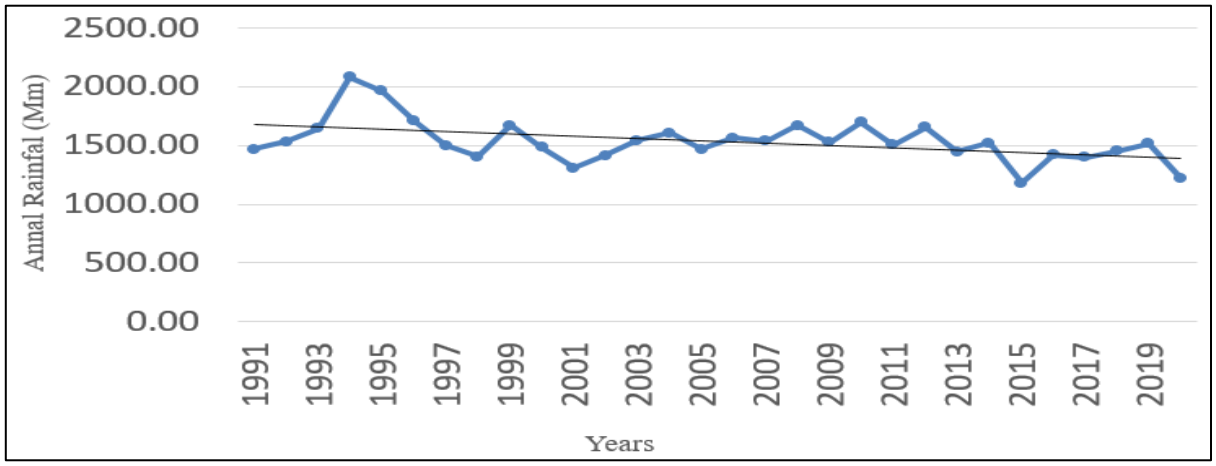


Fig 6 Annual Rainfall Variation Over Ilaje for the Period 1991-2020

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The analysis of annual rainfall variation over Ilaje between 1991 and 2020 reveals a pattern of fluctuations that indicates both short-term variability and long-term changes. Results showed that rainfall peaked in 1994 with about 2083.4 mm, after which there was a noticeable decline. This point to a long-term downward trend in annual rainfall totals. The general trend shows a downward shift from 1994 onward, indicating a long-term decline in rainfall. The variability in annual rainfall also underscores the area's exposure to extremes. High rainfall years, such as those recorded in the 1994 increase the risk of flooding, erosion, and coastal inundation, while drier years in the 2000s which dropped rapidly in year 2015 (1177.7mm) contribute to water scarcity, crop failure, and reduced fish productivity. This irregularity makes planning for water resources and agricultural activities particularly challenging in Ilaje.

➢ *Monthly Normal Rainfall Distribution*

The monthly normal table represents the long-term average rainfall per month. During the dry season (November to March), rainfall is generally low, with the driest months being December and January (less than 50mm).

