

# **WORLD ENVIRONMENTAL CONSERVATION CONFERENCE 2023**

## **CLIMATE CHANGE PARTNERSHIP ACTIONS FOR SUSTAINABLE FUTURE AND RESTORING LIFE ON EARTH**

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## MODELLING THE IMPACT OF CLIMATE CHANGE ON OSUN OSOGBO SACRED GROVE

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### ABSTRACT

Climate change sometimes known as global warming, is now widely acknowledged as the biggest concern of the century. The research was conducted to determine the impact of change in climate in Osun Osogbo sacred grove. The study made use of structured questionnaire, interview and secondary data. A total of 152 questionnaires were administered to visitors in the grove. Data were analyzed using descriptive and inferential (Chi-square) statistics. Data was also analyzed using R Statistical Package. Readxl, Ggplot2 and Gridextra were used in R Statistical Package. Findings from this study revealed that 95% of the respondents were aware of the current change in climate. 77% of them became aware by personal experience. 85% of the respondents claimed the temperature has been hotter than before. Majority of the respondents (92%) claimed there has been change in rainfall pattern. 78% of the respondents consider weather condition before going to a tourist site. 34.2% of the respondents were satisfied with the current state of the site, 80.3% will revisit the site while 83.6% will recommend the site to others. Furthermore, the research showed that respondents perspective on rainfall and change in climate, recent floods in the site are due to change in climate (4.03) had the highest mean while disruption of tourism festivals by change in rainfall pattern has the lowest mean of 2.76. In addition, there is a significant relationship between respondents' age, marital status, place of residence, income and their perception of the impact of climate change in the site ( $p < 0.05$ ). From this study it was obvious that the management of the site have indigenous method of preserving archeological and cultural materials in the site. Moreover, in the study, it was discovered that there is also an increase in temperature over the period of 40 years, there is reduction in relative humidity and this can be justified from the increase in temperature because very high temperature reduces the relative humidity in the atmosphere. The study therefore concludes that change in climate has an impact on the Osun Osogbo Sacred Grove. The study recommends that scientific measures should be used as they are globally accepted to reduce the impact of climate change.

**Keywords:** Climate change, Cultural, Osun Osogbo, rainfall pattern, sacred grove,

### INTRODUCTION

Climate change is a global phenomenon that is affecting natural and human systems worldwide. Climate change is a result of human activities that release greenhouse gases into the atmosphere, such as burning fossil fuels and deforestation. The consequences of climate change are already being felt around the world, and if left unchecked, they will have significant and potentially catastrophic impacts on the environment, economy, and society. Climate change is already having significant impacts on the world's natural systems, including rising sea levels, more frequent and severe weather events, and changes in the distribution of plant and animal species (IPCC, 2018). These impacts have serious consequences for human societies, including food and water insecurity, increased risk of natural disasters, and displacement of people due to sea level rise and extreme weather events (UN, 2020).

Furthermore, climate change exacerbates existing social and economic inequalities. Low-income and marginalized communities are often more vulnerable to the impacts of climate change due to lack of resources and access to infrastructure (EPA, 2020). In addition, climate change can have negative impacts on the global economy, including decreased agricultural productivity and increased healthcare costs. The urgency of addressing climate change is highlighted by recent scientific reports, which warn that the world is rapidly approaching tipping points beyond which the impacts of climate change will become irreversible. The impacts of climate change are not uniform across the globe, and some regions, such as Africa, are particularly vulnerable to the effects of climate change. Africa is a continent that is already experiencing the consequences of climate change, including rising temperatures, more frequent and severe droughts, floods, and other extreme weather events. These impacts are affecting the environment, economy, and society of the continent. Africa is a continent that is already experiencing the effects of climate change. According to the Intergovernmental Panel on Climate Change (IPCC), temperatures in Africa are rising faster than the global average, and the continent is experiencing more frequent and severe droughts and floods (IPCC, 2018). These impacts are affecting the environment, economy, and society of the continent, with consequences such as reduced agricultural productivity, water scarcity, and increased risk of natural disasters.

