BUILDING NIGERIA'S RESPONSE TO CLIMATE CHANGE

Climate Change Scenarios for Nigeria: Understanding Biophysical Impacts

A report published by the

Building Nigeria's Response to Climate Change (BNRCC) Project

Prepared by the

Climate Systems Analysis Group
University of Cape Town
Rondebosch, South Africa

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Acronyms

APSIM	Agriculture Production Systems Simulator Model
BNRCC	Building Nigeria's Response to Climate Change
CRU	Climatic Research Unit
CSAG	Climate System Analysis Group
EE	Equatorial Easterlies (wind current)
GCM	Global Climate Models
IPCC	Intergovernmental Panel on Climate Change
ITD	Inter-Tropical Discontinuity
LRS	Length of Rainy Season
NEST	Nigerian Environmental Study/Action Team
NIMET	Nigeria Meteorological Agency
NPP	Net Primary Productivity
SOMD	Self-Organising Maps
SRES	Special Report on Emissions Scenarios
TC	Tropical Continental (wind current)
TM	Tropical Maritime (wind current)

Preface and Acknowledgements

The heightened impacts of climate change in Nigeria and other developing countries, which are likely to intensify in the coming years, have overwhelmed local and traditional knowledge and technologies, leaving many people with inadequate information and little means to deal with the challenges. In addition, there are too few government policies and strategies to address climate change impacts. To tackle these issues, the 'Building Nigeria's Response to Climate Change' (BNRCC) project, was implemented between 2007 and 2011, by the consortium of ICF Marbek and CUSO-VSO and by the Nigerian Environmental Study/Action Team (NEST), with financial support from the Canadian International Development Agency (CIDA).

The BNRCC project components included research and pilot projects, policy development, communication and outreach as well as youth and gender initiatives. The research projects involved community-level socio-economic and future climate scenario studies, while the pilot projects engaged partners and communities in all of Nigeria's ecological zones. Mainstreaming gender equality was integrated throughout all components, and communications activities built awareness at all levels, from the communities to government agencies. Lessons and knowledge generated from the project components fed into the development of the National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN), which was prepared in partnership with the Special Climate Change Unit (SCCU) of the Federal Ministry of Environment, and other partners.

Publications that have emerged from the BNRCC Project include: the *National Adaptation Strategy and Plan of Action on Climate Change for Nigeria* (NASPA-CCN); the *Climate Change Adaptation Strategy-Technical Report* (CCASTR), which is a precursor to the NASPA-CCN; *Climate Change Scenarios for Nigeria: Understanding Biophysical Impacts; Gender and Climate Change Adaptation: Tools for Community-level Action in Nigeria*; and *Learning from Experience – Community-based Adaptation to Climate Change in Nigeria*, a practitioners' guide to climate change adaptation based on BNRCC's experience with pilot project in vulnerable communities. In addition, BNRCC produced two documentary films on climate change in Nigeria: *Water Runs Deep* and *In the Red Zone*. All publications and films are available on-line at www.nigericlimatechange.org and www.nestintractive.org.

BNRCC appreciates the voluntary contributions and commitment made by members of the Project Steering Committee (PSC), the Advisory Groups for the research, pilot projects and communications activities. This includes the contribution of Dr. Austin Nnaji, Chair of the Research Advisory Group who has helped in the development of scenarios to better understand the impacts of climate change in Nigeria. Also deeply appreciated are those people in the public and private sectors, including NGO representatives, who assisted in various capacities during the five years of the BNRCC project. All of these efforts - and sacrifices - and the resources expended will enhance Nigeria's capacity to adapt to climate change and we expect they will be of benefit to the service of humanity.

Executive Summary

This report presents the outcome of research undertaken as part of the Building Nigeria's Response to Climate Change (BNRCC) project. The project aimed to study how global warming could induce climate change in Nigeria, and to understand the potential impacts of climate change on agriculture and human health in the country. The knowledge gained from this research is intended for use by policy makers in developing suitable climate change mitigation and adaptation strategies for Nigeria.

In the study, trends in the present-day climate of Nigeria were investigated by analyzing the historical climate records. Future scenarios were created by downscaling two climate projections using Global Climate Models (GCM). Subsequently, the impacts of the projected climate changes on agriculture and human health were assessed through an analysis of crop-yield and disease-epidemic models respectively.

Following is a summary of the major findings, problems encountered, and recommendations for future work.

Scientific Findings:

- The historical record between 1971 and 2000 shows a trend in rising temperature in Nigeria. The positive trend, which is statistically significant at 95% confidence level, is approximately 0.014°C per year for maximum temperature and 0.025°C per year for minimum temperature. In total, over the thirty year period studied, the maximum and minimum temperatures have increased by 0.4°C and 0.8°C respectively. In addition, the incidence of heat waves (defined as continuous hot days) has increased by more than 20 days over the period.
- A significant trend[1] of increasing rainfall was found in most ecological zones of Nigeria between 1971 and 2000, totaling approximately 6 mm day^{-1} per year. In addition, the onset of rainfall is earlier, and the duration of the rainy season is increasing.
- The simulation of the present-day climate (for the baseline years of 1971 to 2000) downscaled from the nine GCMs provided an accurate replication of the current Nigerian climate. The simulation replicated all of the essential climatic features in the spatial and temporal distributions of temperature and rainfall over the county. The greatest error in the simulated temperature was less than 2°C, and for rainfall was approximately 2 mm/day. The simulation also matched the positive trends in rainfall and temperature (maximum and minimum) in Nigeria from 1981- 2000. Hence, the level of the agreement between the downscaled simulation and actual observation data are considered sufficiently reliable.
- Two future climate projections were downscaled using the nine GCMs. These scenarios are referred to as A2 and B1 scenarios. The A2 scenario assumes future development will follow economic and regional considerations, whereas the B1 scenario assumes a predominance of environmental and global considerations. A more detailed explanation of the assumptions underlying these two scenarios is provided in the full body of this report (see Box 4). In general, both scenarios suggest that there will be an increase in temperature over the entire country. The B1 scenario projects a consistent temperature increase of approximately 0.02°C per year from 2000 until 2100, whereas the A2 scenario projects a greater temperature increase of approximately 0.04°C per year from now until 2050, and approximately 0.08°C from 2050 till 2100. Both scenarios suggest a higher temperature increase over the inland regions compared with the coastal regions. For example, the highest increase in maximum temperature (approximately 4.5°C between 2008 and 2011 in the A2 scenario) is expected over the inland northeast regions (Short Grass Savanna ecological zone). The lowest increase (approximately 3.5°C between 2008 and 2011 in the A2 scenario) is over the coastal southwest (Rainforest ecological zone). This temperature distribution is consistent with those reported for Nigeria in the 2007 Intergovernmental Panel on Climate Change (IPCC) report.

[1]The term 'significant' is used throughout this report to mean statistically significant at a rate of more than 95% confidence level

- The future projections do not show an identifiable trend in rainfall when considering data at the national level, but some trends are evident at the regional level. Both A2 and B1 scenarios predict a wetter climate in the south (at least 0.2 mm/day south of 8°N), and a drier climate in the north. In the B1 scenario, the southern zones would experience a moister climate than predicted under the A2 scenario, while the A2 scenario for the northeast zone would be much drier than projected by the B1 scenario. The highest rainfall variability in all zones occurs in July, and the variability is from about ±0.5 mm/day in B1 scenario to approximately ±2 mm/day in the A2 scenario.
- Both A2 and B1 scenarios predict a longer duration of the rainfall season (i.e. earlier onset and later cessation) in the future over Mangrove, Rainforest and Tall Grass Savanna ecological zones, and a shorter rainfall season (i.e. early cessation) over the Short Grass Savanna ecological zone. In both scenarios, the maximum expected increase in the rainfall season is approximately two weeks, and the maximum decrease is approximately one week.
- In the two future periods of 2046 to 2065 and 2081 to 2100, an increase in the number of days of rain, an increase in days with extreme rainfall, and increased flooding are projected over most ecological zones, except in the northeast zone, where the A2 scenario suggests fewer extreme events related to flooding and rainfall.
- Heat waves are projected to occur more frequently over the entire country in the future. In the Short Grass Savanna zone in the 2046-2065 time period, the duration of heat waves is expected to increase by 85% according to the B1 scenario and by 95% according to the A2 scenario. These durations are projected to double for both scenarios between 2081 and 2100.
- The predicted climate changes could have devastating negative impacts on agriculture in Nigeria causing decreased crop productivity (i.e. maize yields) over the entire country. The greatest impact would occur in the northeast zone, where a drier and hotter climate is projected. It should be noted that the A2 scenario depicts a greater impact on maize crop yields than the B1 scenario. Specifically in the 2046-2065 time period, the B1 scenario projects a 10% decrease in crop productivity across all zones of Nigeria, while the A2 scenario projects a 10% decrease in the southern zones and a 20% decrease in the northern zones. Between 2081 and 2100, the B2 and A1 scenarios suggest that the decrease could be as great as 30% and 50% respectively over the northern zones of the country.
- Climate change is predicted to have a severe effect on the health sector due to increases in the incidence of disease epidemics (i.e. malaria) over the entire country. The greatest increase in malaria incidence is projected to occur in the southern zones, where a hotter and wetter climate is expected. The A2 scenario predicts a greater increase in malaria than the B1 scenario. Specifically, according to the B1 scenario, a 40% increase in malaria epidemics is expected in the Mangrove zone between 2081 and 2100 and in the A2 scenario, the increase is approximately 60%. For both scenarios the number of months with malaria epidemics would increase by three months in the Mangrove zone.