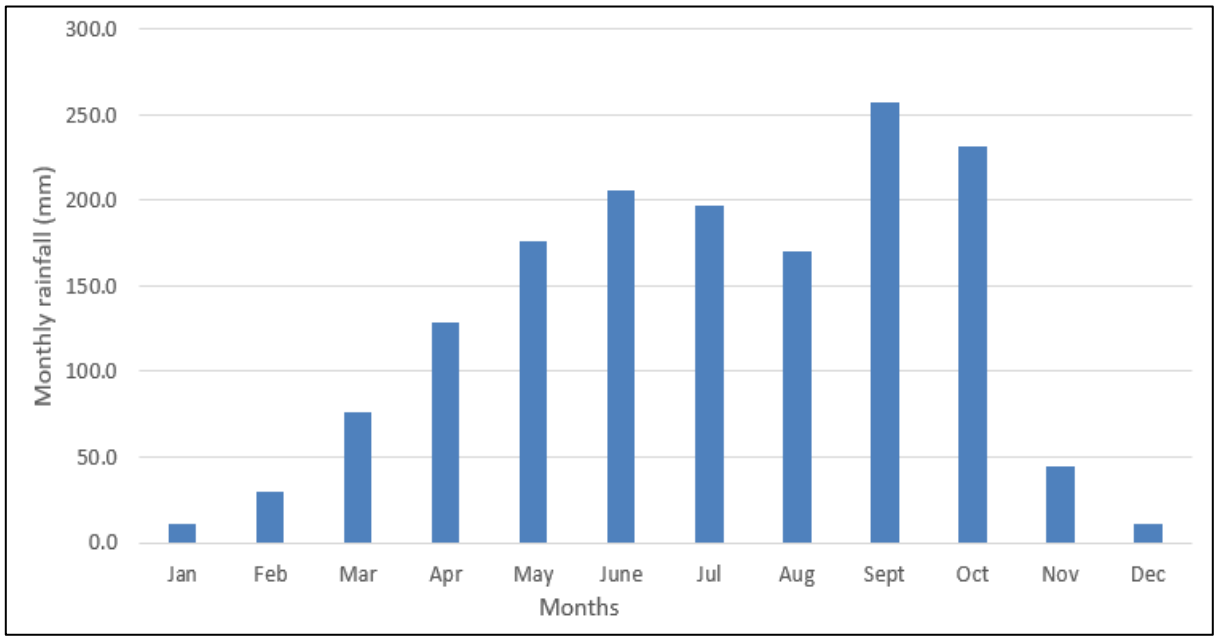


Fig 7 Monthly Normal Rainfall Distribution OverIlaje

The monthly normal chart shows the average rainfall distribution across the 12 months of the year, giving a steady state of monthly rainfall cycle in Ilaje.

- Onset of Rainfall (February–April): Rainfall begins gradually from February, with a small amount. By March and April, rainfall increases significantly, marking the onset of the rainy season. This early onset is critical for farmers in llaje, as it signals the time for land preparation and planting of crops.
- Peak Rainfall Period (May–October): From May onward, rainfall intensifies, with values exceeding 150mm monthly. The highest rainfall is recorded in September (256.7mm), closely followed by October (231.6mm). This long period represents the core rainy season, which supports agriculture, fishing activities, and replenishment of water bodies. However, this is also the flood-prone season for Ilaje, given its coastal terrain.
- Mid-season Decline (July–August "August Break"): Around July and August, rainfall shows a slight dip compared to June and September, this pattern is known as the "August Break", a common feature of West African rainfall, where rainfall reduces temporarily before picking up again. This short dry spell can affect crop development if it coincides with sensitive growth stages, though it also provides a brief window for drying and harvesting.
- Withdrawal of Rainfall (November–December: By November, rainfall drops sharply to (44.9mm, and by December (10.9mm), it is at its lowest. This marks the onset of the dry season, when most agricultural activities rely on irrigation.

➢ *Highest Monthly Rainfall Pattern*

The highest rainfall pattern indicates that years 1993, 1994 and 2010 are the wettest years in Ilaje, for the 30 years period of study.