According to the Intergovernmental Panel on Climate Change's Special Report on Global Warming of 1.5°C, human-induced climate change is resulting in a variety of adverse effects on the natural environment, ecosystems, and human society. These effects include rising temperatures, sea level rise, ocean acidification, changes in precipitation patterns, more frequent and severe extreme weather events, loss of

biodiversity, and human health impacts. These impacts have already been observed in many parts of the world and are expected to worsen over time, particularly if no action is taken to reduce greenhouse gas emissions and adapt to the changing climate. The report further emphasizes that limiting global warming to 1.5°C above pre-industrial levels is essential to avoid the most severe impacts of climate change. However, achieving this goal will require rapid and far-reaching transitions in energy, land, urban, and industrial systems, as well as significant reductions in greenhouse gas emissions. Failure to act will result in even more severe impacts on ecosystems, human health, and the global economy (IPCC, 2018). Therefore, the challenge is to mitigate and adapt to the impacts of climate change by taking urgent and sustained action to reduce greenhouse gas emissions and promote resilience to the changing climate, in order to ensure the long-term sustainability of the planet and human civilization. Climate change, caused by human activities such as burning fossil fuels and deforestation, is resulting in a variety of adverse effects on the natural environment, ecosystems, and human society. These effects include rising temperatures, sea level rise, changes in precipitation patterns, more frequent and severe extreme weather events, loss of biodiversity, and human health impacts (National Climate Assessment, 2018). These impacts have already been observed in many parts of the world, including the United States, and are expected to worsen over time, particularly if no action is taken to reduce greenhouse gas emissions and adapt to the changing climate. In addition, climate change is expected to have significant economic impacts, including damage to infrastructure, increased healthcare costs, and loss of productivity due to extreme heat, among other factors (U.S. Global Change Research Program, 2018)

Additionally, there is negative economic effects from climate change, such as reduced tourism-dependent communities' income. Due to shifts in the cost or accessibility of travel, lodging, or other tourism services, this may also have an impact on the sociodemographic features of visitors. Since the location is a popular tourist destination, changes in the weather may have an impact on both the quantity and type of visitors. Extreme weather events and other climate-related disruptions can also affect the local economy and infrastructure, which can have a ripple effect on tourism, way of life, and wellbeing. The Osun-Oshogbo Sacred Grove needs adaptive strategies that support resilience and sustainability to lessen the effects of climate change on it.

Nigeria is a country in West Africa that is already experiencing the effects of climate change. The impacts of climate change, including rising temperatures, more frequent and severe droughts and floods, and other extreme weather events, are affecting the environment, economy, and society of the country. The urgency of addressing climate change in Nigeria is highlighted by recent scientific reports, which warn that the country is particularly vulnerable to the impacts of climate change and that action is needed to mitigate the effects (IPCC, 2018). Different researchers in time past till present time has carried out various researches on climate, climate change and many has carried out research in Osun Osogbo Sacred Grove. These researches include; Climate Change: Causes, Effects and Mitigation Measures (Onoja *et al.*, 2011), An Introduction to the Impact of Climate Change, the economic crisis, and the increase in food prices on malnutrition (Bloem *et al.*, 2010), Climate Change: Causes, Effects, and Solutions (Kaddo, 2016), Climate Change (Chris, 2015), Phycology and Global Climate Change addressing a multifaceted phenomenon and set of challenges (APA Climate Change Task Force Report, 2009), Assessment of the Conservation Values of Osun Osogbo Sacred Grove, Osun State, Nigeria (Oladeji *et al.*, 2021), Solidarity at the Osun Osogbo Sacred Grove- a UNESCO World Heritage Site (Aleshinloye and Maruyama, 2015), Causes of Climate and Environmental Changes: The Need for Environmental-Friendly Education Policy in Nigeria (Nwankwoala, 2015) and others but there is dearth of information on the impact of change in climate in Osun Osogbo Sacred Grove. For this reason, this study proposes to find out the impact of the change in climate in Osun Osogbo Sacred Grove, Osun State, Nigeria. The country is experiencing a rise in temperatures, leading to increased water scarcity and reduced agricultural productivity (Oladipo *et al.*, 2019). In addition, Nigeria is experiencing more frequent and severe droughts and floods, which are affecting the country's infrastructure, including roads, bridges, and buildings (National Bureau of Statistics, 2018). This forms the basis for undertaken this study aimed at assessing the impact of climate change in Osun Osogbo sacred grove. The hypothesis that there is no significant relationship between respondents' socio-demographic characteristics and their perceived impact of climate change at Osun Osogbo Sacred Grove was formulated.