Problems Encountered:

- Due to the large geographical area and population density of Nigeria, the forty synoptic weather stations (hereafter referred to as 'stations') in Nigeria do not have the capacity to generate complete meteorological data for the country with the coverage being weakest in the northern regions. In addition, the data from the stations required rigorous quality control before use in the trend analysis. In some cases, data gaps from certain stations limited the application of the data for the trend analysis, so data had to be combined with the Climate Research Unit's (CRU) observation dataset.
- It was difficult to obtain observed crop yield data for Nigeria to validate the baseline simulation from the crop model. Many stations had no crop yield records, and even in the few stations that did have records, the data contained gaps and covered only short time periods. Hence, it was difficult to make comparisons between simulated long-term means and yearly variability with that of observed data. To circumvent this problem, a combination of available station data and zonal crop yield data reported

in the literature was made. Thus, the model validation was based on zonal comparison rather than comparisons from the individual stations.

- Accessing health-related records in Nigeria for this study was challenging. For example, malaria occurrence data from only three cities (Akure, Ibadan and Lagos) could be obtained. These data only covered ten years and there were many data gaps. There was virtually no literature on malaria epidemics in Nigeria from which more data could be gleaned. Thus, the validation and fine-tuning of the malaria model used in this study was based on data from these three stations only. However, this does not have a significant effect on the model results because observed data were not used as input in this portion of the study.

Recommendations:

- It is recommended that a follow-up study undertake a dynamical modeling approach to downscale climate change over Nigeria in order to confirm the results of the present study which relied on statistical modeling. This dynamical approach is described in more detail on page 7 of this report.
- Reforestation remains one of the most viable climate change mitigation options for Nigeria. However, before going forward on this, it is recommended that a series of climate modeling experiments be undertaken, using reforestation scenarios, in order to quantify how much reforestation of the various regions is needed to reduce the projected temperature increase for Nigeria.
- Future studies should aim to develop scenarios of near-term climate change based on the existing trends and knowledge of how climate may change in the next twenty years. This should be developed as scenarios rather than using CGMs to model the future climate. However, a good understanding of signal-to-noise ratio over the country would be required to predict differential changes due to climate change and climate variability.
- To facilitate accurate study, the Nigerian government should ensure that crop yield and disease data are more accessible for research purposes.

1. Introduction

This report provides an overview of the outcomes of a study of the recent changes in the climate of Nigeria, projected future changes in the climate due to global warming, and the potential impacts of future climate change on agriculture and human health in the country.

Box 1: What is climate change?

Change refers to a change in the average weather experienced in a particular region or location. The change may occur over periods ranging from decades to millennia. It may affect one or more seasons, e.g. summer, winter or the whole year, and involves changes in one or more aspects of the weather e.g. rainfall, temperature or winds. The causes may be natural, for example due to periodic changes in the earth's orbit, volcanoes and solar variability, or attributable to human (anthropogenic) activities, for example increasing emissions of greenhouse gases such as CO_2, land use change and/or emissions of aerosols. In contemporary use, the term "climate change" often refers to changes due to anthropogenic causes.

1.1 Overview of the Nigerian Context

Nigeria lies on the south coast of West Africa between latitudes 4°-14°N and longitudes 2°-15°E. It has a total landmass of approximately 925,796 km^2. The climate of Nigeria varies more than any other country in West Africa due to its great length from the south to the north (1100 km). This results in virtually all of the climatic belts of West Africa being included within Nigeria's borders. The climate is dominated by the influence of three main wind currents: the Tropical Maritime (TM) air mass, the Tropical Continental (TC) air mass, and the Equatorial Easterlies (EE) (Ojo, 1977). The TM air mass originates from the southern high-pressure belt located off the Namibian coast, which then picks up moisture from over the Atlantic Ocean, thus becoming a moisture-laden air mass. The CT air mass originates in the high-pressure belt north of the Tropic of Cancer and is always dry given that it picks up little moisture as it travels towards Nigeria over the Sahara desert. The TM and CT air masses meet along a surface called the Inter-Tropical Discontinuity (ITD). The EE air mass is an erratic cool air mass which comes from the east and flows in the upper atmosphere along the ITD. The EE air mass penetrates occasionally to actively undercut the TM or CT air masses giving rise to squall lines or dust devils (Iloeje, 1981).

The Nigerian climate is humid in the south with annual rainfall over 2000 mm and semi-arid in the north with annual rainfall less than 600 mm. Generally speaking, there are three climatic zones which cover the north, middle and southern areas of the country: the Sahel (11°-14°N), Savanna (8°-11°N) and the Guinea (4°-8°N) zones. Rainfall commences in approximately March/April in the southern coastal zones, spreads through the middle zone in May/June, and reaches the northern zone in June/July, reaching its peak over middle and northern zones between July and September. The rainfall retreat period follows a reverse of this progression (Ojo, 1977).

Climate plays a significant role in the distribution of vegetation and agriculture in Nigeria. The ecological zones of the country are grouped into seven zones: from south to north these are Mangrove, Freshwater Swamp, Rainforest, Woodland (or Tall Grass Savanna), Montane, Short Grass Savanna and Marginal Savanna[2]. Approximately two-thirds of the agricultural area of Nigeria occurs in the north, with the remaining one-third of the agricultural area distributed between the middle and southern zones.

Nigeria is the most populous country in Africa with over 140 million people and a population density of 138 people per square km, according to the 2006 census. Over seventy percent of Nigerians are classified as poor and thirty-five percent live in absolute poverty (IFAD, 2009). As the increasing population puts more pressure on diminishing resources, escalating environmental problems further threaten food production. Land degradation as a result of deforestation and overgrazing is already severe in many parts

[2] Note that there are three climatic zones and seven ecological zones.

in the country. Drought is a common problem in the north, while heavy rains and floods are major problems in the south and southeast (IFAD, 2009). Climate change is likely to further aggravate these environmental problems in the future.

1.2 Global and Regional Climate Changes

It is widely known that there has been a detectable rise in global temperature during the last forty years, and that this rise cannot be explained without taking into account the role of human activities (IPCC, 2007, WGI). However, the global distribution of temperature increase is not uniform. Some regions experience greater change than others, especially the interior of continental regions such as the Sahel in West Africa (see Figure 1). Furthermore, there is an increasing rate of change in the global average temperature indicating that temperature is rising more quickly during the latter half of the twentieth century (see Figure 1). Importantly, this increase in the rate of change is expected to continue potentially resulting in more rapid changes in climate in the future.

Changes in rainfall levels are typically harder to detect due to greater variability in both time and space. Even so, changing rainfall patterns have been detected for many parts of the globe. Recent studies have shown that Africa has been drier in the last few decades (Nicholson *et al*., 2000; L'Hóte *et al*., 2002; Oguntunde *et al*., 2006). There are two schools of thought regarding this recent decreasing trend in Sahelian rainfall. Some researchers believe that the Sahelian drought continued until the end of the twentieth century (L'Hóte *et al*., 2002), while others argue that it may have ended earlier in the 1990s (Ozer *et al*., 2003). Also, one study of the characteristics of rainfall variation between 1901 and 1985 in West Africa found no observable regular patterns in trends or cycles (i.e. regularly reoccurrence pattern) in the annual rainfall variation (Ojo,1987). In Nigeria specifically, an analysis of rainfall data between 1911 and 1980 from twenty-eight synoptic weather stations examined trends in precipitation patterns and a general decrease of dry season contribution to annual rainfall was observed (Adefolalu, 1986).