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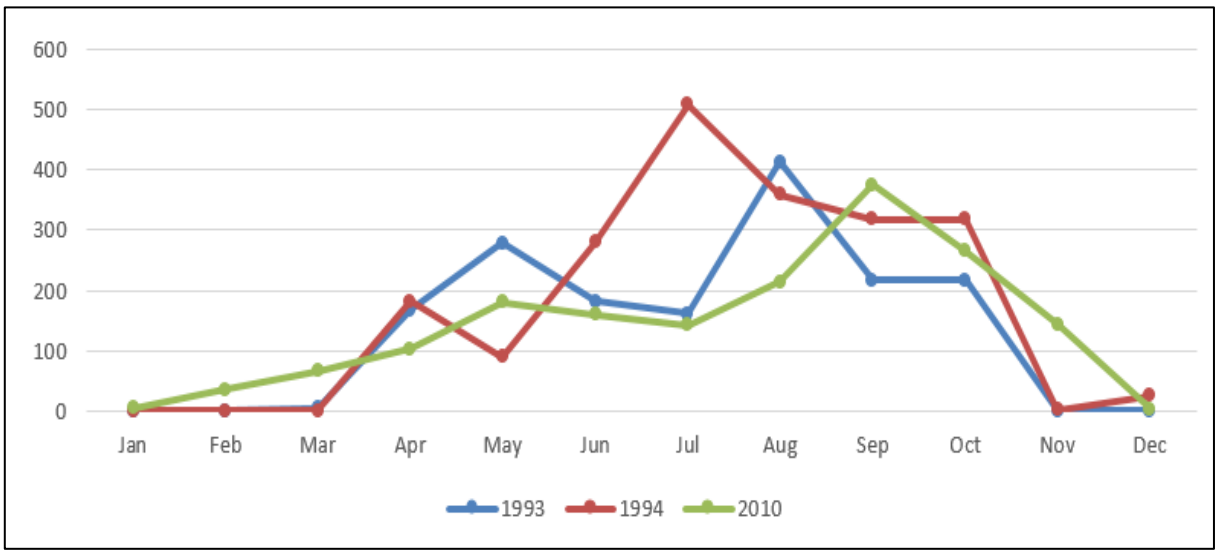


Fig 8 Highest Monthly Rainfall Pattern Over Ilaje for the Period 1991-2020

The rainfall pattern across the selected years (1993, 1994, and 2010) showed that the onset of rainfall typically begins around March–April, gradually intensifying towards the mid-year. The wettest period occurs in July, August and September, which corresponds to the peak of the rainy season in the coastal area. Notably, the year 1994 recorded an exceptional rainfall peakvalueof508.3mmin July, which is significantly higher than rainfall values of 1993 and 2010, which shows a moderate and consistent peak in rainfall. After October, rainfall declines rapidly toward the dry months (November–December). This suggests that while the seasonal cycle of rainfall has remained fairly stable, the magnitude of rainfall events differs substantially across years.

V. CONCLUSION AND RECOMMENDATIONS

➢ *Conclusions*

This study analyzed thirty years (1991-2020) of daily historical rainfall data of Ilaje, Ondo State, a coastal area along the Atlantic Ocean. Results revealed significant variations and a general declining trend in rainfall over the decades. The highest annual rainfall occurred in 1994, while the lowest was recorded in 2015. Monthly rainfall data also showed extreme values, indicating increased rainfall variability. The analysis of rainfall deviations and standardized anomalies showed that rainfall patterns in Ilaje have become less stable over time. Pentad and decadal assessments further confirmed that the average rainfall has been decreasing, particularly from the 1991–1995 to the 2016–2020 periods. This downward trend aligns with the IPCC (2014) report, which states that rainfall is likely to decrease while anomalies may increase across Sub-Saharan Africa. These findin gs highlight the growing impact of climate change on the Ilaje coastal region and point to the urgent need for climate adaptation strategies in crops planting, fishing, and local water resource planning.

➢ *Recommendations for Future Studies*

Rainfall dynamics directly impact local fish breeding and catch volumes, hence the needs to empower coastal residents with diversified economic skills (e.g., modern aquaculture, crop adaptation) to reduce adverse effects of the anomalies of weather and climate. The decrease in rainfall over the years means that farmers and fishermen in Ilaje need new ways to adapt, such as better water management and planning for dry periods. Additionally, the results of this study should be shared with government officials and local groups so they can create helpful policies and programs to support the community. It is further recommended that, researchers from different fields, such as weather experts, ocean scientists and agricultural specialists should work together to help protect and improve life in the coastal areas.

➢ *Ethical Statement*

We will conduct ourselves with integrity, fidelity, and honesty.

➢ *Conflict of Interests*

We declare that we have no conflict of interests in the subject matter or materials discussed in this paper.

➢ *Data Availability Statement*

The data associated with this paper are available with the authors and can access if needed.

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