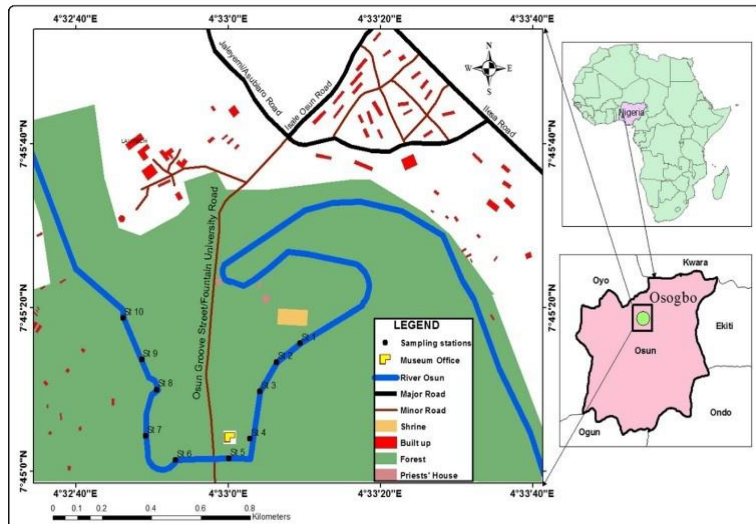
## **MATERIALS AND METHODS**

### **The Study Area**

The study was conducted at Osun Osogbo Sacred Grove, Osun State, Nigeria. Osun Osogbo Sacred Grove and Shrine is located in Osogbo city in western Nigeria. Osogbo is the capital of Osun State and lies at coordinates 7°46' North and 4°34' East with an area of 47km<sup>2</sup>. Osun State is situated in the tropical rain forest zone and covers an area of approximately 14,875km<sup>2</sup> the grove also covers an area of 75 hectares of land (Okonkwo and Eyisi, 2020). The dense forest of the Osun Sacred Grove, on the outskirts of the city of Osogbo, is one of the last remnants of primary high forest in southern Nigeria. Regarded as the abode of the goddess of fertility Osun, one of the pantheon of Yoruba gods, the landscape of the grove and its meandering river is dotted with sanctuaries and shrines, sculptures and art works in honour of Osun and other Yoruba deities. The Grove, which is now seen as a symbol of identity for all Yoruba people, is probably the last sacred grove in

Yoruba culture. It testifies to the once widespread practice of establishing sacred groves outside all settlements (The Government of the Federal Republic of Nigeria National Commission for Museums and Monuments Abuja, 2004).

The grove covers an area of 75 hectares and it is a typical example of a true primary rainforest that is fast disappearing in the West African Sub-region and one of the few vestiges of the rainforests in Nigeria. The grove is fenced with a 4 kilometers chain link or wall in areas where land pressure exists. It has a buffer zone of about 47 hectares surrounding it. The microclimate within the grove is less humid than it is in a greater part of Southern Nigeria. The average rainfall is about 50 inches per annum (The Government of the Federal Republic of Nigeria National Commission for Museums and Monuments Abuja, 2004).



**Figure 1:** Location Map of Osun Osogbo Sacred Grove and Shrine

**Source:** Akindele *et al.* (2017)

Questionnaire was used to ask specific questions from visitors of the sites on the perceived impact of climate change in Osun Osogbo Sacred Grove. The study also made use of interview guide to ask specific questions from the curator and staff of the sacred grove. The interview helped to address their perception of change in temperature in the grove, its effect on the health of people living around the grove, its effect on the way of life of the people. Secondary data was collected from the satellite dish in year 2021. Satellites use sensors and other gear to gather climate data, which they then communicate to Earth through radio waves to a ground station using a satellite dish. The data is received by the dish, which transforms it into electrical impulses before being analyzed, encoded, and saved in a database. In order to study Earth's climate and weather patterns, track changes through time, and develop forecasts and projections, scientists and researchers access the data. This data was used to obtain the variation of different meteorological variable data in osogbo over the last forty years. Data were analyzed using Statistical Package for Social Scientists (SPSS 21) and the results were presented descriptively (frequencies, percentages, charts), inferentially (chi-square and correlation).

Data were also analyzed using R Statistical Package. Readxl, Ggplot2 and Gridextra were used in R Statistical Package. Results were presented descriptively (Charts).

The population for this study were the visitors at Osun Osogbo Sacred Grove. A total of one hundred and fifty-two (152) questionnaires were administered to visitors in the site. fifty (50) questionnaires were administered daily for five (3) working days except for the third day which fifty-two (52) questionnaires were administered and the time spent per day varies depending on visitor's willingness to answer the questionnaires. Some of the staff of the site were also interviewed.