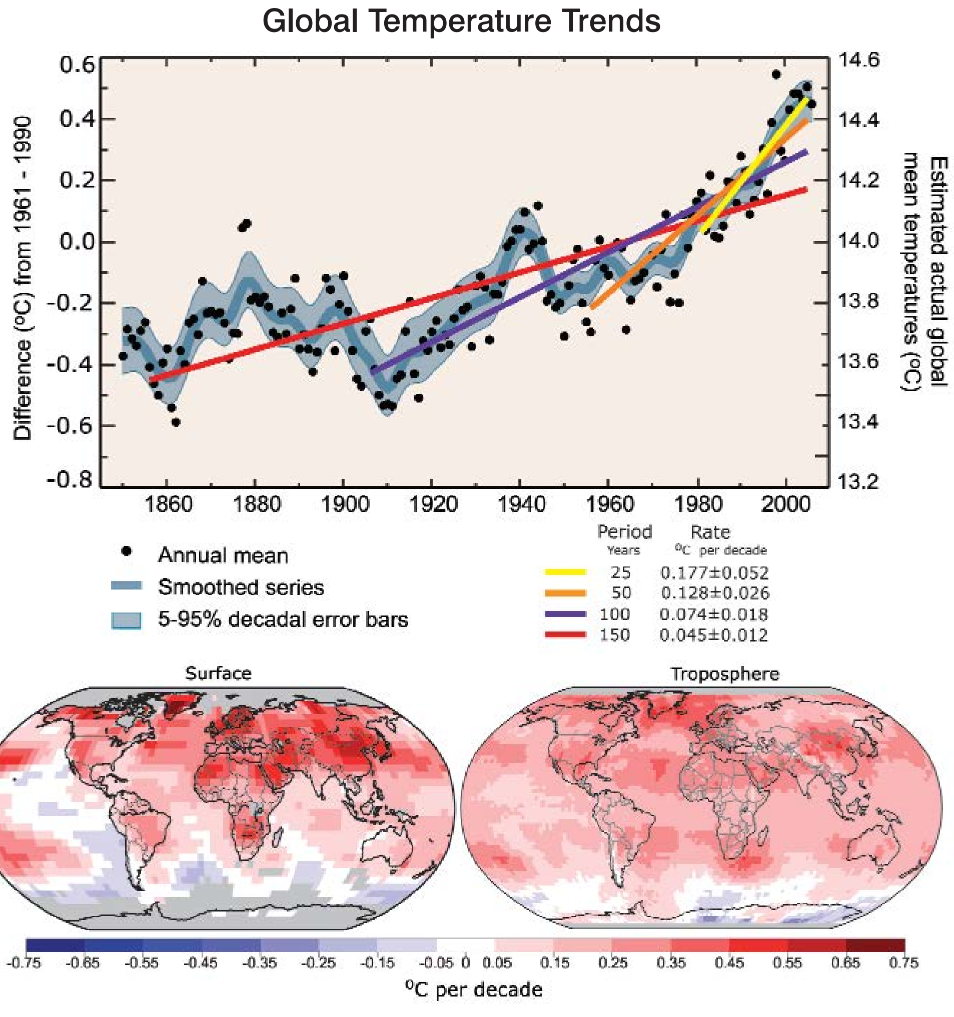


Figure 1 Top: The average global temperature since 1850 indicating the increased rate of change during the latter part of the 20th century. Bottom: Distribution of global temperature trends (1979-2005) for the surface (left) and for the troposphere (right) from satellite records. (IPCC, 2007 Fourth Assessment Report, Working Group II, Chapter 3, page 253).

In addition to changes in temperature and rainfall, other aspects of global climate change are notable (IPCC, 2007):

- Increases in intensity and spatial extent of droughts since the mid-1970s;
- Decreases in northern hemisphere snow cover;
- Increases in the duration of heat waves during the latter half of the twentieth century;
- Shrinking of the arctic sea ice pack since 1978;
- Widespread shrinking of glaciers, especially mountain glaciers in the tropics;
- Increases in upper-ocean (0-700m) heat content;
- Increases in sea level at a rate of 1.8 mm yr-1 between 1961 and 2003, with a faster rate of 3.1 mm yr-1 between 1993 and 2003.

There is compelling evidence for climate change attributable to human activities at the global level, as well as in continental West Africa (see Box 2). The understanding of how global climate change may affect individual countries and regions within a country is therefore a topical issue for research and is inherently linked to issues of uncertainty (see Box 3). The observed global changes serve to highlight that climate change is a reality that is likely to continue and potentially accelerate. Going forward, it is necessary to explore how local, national and regional climates may already be changing as well as how they are expected to change in the future. This knowledge will enable authorities at local, national or regional levels to accurately design effective adaptation and/or mitigation strategies. Without this evidence-based knowledge, many current mitigation and adaptation strategies are based on potentially inaccurate data and predictions.

Box 2: What causes climate change?

Greenhouse gas emissions, the main cause of anthropogenic climate change, have increased steadily since the Industrial Revolution. However, the rate of emissions has been steadily increasing over time and computer models of the earth's climate system (including both natural and human causes) are unable to simulate recent warming without the inclusion of anthropogenic causes. Computer simulation models of the earth's climate which include only natural forces (for example solar variability due to both internal and orbital variations, volcanic activity etc.) indicate a cooling of the earth after 1960, which is inconsistent with the observed warming (see Figure 1). This has led the IPCC to conclude recently that most of the warming of the last 50 years is attributable to human activities (IPCC, 2007, WGI, Chapter 9)

1.3 Potential Impact of Climate Change on Food Security and Health

The IPCC (2007) report predicted that by 2020 between 75 and 250 million people in Africa will be exposed to increased water stress caused by climate change, hence agricultural production and access to food in many African countries may be further threatened. This will adversely affect food security, aggravate malnutrition and increase diseases on the continent.

Within Africa, Nigeria is particularly vulnerable to climate change. Most agricultural practices in Nigeria rely on rainfall and over 70% of the country's population relies directly or indirectly on rain-fed agriculture (IFAD, 2009). Hence, any change in climate in the country would have a great impact on both the agriculture and economy of the nation. In addition, Nigerians are highly vulnerable to diseases related to the warm and moist climate and occurrence of extreme climatic events. Epidemics of malaria and meningitis are common in Nigeria. As these diseases thrive better in warmer climates, any increase in temperature in the country will likely aggravate the epidemics.

These specific effects of climate on agriculture and health are related to variability in the local climate rather than in the global climate patterns. This reinforces this importance of assessing the impacts of climate change for each local area or ecological zone in the country.

1.4 Aim and Objectives of the Study

The aim of the study was to bring together an assessment of climatic trends for Nigeria, the likely future climate change impacts, an examination of what these impacts mean for crop productivity and human health, and suggestions for adaptation strategies for Nigeria.

The specific objectives were to: (i) evaluate trends in historical and projected future climate data; and (ii) assess the impact of projected climate change on crop productivity and the occurrence of epidemic diseases in Nigeria. Where possible, the results are specific to the different ecological zones of Nigeria.

Box 3: Understanding uncertainty and risk

The issue of uncertainty is crucial to understanding past and future climatic change, especially when designing adaptation strategies that will benefit both present and future socioeconomic situations. All climate projections, including seasonal forecasts, are presented in terms of the probability of particular climate conditions occurring in the future. Despite this uncertainty, this approach provides a framework which allows for assessing future risks, e.g. consideration of financial and investment opportunities. To be able to assess risk, one needs to consider all sources of information. It is therefore essential that a probability framework is used to develop projections which incorporate different sources of information. The IPCC define four sources of uncertainty that currently limit the detail of the regional projections (IPCC, 2007, WGI, Chapter 11):

1. **Natural variability.** Due to the challenges of observations (both in time and space), there is a limited understanding of natural variability. It is difficult to characterise this variability and the degree to which it may exacerbate or mitigate the expected background change in climate. This variability itself may change due to anthropogenic factors, e.g. increases in the frequency of droughts and floods;
2. **Future emissions.** Much of future projected change, at least in terms of the magnitude of change, is dependent on how society will change its future activity and emissions of greenhouse gases. Even so, the course is already set for a degree of change based on past emissions (at least another 0.6°C warming in the global mean temperature). Human responses to managing emissions may result in a projected global mean temperature change of between 1.5° and 5.6°C;
3. **Uncertainty in the science.** This is further complicated within Africa because of limited understanding of the regional dynamics of the climate of the continent. There may be aspects of the regional climate system which could interact with globally forced changes to either exacerbate or mitigate expected change, for example land-use change. One consequence is the possibility of rapid nonlinear change, with unforeseen and sudden increases in regional impacts;
4. **Downscaling.** This term defines the development of regional scale projections of change from the Global Climate Models. Downscaling tools can introduce additional uncertainty, for example between downscaling using regional climate models and statistical techniques. This uncertainty limits the confidence in the magnitude of change, not the patterns of change, which are predicted with more certainty.