### Visitors Perspective on Rainfall and Change in Climate

Table 1 reveals respondents perspective on rainfall and change in climate. The statements were measured according to their weighted means. The weighted mean score ranged from 4.03-2.76. Recent floods in the site are due to change in climate (4.03) had the highest mean. There is a reduction in patronage of people at this destination due to climate change also has a high mean (4.0). Change in solar radiation and rainfall has led to destruction to some building in the site has a mean of 3.98, the change in climate has affected the mode of living around and in Osun Osogbo sacred grove has a mean of 3.97. However, disruption of tourism festivals by change in rainfall pattern has the lowest mean of 2.76. The study also revealed that visitors were aware of recent change in climate and they became aware through personal experience. The study also shows that there has been a change in rainfall pattern and it also showed that visitors consider weather condition

before going to a tourist site. Mohamed (2022) discovered that most visitors are aware of change in climate and most of them got to know about climate change by scientist. The research by Mohamed (2022) also showed that there has been alteration in the rainfall pattern. Nduduzo (2021), also discovered that many visitors consider the climatic condition before going to a tourist site.

**Table 1: respondents' perspective on rainfall and change in climate**

FACTORS	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Weighted Sum	Weighted mean	Decision
Disruption of tourism festivals by change in rainfall pattern.	49	59	30	9	5	421	2.76	N
Change in temperature has caused decrease in animal species through migration.	49	73	9	16	5	601	3.95	A
Change in rainfall pattern has caused decrease in animal species through migration.	52	67	7	22	4	597	3.92	A
Change in rainfall pattern has caused starvation of wild animals.	34	56	34	20	8	544	3.57	A
There is a reduction in patronage of people at this destination due to climate change.	57	56	21	18	0	608	4.00	A
This site has become less attractive due to change in climate.	52	46	12	34	8	556	3.65	A
There is a notable reduction in flora species at the site.	43	61	25	16	7	573	3.76	A
Change in solar radiation and rainfall has led to destruction to some building in the site.	61	48	25	16	2	606	3.98	A
Recent floods in the site are due to change in climate.	57	63	16	13	3	614	4.03	A
Change in climate has affected the physical and cultural way people relate with the environment and lifestyle.	51	68	15	14	4	604	3.97	A
There is decrease in the flooding pattern compared to previous flooding pattern in Osun Osogbo sacred grove river.	28	44	30	33	17	489	3.21	N
There is increase in the flooding pattern compared to previous flooding pattern in Osun Osogbo sacred grove river.	45	64	22	14	7	582	3.82	A
The increase in the flooding pattern has affected the animal health and feeding.	46	58	25	19	4	579	3.80	A
The change in climate has affected the mode of living around and in Osun Osogbo sacred grove.	43	74	24	10	1	604	3.97	A

### Relationship between the Socio-Demographic Characteristics of Visitors

Table 2 shows the relationship between the socio-demographic characteristics of visitors at the site and their perception of the impact of climate change in the site. There is a significant relationship between respondents' age, marital status, place of residence, income and their perception of the impact of climate change in the site. There is no significant relationship between respondents' gender, religion, education and their perception of the impact of climate change in the site.

**Table 2: Relationship between visitors' socio-demographic characteristics and their perception of impact of climate change at the site**

Variables	Chi square ( $\chi^2$ ) value	P-value	Remark
<b>Age</b>	176.69	0.00	*
<b>Gender</b>	42.20	0.06	NS
<b>Marital Status</b>	81.23	0.03	*
<b>Place of Residence</b>	244.02	0.05	*
<b>Religion</b>	65.09	0.97	NS
<b>Education</b>	76.13	0.07	NS
<b>Income</b>	268.24	0.00	*

p<0.05, \* - Significant, Ns - Not significant

### Qualitative analysis

The staff of the site that were interviewed include the head of education, curator and tour guide. All the staff that were interviewed agreed that there has indeed been a change in rainfall pattern at the grove and this change has effect on the grove. Rainfall in the site cause erosion and eroding of some part of the grove. The rainfall pattern was said not to be stable over the years and recently there has been constant rainfall at the grove, even though this change in rainfall pattern has an advantage in that, it reduces the falling of the trees by the heavy wind that comes along with the rain, since it is not very heavy it doesn't really erode the root of the trees, but when the erosion carries away all the particles and nutrients around the root, it expose the root of the trees and some of them weak and fall off. For the past 20-30years rainfall pattern has never been constant. The staff of the sites were also asked if there were any indigenous strategies, they apply to reduce the effect of this change in rainfall pattern and they mentioned that there is actually a strategy which was given by the deity Olodumare to some people who have the ability to control the rain and this is not scientific, this method was said to be an excellent method.

The head of education mentioned that the change in temperature has little effect on the grove because the grove is a thick forest and the wind also has less effect because of the canopy cover of the trees. It was also recorded that the change in temperature is beneficial to some flora and fauna species in the grove. The indigenous measure put in place to combat the effect of change in temperature according to the curator is the construction of rural shelters for tourist and staffs has been put in place in the grove and this strategy has been said to be a good one.