2. Data Used for the Climate Analysis

The study included an analysis of observation data (based on station data and gridded CRU datasets) as well as downscaled GCM simulations. The station data, which were supplied by the Nigeria Meteorological Agency (NIMET), comprise daily maximum and minimum temperature and rainfall from 1971 to 2000 for forty synoptic weather stations in Nigeria. The forty stations and their geographical locations and ecological zones are presented in Figure 2 and Table 1.

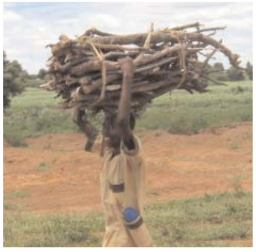
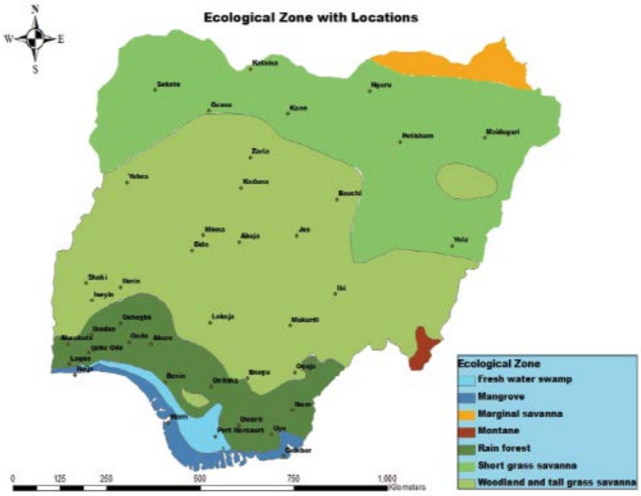


Table 1 List of the forty synoptic weather stations used in the study.

Station ID	Station Name	Zone	Longitude (°W)	Latitude (°N)	Altitude (MSL)
65201	Ikeja	Mangrove	3.2	6.35	40
65250	P. Harcourt		6.57	5.01	18
65264	Calabar		8.21	4.58	62
65236	Warri		5.44	5.31	6
65213	Abeokuta	Rainforest	3.03	7.02	104
65232	Akure		5.03	7.02	375
65229	Benin		5.36	6.19	77.8
65208	Ibadan		3.59	7.22	234
65210	Ijebu_Ode		8.93	6.83	77
65222	Ondo		4.5	7.06	287
65252	Owerri		7.13	5.25	91
65203	Lagos		3.06	6.58	13
65273	Ikom		8.43	5.58	93
65215	Oshogbo		4.29	7.47	305
65245	Onitsha		6.47	6.09	86
65260	Uyo		7.92	5.05	38
65257	Enugu	Tall Grass Savanna	7.34	6.28	137
65145	Ibi		9.45	8.11	111
65272	Ogoja		8.48	6.4	117
65200	Iseyin		3.6	7.97	330
65271	Makurdi		8.37	7.42	113
65243	Lokoja		6.44	7.48	41
65101	Ilorin		4.3	8.26	308
65125	Abuja		7.15	9.24	344
65055	Bauchi		9.49	10.17	591
65019	Kaduna		7.19	10.42	645
65123	Minna		6.28	9.39	262
65108	Shaki		3.47	8.35	312
65001	Yelwa		4.45	10.53	244
65134	Jos		8.52	9.38	1295
65112	Bida		6.01	9.06	137
65030	Zaria		7.41	11.08	664
65064	Nguru	Short Grass Savanna	10.28	12.53	343
65167	Yola		12.26	9.16	191
65046	Kano		8.32	12.03	476
65028	Katsina		7.41	13.01	427
65082	Maiduguri		13.05	11.51	354
65073	Potiskum		11.02	11.42	488
65010	Sokoto		5.12	12.55	351
65015	Gusau		6.42	12.1	463



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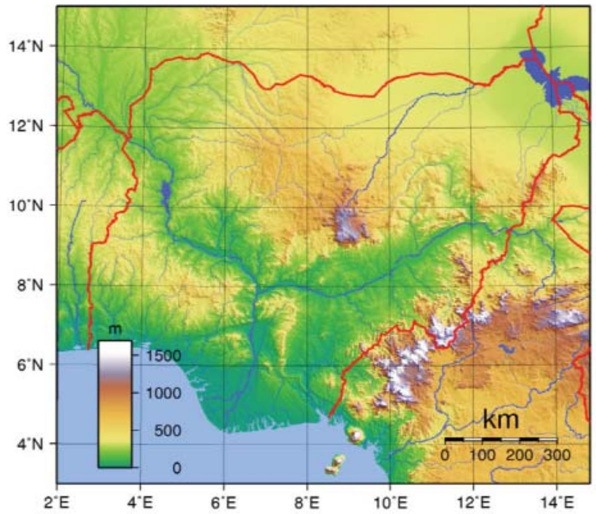


(b)

Figure 2 (a) Ecological zones in Nigeria (source: www.lib.utexas.edu/maps/africa/nigeria_veg_1979.jpg) and location of synoptic weather stations used in for historical trends and downscaling the future climate; (b) Topographic of Nigeria (source: wikipedia.org/wiki/Geography_of_Nigeria)

The station data were used for trend analysis and for downscaling of the GCM simulations. All stations meet constraints of a minimum of 10 years of daily data post-1979 for the statistical downscaling. Given Nigeria's land area of 925,796 km^2, the station network provides an approximate station density of one station every 23,145 km^2, which is a vast area for each station to cover[3]. The stations are spread throughout Nigeria but are more densely situated along the coast. Consequently, there are large areas without stations further inland, especially in the northeast and northwest. It can be seen in Figure 2 that the station network used in this analysis does not adequately cover some ecological zones, including: Fresh Water zone (only one station therefore it is merged with Mangrove zone in the study), Montane and Marginal Savanna zones. Hence, our analysis only covers Mangrove, Rainforest, Short Grass Savanna and Tall Grass Savanna zones.

Figure 2(b) presents the topography of Nigeria. Low-lying coastal plains (coloured green) cover much of the country in the south region and along basins of River Niger and River Benue. The higher inland mountains are also clearly visible (coloured white). A comparison of Figure 2(a) and (b) indicates that the station network used in this analysis include the Jos plateau (located at the centre), but does not include the Manbilla plateau (located at the east).

2.1 Quality Control of Station Data

The data from the forty stations underwent rigorous quality control including checking for unrealistic rainfall and temperature values, as well as testing each time series for homogeneity. Suspicious data were set to missing values before proceeding with the tests for trends and downscaling the future climate scenarios (see section 5). Complex statistical techniques that detect discontinuities in time series (usually indicating the relocation or deterioration of a sensor) can be used with historical data. Alternatively, some relatively simple quality control tests can be used:

- Remove negative rainfall, or rainfall above station-specific unrealistic values;
- Remove where maximum temperatures and less than minimum temperatures or either is within 3 - 6 standard deviations of the long-term mean.

In this study, the following tests were conducted and data were removed these requirements were not met:

- Checking for negative rainfall;
- Rainfall > 500 mm in one day;
- Minimum temperatures greater than maximum temperatures;
- Minimum and maximum temperatures greater than 6 standard deviations from the long-term (full dataset) mean value;
- Inconsistencies due to changing instruments or location.

[3] To provide a continental comparison, in South Africa there are approximately 1,200 stations over a land area of 1221,040 km^2 which equals approximately one station every 1,000 km^2.

The first four tests were completed before undertaking the final test step[4]. In order to further establish the credibility of the station data following the completion of these five tests, a comparison was made of some of the results (i.e. mean and trends) to data from the Climatic Research Unit's gridded dataset (CRU; Mitchell *et al*., 2004).