It was also discovered from the interview that the change in climate has affected the health of the people living around the grove and also working within grove premises, especially the change in rainfall pattern. The grove becomes too cold and there is a limit to the cold that the human body can tolerate, and the human body get older yearly likewise does the change in temperature and rainfall increase yearly. It gets really colder from 3:30pm when the weather is raining which may actually lead to asthma, malaria, catarrh, pneumonia, cough and other cold related sickness. Literally nothing special has been done to intercept this effect on the staff and dwellers, the tour guide stated this.

The curator and the head of education stated that the strategies that are employed by the management of the grove to encourage tourist to visit cultural heritage despite impact of the change in climate in Osun Osogbo Sacred Grove include, reduction of the entrance fee for domestic tourist, visit to schools in order to enlighten them on what the grove is all about and teaching of local crafts in schools and craft centers.

Due to the effect of eroding rapid flowing water, some methods were applied to take the archeological sites and monuments out of risk of flooding and this include the application of natural things in the environment like the hardcore, gravels and all so as to make sure nothing affect original look of the grove, and it was recommended that to avoid the over flooding the government should try to enlarge the size of the river present in the grove. It was also stated that some chemicals applied to on the sculptures in the grove in order to keep them natural as they are ought to, this was said by the curator.

The native mechanism appertained to desiccate the ancient building materials to withstand prolonged immersion include the palm front and coconut plank which are used for roofing in the grove, and due to urbanization the local materials used for replacement are used zinc that brings the brownish old color and for the body of building it is the mud materials "Clay". The clay must be fired and mixed with some that has not been fired, so it will be so solid and used to build the house. For the flooring they make use cowries palm kernel shell and utility stone those are the local materials used in designing the floor and not tiles.

According to the tour guide and the curator of the grove, change in climate has positively improve the farming of the farmer living around the grove and also the change in rainfall pattern as increased since the past years and helped the forest become thicker, which has helped in



the security of lives and properties against sudden terrorism by unknown intruders. In addition, this research found out visitors' perspective on rainfall and change in climate. It was discovered that recent floods in the site are due to change in climate, there is a reduction in patronage of people at this destination due to climate change, change in solar radiation and rainfall has led to destruction to some building in the site, the change in climate has affected the mode of living around and in Osun Osogbo sacred grove. This is in sync with Idowu et al, (2011) which discovered that flood that occur with sea transgression sometimes with heavy rainfall becomes the cause of destruction of some buildings, it also affect mode of living, affect the health of people and Nduduzo (2021), claimed it climate change also facilitate the reduction of visitors to a destination. Furthermore, from the research it was discovered that there has been change in rainfall pattern over the years and the management of the grove apply both the indigenous method of reducing the effect of rainfall and the natural method. The indigenous method was discovered to be not scientific but it was said to be an effective method, in which some people have the ability to control the rain. The natural method include the application of hardcore, gravel etc. Mohamed (2022) in a research carried out in Mashar National Park, Hail-Saudi Arabia revealed that the method used to reduce the impact of climate change include reducing energy consumption, reducing water consumption, waste recycling, reducing consumption of disposable items, buying environmentally friendly products and installing renewable energy equipment.

It was revealed from this study also that change in climate affect the health of both workers at the grove and people living around the grove. This is consistent with Hassan (2020), which stated that change in climate has an adverse effect on health. The research also found out that the change in temperature is beneficial to some flora and fauna. Hassan (2020) also stated that though climate change has a great impact on life, some animals and plant can adapt to the change in climate.

**Variation of different meteorological variable in Osogbo over the last forty years.**

Figure 2 reveals the variation in rainfall in Osogbo over the last forty years and it was recorded in millimeter. From the result it was noted that rainfall occurs throughout the year or almost throughout the year with varying values. To get a better understanding of the trend the mean value of each year was calculated. Form the chart above it can be deduced that rainfall has steadily increased over the past forty years. And this increment can have positive or negative impact to the local community.

Figure 3 reveals the mean maximum temperature in Osogbo over the last forty years. From the chart we can draw insight that temperature has rapidly increased in the last forty years.

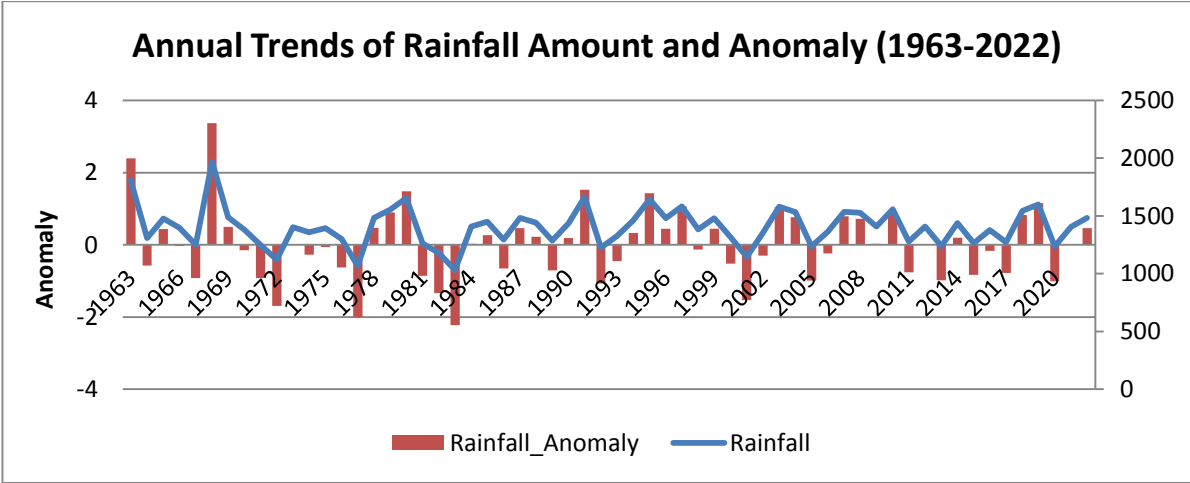
Figure 4 reveals the mean minimum temperature in Osogbo over the last forty years. This shows that there is also an increment in the mean minimum temperatures as the mean maximum temperature.

Figure 5 reveals the mean maximum relative humidity in Osogbo over the last forty years. The chart shows that the relative humidity over the years has reduced. This can be justified from the increase in temperature because very high temperature reduces the relative humidity in the atmosphere. However, the atmosphere will always want to balance back leading to high rate of evaporation.

Figure 6 reveals the mean minimum relative humidity in Osogbo over the last forty years. The chart gave the same result as the maximum relative humidity.

Figure 7 reveals the variation in solar radiation in Osogbo over the last forty years. The chart shows that the incoming solar radiation has increased over the last forty years.

Figure 8 reveals the mean surface pressure at the site, the surface pressure is slightly reducing over the years.