2.2 Downscaling GCMs Simulations of Nigeria

GCMs are the primary tools for simulating past climate and projecting the future climate using different climate forcing scenarios. They are complex computer models that represent interactions between the different components of climate such as the land surface, the atmosphere and the oceans. GCMs solve various complex equations and adopt parameterization schemes to represent atmospheric processes, and provide physically self-consistent explanations of observed climate variations on various time scales (IPCC, 2007, WGI, Chapter 8). Various studies have demonstrated that the models are capable of providing reliable climate projections for the future (IPCC, 2007). In making projections of climate change, several GCMs and scenarios of future emissions of greenhouse gasses are used to predict the future (see Box 4 and Box 5). This process generates a suite of possible future scenarios, each valid but some scenarios can be considered more likely than others.

GCMs typically work at a spatial resolution of 200-300km which is useful for projected future climate at a global scale. However, at a regional scale GCMs are less useful because they cannot resolve local scale features (for example, sea-breeze or mountain-induced flows) which play an important role in regional climate. This limits the application of GCM projections for assessments of change at the local or regional scales. Therefore, the technique of downscaling is typically used to produce projections at a finer spatial scale. Downscaling is effective because the GCMs are generally good at projecting changes in atmospheric circulation (high and low pressure) but do a poor job of translating that information into changes in rainfall.

There are two possible approaches to downscaling: statistical and dynamical. Statistical downscaling uses statistical/empirical equations to represent the relationship between the large features and local climate variables at stations, while dynamical methods use physically based laws to represent the relationship. Each method has its advantages and disadvantages. In the present study, statistical downscaling was used because it is faster and more robust than the dynamical techniques (Hewitson and Crane, 2006).

Details of the downscaled GCMs simulation of the forty stations for B1 and A2 scenarios (described in Box 4 below) are provided in Table 2 below. The statistical downscaling method used in this report was based on the Self-Organising Maps Downscaling (SOMD) (Hewitson and Crane, 2006), the results of which have been used by the IPCC across Africa (IPCC, 2007, WGI, Chapter 11).

Box 4: What is a scenario?

Scenarios describe potential futures which can be based on changes in the climate system, socio-economic circumstances or other potential future changes. In the context of climate change, the IPCC published its Special Report on Emissions Scenarios (SRES) which describes a range of possible scenarios based around four 'storylines': A1, A2, B1 and B2 (IPCC, 2000). These storylines assume different future paths for the world taking into consideration two dimensions of development: greater weight given to Economic (A) or Environmental (B) factors; and greater weight given to either Global (1) or Regional (2) factors

This results in four possible scenarios:

A1 = Economic / Global
A2 = Economic / Regional
B1 = Environmental / Global
B2 = Environmental / Regional

Each of these scenarios has an associated emissions pathway for the period 2000-2100. These emission pathways describe the amount of greenhouse gases (and other atmospheric gases) emitted through human activity in the future. Global Climate Models (GCMs) are then applied which then utilize these future emissions (which define changes in the concentration of these gases in the atmosphere) to model the future climate.

[4] This test for inconsistencies was conducted utilised software distributed by (ETCCDMI89 http://cccma.seos.uvic.ca/ETCCDMI/software.shtml).

Table 2 List of Global Climate Models (GCMs) used in this study.

Originating Group(s)	Country	I.D.	B1 scenario	A2 scenario
Bjerknes Centre for Climate Research	Norway	BCCR-BCM2.0	Yes	Yes
Canadian Centre for Climate Modeling & Analysis	Canada	CGCM3.1(T63)	Yes	Yes
Météo-France / Centre National de Recherches Météorologiques	France	CNRM-CM3	Yes	Yes
CSIRO Atmospheric Research	Australia	CSIRO-Mk3.5	Yes	Yes
Meteorological Research Institute	Japan	MRI-CGCM2.3.2	Yes	Yes
Max Planck Institute for Meteorology	Germany	ECHAM5/MPI-OM	Yes	Yes
US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory	USA	GFDL-CM2.0	Yes	Yes
US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory	USA	GFDL-CM2.1	Yes	Yes
Meteorological Institute of the	Germany/ Korea	ECHO-G	Yes	Yes
Institut Pierre Simon Laplace	France	IPSL-CM4	Yes	Yes
Instituto Nazionale di Geofisica e Vulcanologia	Italy	INGV-SXG	No	Yes
Institute for Numerical Mathematics	Russia	INM-CM3.0	Yes	Yes
Center for Climate System Research (The University of Tokyo), National Institute for Environmental Studies, and Frontier Research Center for Global Change (JAMSTEC)	Japan	MIROC3.2 (medres)	Yes	Yes
Hadley Centre for Climate Prediction and Research / Met Office	UK	UKMO-HadCM3	Yes	Yes
Hadley Centre for Climate Prediction and Research / Met Office	UK	UKMO-HadGEM1	No	Yes

Box 5: Is one GCM better than another at projecting future change?

While some GCMs are better at simulating the present observed climate, this does not necessarily mean that they are better at simulating future change. Evaluating one GCM against another is not an easy task; one GCM may better simulate monthly mean rainfall and temperature but it may not better simulate the daily frequency or diurnal cycle of rainfall (Collier and Bowman, 2004; Bergman and Salby, 1997). Another challenge when using a single GCM is that only a limited number of future scenarios can be generated which can create the impression of a narrowly determined future that may not fully span the range of potential future change. It is therefore recommended that future change is expressed either as a range of future scenarios or as an average statistic (e.g. median) with some measure or recognition of the spread of possible future scenarios

3. Present-day Climate of Nigeria: Observation and Downscaled GCM Data

The study included an analysis of historical observations from 1971-2000 and downscaled GCM data in order to understand recent trends in the climate of Nigeria and to validate the downscaled simulation for the country. The downscaled data also provided the baseline for assessing the future climate change. Using SOMD, the GCM simulations were downscaled for each of the forty synoptic weather stations. To obtain data over a zone, the station data within a zone were averaged to obtain a spatial distribution of the data over Nigeria, the data of the forty stations were gridded at resolution of 50 km over the country. Below, a comparison is made between the observed and downscaled climate of Nigeria.

3.1 Temperature

3.1.1 Seasonal Variation

Figures 3 to 6 present the seasonal variations of the downscaled simulations for each of the GCMs and their ensemble as well as the observed temperature, maximum and minimum, for four of the seven ecological zones in Nigeria. Each model simulates seasonal variation of temperature as observed over the zones although there are differences in the simulated and observed values. The models ensemble (i.e. the average of the model simulations) provides a closer reproduction of the seasonal variability compared to any of the individual models. This supports the idea that climate projections from an ensemble of multi-models are more reliable than those from a single model (Rajagopalan *et al.*, 2002; Mylne *et al.*, 2002).

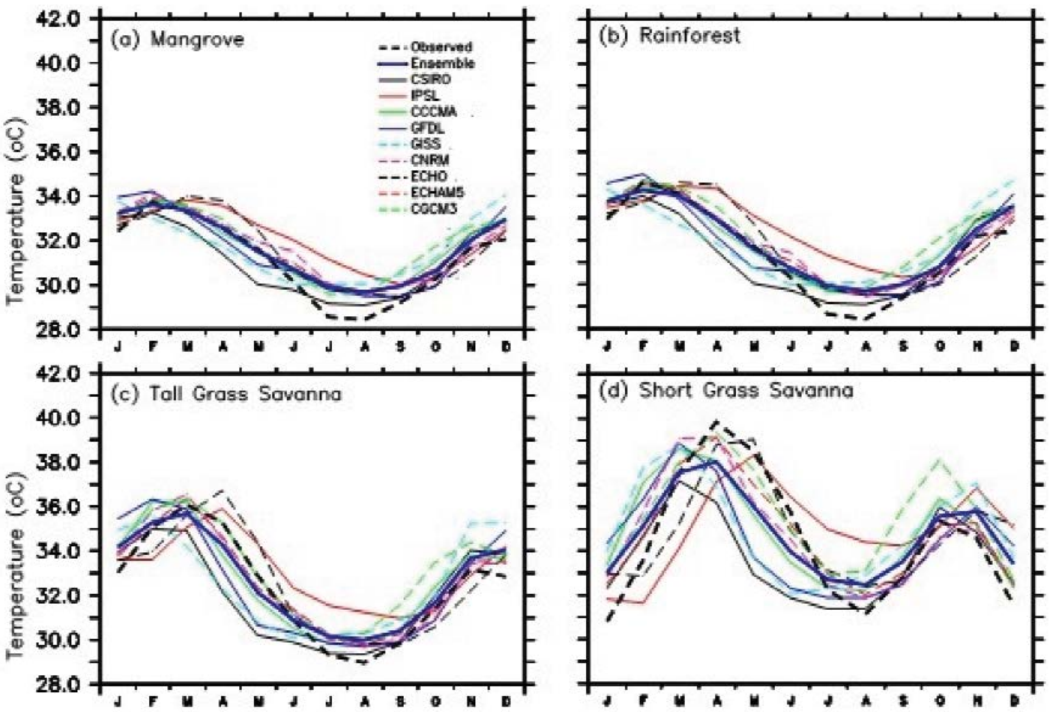


Figure 3 Observed and simulated mean (1971-2000) seasonal variation of maximum temperature for Nigeria.