**Figure 1: Total Annual Rainfall (mm) over the study area**

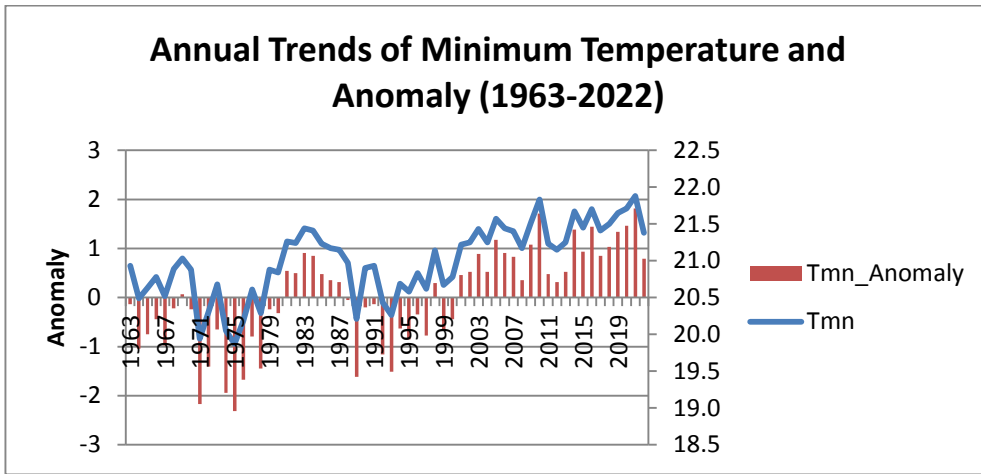


Figure 2: Mean Annual Minimum Temperature (0C) over the study area

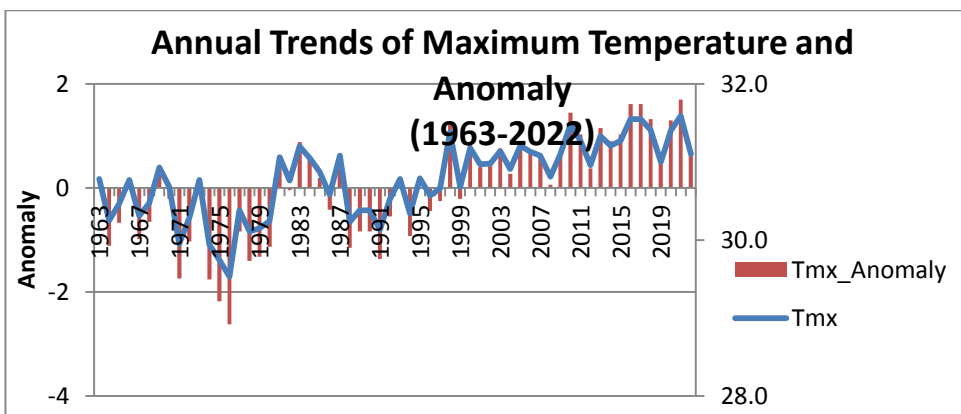


Figure 3: Mean Annual Maximum Temperature (0C) over the study area

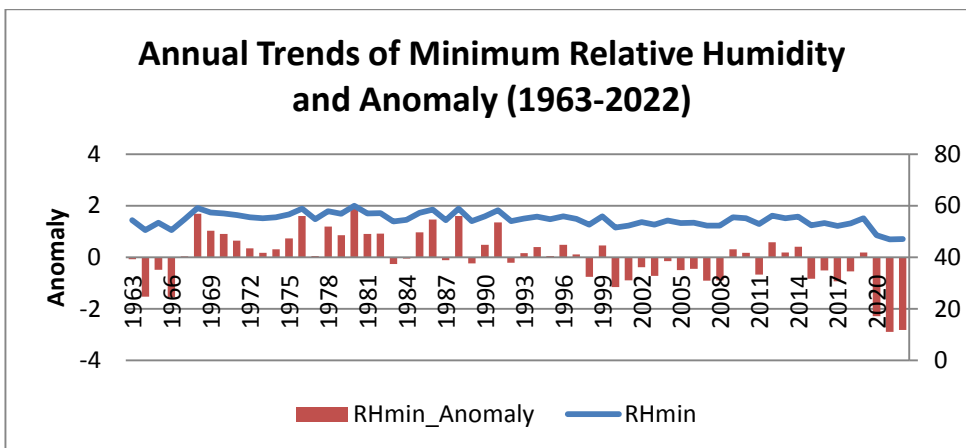
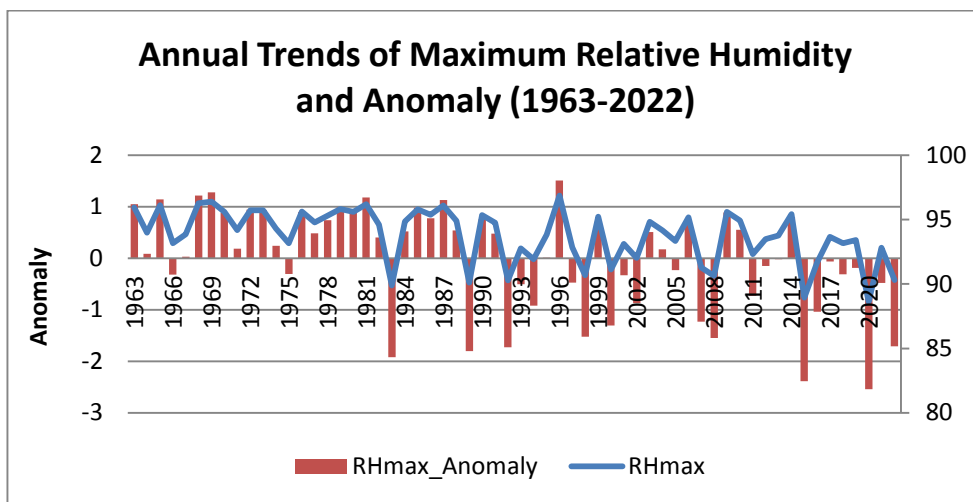
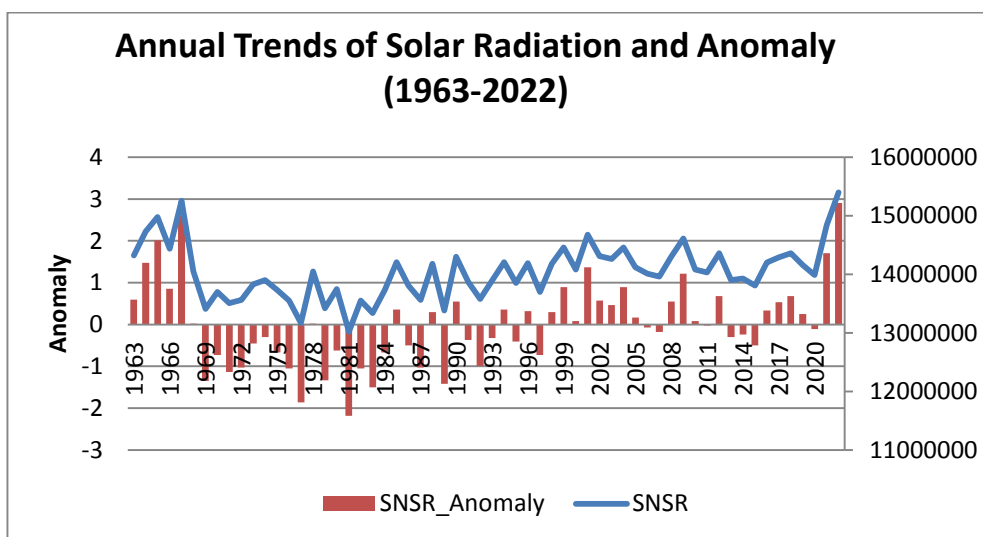


Figure 4: Mean Annual Minimum Relative Humidity (%) over the study area





**Figure 5: Mean Annual Maximum Relative Humidity (%) over the study area**



**Figure 6: Mean Annual incoming solar radiation over the study area**

Annual mean minimum and maximum temperature over the study area from 1963-2022 for the were shown in Figures 2 and 3. The minimum temperature is observed to increase with margins ranging from 19.1OC to 22OC; similar results were obtained for the maximum temperature as it also increased from 28.5OC to 31OC.

The results of the analyses of standardized annual anomalies of temperature over Osun Osogbo groove clearly shown that the decades 1 (1963-1972) and 2 (1973-1982) have negative and normal anomalies There was an increase in the third decade (1983-1992) and has upward trend till the sixth decade (2013-2022). Similar results were obtainable for both the minimum and the maximum temperatures over the study area.

Decadal anomaly of rainfall over the study area is shown in Figure 1 with an increase in the rainfall amount in within the first decade (1963-1972) while there is a downward trend in the following decade. There is however normal trends over the third (1973-1982) and fourth (1983-1992) decades. This gradual reduction in rainfall amount may be attributed to variation in local factors such as orography, boundary layer forcing and moisture build up over the Osun osogbo groove and its environs.

The variation of different meteorological variables in the study area for over the last 60 years was carried out in this research and it was discovered that rainfall occur throughout the year, there is also an increase in temperature over the years, there is reduction in relative humidity and this can be justified from the increase in temperature because very high temperature reduces the relative humidity in the atmosphere. However, the atmosphere will always want to balance back leading to high rate of evaporation. It was also discovered that there is an increase in solar radiation and there is a reduction in surface pressure at the site. According to Hassan (2020) if these variations are not managed properly, it can lead to a great climate change consequence.

## CONCLUSION

This study provides valuable insight on the spatial and temporal patterns of temperature, rainfall, solar radiation and relative humidity over the Osun osogbo groove. The results revealed that there is significant increase (positive trend) in temperature, while the rainfall has also been on the increase within the years of study. The rainfall anomaly over all the stations revealed that there was a composite nature in which some of dry years were mixed with wet years and vice versa and this occurred in all seasons in all stations. The decrease in rainfall may be due to failure of rain-producing mechanism such as the Inter-Tropical Discontinuity (ITD) to organize thunderstorm, squall line that are responsible for larger percentage of the total annual precipitation in Nigeria.

From this research, it can be concluded that change in climate has an impact on the Osun Osogbo Sacred Grove. These impacts include change in rainfall pattern, change in temperature, change in relative humidity, change in solar radiation, change in surface pressure etc. It can also be concluded that change in climate has an effect on the life of human, plants and animals in and around the grove. It can be concluded that the change in climate has affected some aging staffs health in the grove and there is no health hospitality provision or allowance to tackle this issue.

Furthermore, it can be concluded that this change in climate has an effect on tourist patronage at the site. It is recommended that adequate measures should be put in place to combat the impact of climate change at the site; and scientific measures should be used as they are globally accepted to reduce the impact of climate change.

The findings of this study may help different sectors, such as agriculture, disaster risk reduction, biodiversity conservation, ecological and infrastructure development, and climate resilience to enhance respective activities towards the wellbeing of humans and the environment. Furthermore, they are also useful for policy-makers and decision-makers in determining the implications of respective climate adaptation policies in protected areas and wetlands. It is recommended to perform country-level comprehensive analysis on extreme events and climate fluctuations to enhance relevant policies in respective in heritage sites and protected areas across Nigeria that indicate increasing or decreasing climatic trends. Thus, it is recommended to conduct a detailed study to explore courses on changes in trends in rainfall and other climatic variables for environmental sustainability.

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