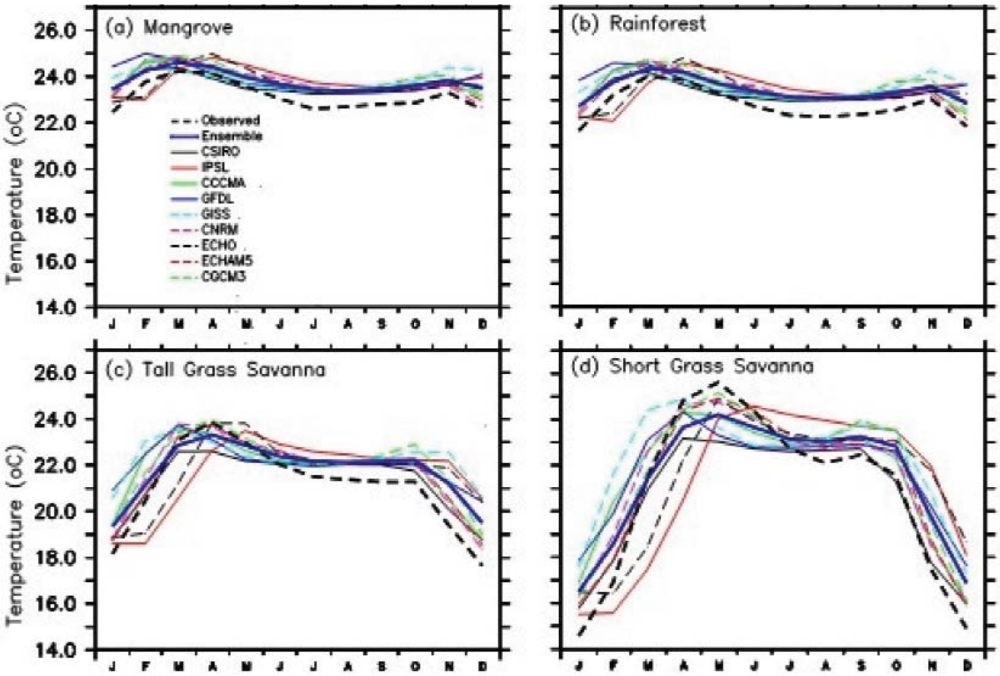


Figure 4 Observed and simulated mean (1971-2000) seasonal variation of minimum temperature for Nigeria.

3.1.2 Spatial Distribution of Annual Mean

The downscaled ensemble simulation reproduces the spatial distribution of maximum and minimum temperature very well. Figures 5(a) and 5(b) show that in both observation and simulation, maximum temperature generally increases from the coastal region (about 30°C) to the inland regions (about 36°C). It is interesting to note that the simulation captures the influence of topography in producing a local minimum value over the Jos Plateau. This is typically not captured by GCM results that have not been downscaled. However, the simulation underestimates the maximum temperature over the Jos plateau by 1°C. Apart from this, there is no significant difference between the simulated maximum temperature and the observed temperature. In contrast to the maximum temperature distribution, the minimum temperature patterns show a decrease from the southwest (25°C in simulation and 24°C observation) to the northeast (22°C in simulation and 21°C in observation). The simulation shows a warm bias of 1°C over the country in general, but a cold bias (1°C) over the Jos Plateau. Nevertheless, the close agreement between the simulated and observed temperature fields demonstrates that the downscaling technique captures the temperature pattern of Nigeria remarkably well.

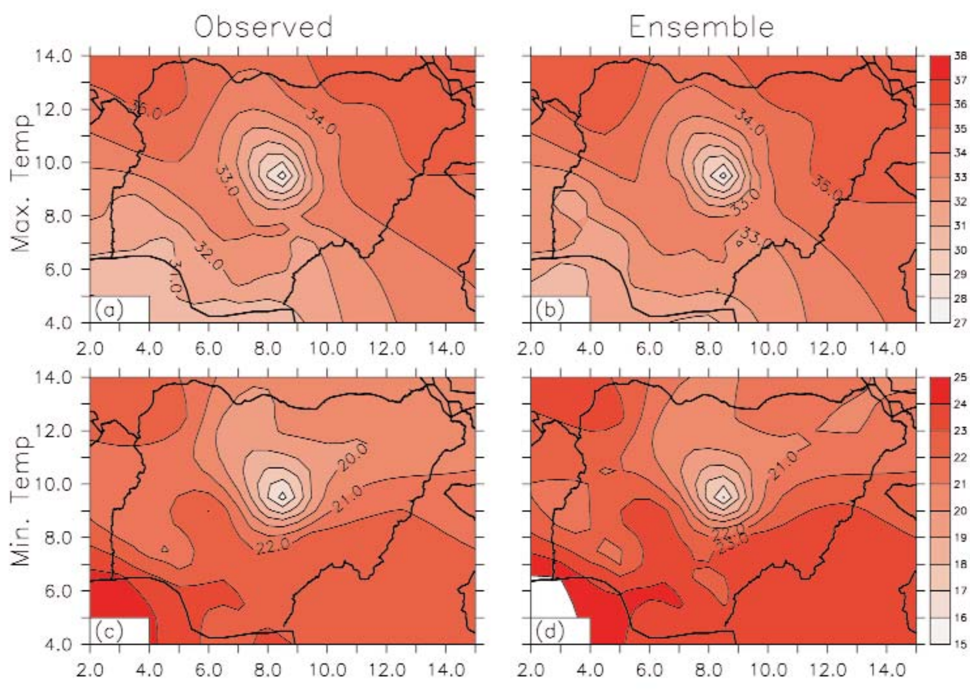


Figure 5 Observed and simulated (ensemble) annual mean (1971-2000) of maximum and minimum temperatures for Nigeria.

3.1.3 Recent Changes

Table 3 presents trends in maximum and minimum temperature for Nigeria in the periods of 1971-2000 and 1981-2000 for downscaled and observation data (obtained from weather stations and the CRU). In 1971-2000, the observations show significant positive trends for maximum temperature (0.014 and 0.018°C per year, respectively) and for minimum temperature (0.025 and 0.025°C per year, respectively). This indicates that over the period, the maximum temperature has increased by approximately 0.5°C and the minimum temperature by 0.8°C. The model ensembles show much lower positive trends (0.004 and 0.003 for maximum and minimum temperatures, respectively). Hence, the ensemble underestimates the temperature trends in 1971-2000. However, the ensemble shows more comparable trends with observation in 1981-2000, although the analysis suggests that none of the ensemble trends is statistically significant.

Table 3 Simulated and observed trends in maximum and minimum temperature and rainfall in present-day climate: 1971-2000 and 1981-2000. Least square regression and Mann-Kendall trend were used for the analysis.
*denotes 95% significant level; ** denotes 99% significant level; and
*** denotes 99.9% significant level

Period	Variable	Observation Station	Ensemble	Observation CRU
1971-2000	Maximum Temperature (°C per year)	0.014*	0.004	0.018*
	Minimum Temperature (°C per year)	0.025***	0.003	0.025**
	Rainfall (mm day^{-1} per year)	6.76*	-4.00	2.67*
1981-2000	Maximum Temperature (°C per year)	0.020	0.010	0.003*
	Minimum Temperature (°C per year)	0.008	0.014	0.006**
	Rainfall (mm day^{-1} per year)	11.25**	7.00	11.267**

Figure 6 presents the spatial distribution of trends in temperature and occurrence of heat waves in 1981-2000 in Nigeria. Heat waves occur when the maximum temperature is greater than 35°C for three days or more consecutively. With the maximum and minimum temperature, the ensemble shows a negative trend over the southern regions of the country and a positive trend over the northern regions. This is largely consistent with trends observed in the station and CRU data, except that the negative trend is limited to the southwest region in the observations and another negative trend occurs at northeast in observed minimum temperature. Nevertheless, both observation and model ensemble suggests a distribution of positive and negative temperature trends for Nigeria in 1981-2000. This pattern is the same with the trends of 1971-2000 (not shown), except that the ensemble trends are lower by a factor of ten. In addition, for both periods (1971-2000 and 1981-2000) the models and observation show an increase in the occurrence of heat waves (about 1-2 days per year) over the most parts of the country (Figure 6).

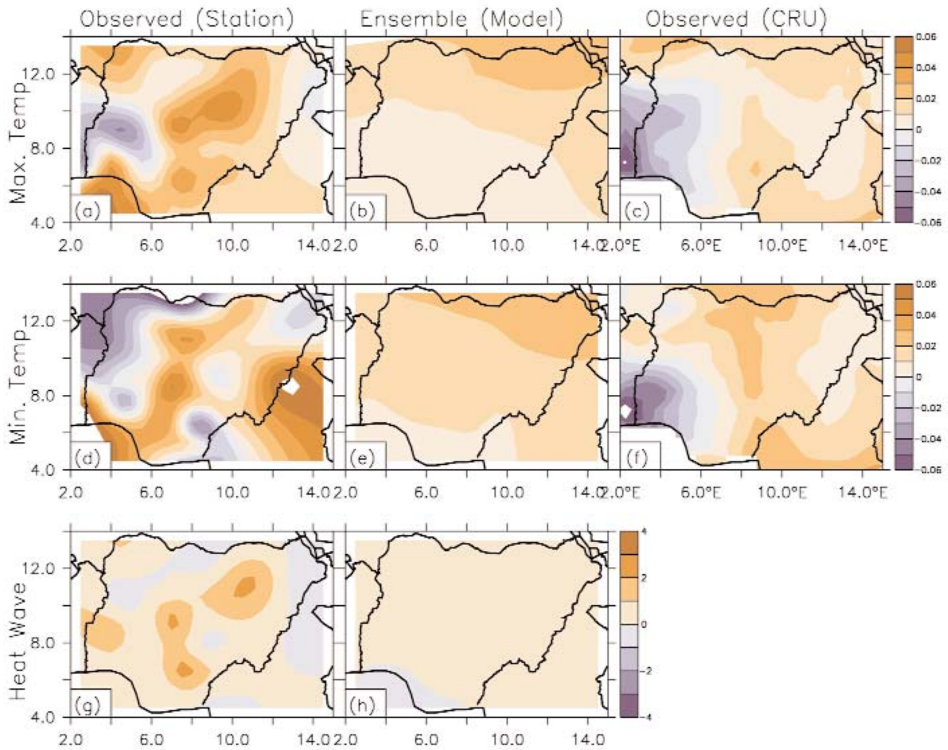


Figure 6 Observed (left and right panels) and simulated (middle panels) trends in maximum temperature (upper panels; °C per year), and minimum temperature (middle panels; °C per year) and heat wave (lower panels; days per year) in Nigeria in 1981-2000.

3.2 Rainfall

3.2.1. Seasonal Variation

Figure 7 presents the seasonal variations of the downscaled and observed rainfall over four ecological zones in Nigeria. Each model reproduces the seasonal variation of rainfall pattern, except that they all fail to capture the short dry season in August over the Mangrove and Rainforest zones. The reason for this failure is not known and is under investigation[5]. The multi-model ensembles give better results than any of the individual models; however, they underestimate the rainfall during the peak of the monsoon (between July-Sept.) over all zones. Nevertheless, the level of agreement between the simulated and observed seasonal rainfall pattern shows that the downscaling techniques captures the monsoon cycle and the associated rainfall patterns for Nigeria with an acceptable degree of accuracy.

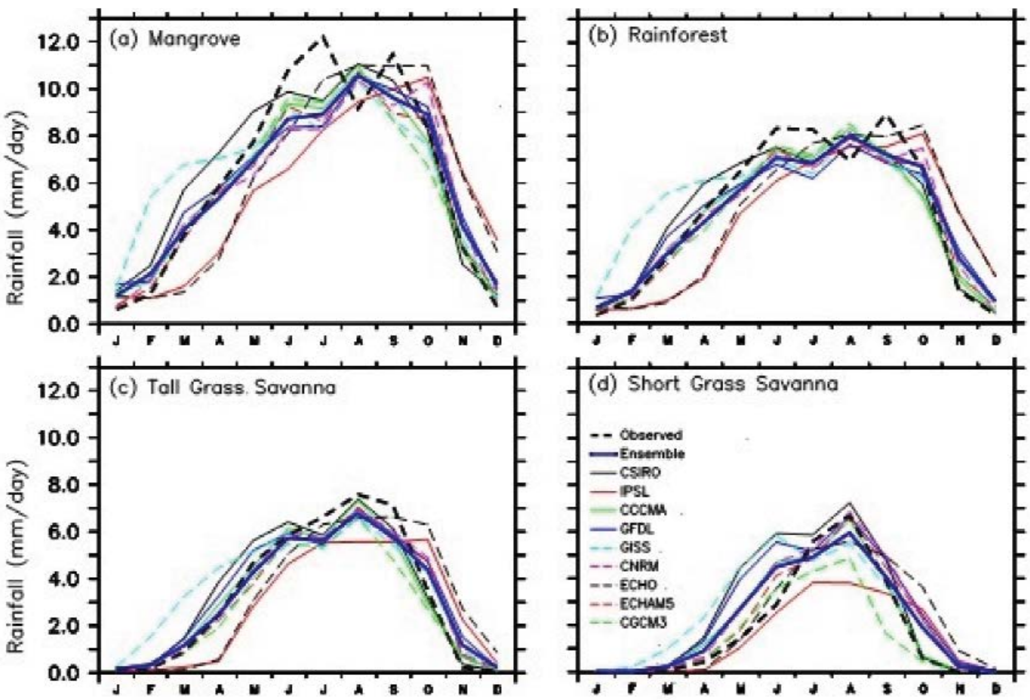


Figure 7 Observed and simulated mean (1971-2000) seasonal variation of rainfall for Nigeria.

[5] Personal communication, Bruce Hewitson, University of Cape Town

3.2.2 Spatial Variation

As seen in Figure 8, the downscaled simulation captures the rainfall spatial pattern. Consistent with observations, the simulated rainfall shows a decrease in rainfall from the coastal region to the inland region. Interestingly, the model also captures the influence of the Jos Plateau on the rainfall pattern (through comparison of Figures 2 and 8). The highest variation in the simulated rainfall pattern is less than less 2 mm/day. Hence, the level of agreement between the simulation and observation rainfall pattern confirms the reliability of the model in capturing the spatial distribution of climatic variability in Nigeria.

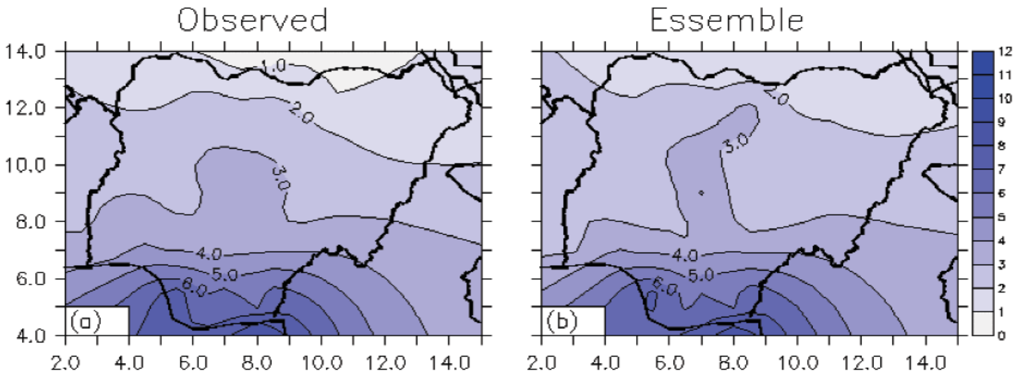


Figure 8 Observed and simulated (ensemble) annual mean (1971-2000) of rainfall (mm/day) temperatures for Nigeria.

3.2.3 Recent Changes

Table 3 presents trends in rainfall for the country in the periods of 1971-2000 and in 1981-2000 for downscaled and observation data (from both weather stations and the CRU). In 1971-2000, the observations show statistically significant positive trend for rainfall (6.76 and 2.67mm day^{-1} per year, respectively). The models ensemble also shows a negative trend (-2.67mm day^{-1} per year). However, the ensemble trend shows a closer agreement with observation in 1981-2000 (+7.00 day^{-1} per year for the ensemble; 11.3 day^{-1} per year for the observations), but the ensemble trend is not statistically significant.

Figure 9 presents the spatial distribution of the trends in rainfall, onset of rainfall and the length of rainfall season for 1981-2000 in Nigeria. Here, the onset of rainfall season is defined as the beginning of the first two rains totaling at least 25 mm in Tall Grass Savanna within 7 days, followed by 2-3 weeks each with at least 50% of weekly water requirement, which are 1.6, 3.6 and 4.6 mm in Guinea, Savanna (Tall Grass Savanna), and Sahel (Short Grass Savanna) region respectively (Omotosho, 2000). The length of the rainfall season is the period between the onset and cessation of rainfall. Figure 9 shows a positive trend in rainfall in Nigeria, except in the weather station observation which indicates a negative trend over Tall Grass Savanna zone.

The ensemble shows opposite scenarios for the southern and northern regions of Nigeria in terms of onset and duration of rain. In the south, the onset of rainfall is becoming earlier and the rainy season is becoming longer. In the north, the onset of rains is later and the duration is shorter. However, the observation data show the earlier onset of rainfall and the longer rainfall season over the entire country.

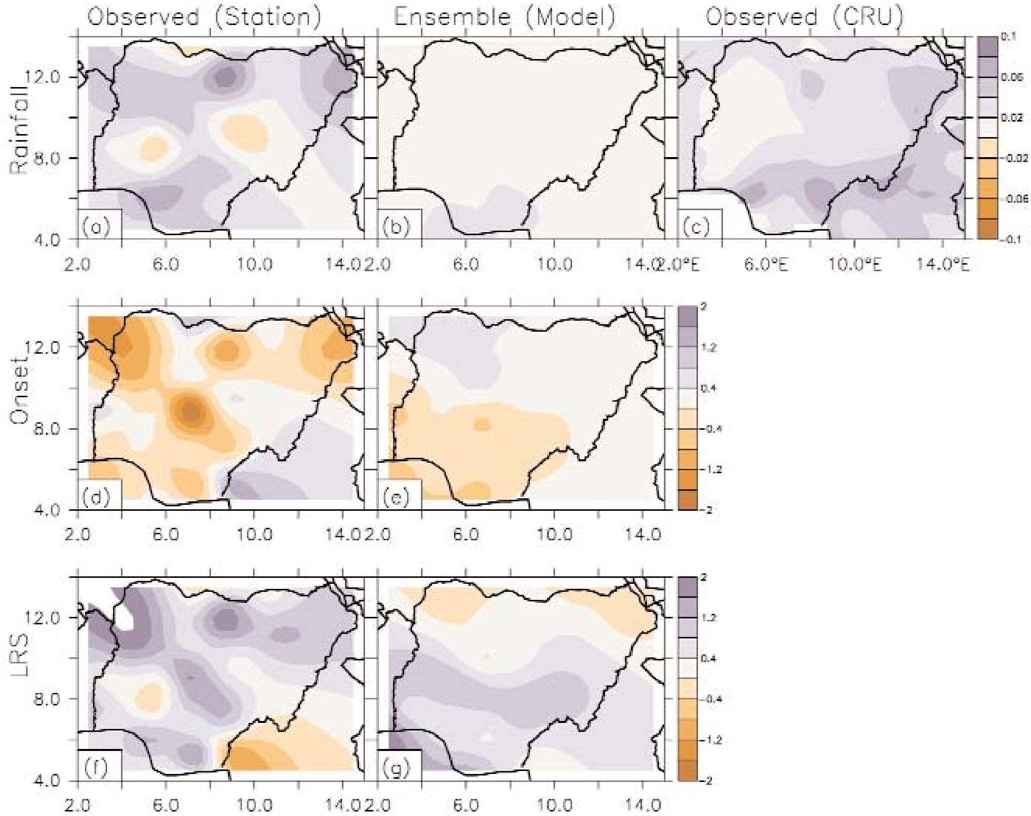


Figure 9 Observed and simulated recent trends in rainfall, onset of rainfall, and length of rainy season (LRS) in Nigeria.

4. Future Climate of Nigeria downscaled from GCMs

Having benchmarked the climate over Nigeria using the capability of SOMD technique, the same technique was then applied to downscale the future climate simulations using B1 and A2 scenarios. This was done for the future periods of 2046-2065 and 2081-2100 in Nigeria. The downscaling was limited to these periods due to a lack of availability of the GCMs daily datasets and A2 and B1 scenarios for the other future time periods (i.e. 2001-2039 and 2066-2079). The downscaling was done for the forty stations and the changes in the climate were obtained by computing the differences between the downscaled present and future climate simulations (i.e. future minus present). Detailed results of climate change for each weather station are given in the appendix. The following section includes a discussion of the effect of climate change on maximum and minimum temperature, onset and duration of the rainfall season, and extreme weather events that produce heat waves, flooding and drought. The focus is on changes at national and zonal levels.

4.1 Temperature

Figure 10 presents the time series of predicted minimum and maximum temperature changes during the periods of 2046-2065 and 2081-2100 using the B1 and A2 scenarios for Nigeria. The anomalies are calculated with respect to the mean of present-day climate. In the figure, the thick line represents the models' average while the shaded region represents the area of a standard deviation away from the average. Both scenarios project a warmer climate in future, but the future climate is warmer according to the A2 scenario compared with the B1 scenario. B1 scenario projects a consistent increase of +0.20°C per decade from 2000 till late-century (2100), while A2 projects +0.40°C per decade from 2000 till mid-century (2046-2065), and +0.80°C per decade in late-century (2080-2100) (Fig. 10). By mid-century, the projected annual temperature changes in Nigeria are +1.5°C and +0.2°C for B1 and A2 scenarios, respectively. These values are within the range of those shown over Nigeria in the IPPC (2007) report. The increase in temperature in Nigeria from global scenarios are higher (by 0.2°C and 0.3°C, respectively) than the global mean given in the IPCC report. Similar to findings in the IPCC (2007) report, the difference between the temperature change in B1 and A2 scenarios becomes wider; it is about 0.5 in mid-century and 2.0 in the late-century (Figure 10).

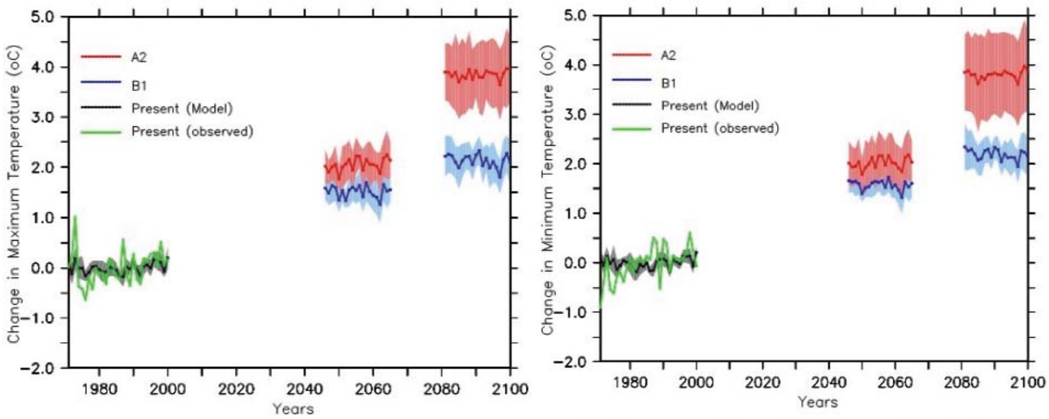


Figure 10 Time series of changes in maximum and minimum temperature for present-day and future climate in Nigeria under B1 and A2 scenarios. The dashed lines show station observation; the full lines represent the models mean, while the shaded regions are areas of a standard deviation away from the mean.

Figures 11 and 12 present the spatial distribution of the temperature changes for Nigeria. The changes are relative to the present-day climate. Both scenarios show positive changes in temperature over the entire country however the level of the change increases with latitude, thus the lowest values is seen in the coastal region and the highest in the northeast. The coastal regions show less warming than the interior due to the cooling effect of the Atlantic Ocean. Hence, the northern stations are expected to be warmer than the southern stations. The temperature changes predicted for each station are in listed in Table A3 of the Appendices. In the northeast, according to the B1 scenario, the temperature change will increase by+1.8°C in mid-century (2046-2065) and by +2.2°C in late-century (2081-2100. According to the A2 scenario, the temperature change will jump from +2.2°C in mid-century (2046-2065) to +4.5°C late-century (2081-2100). This temperature distribution is consistent with those given for Nigeria in the IPCC report. However, it is important to note here that the unequal distribution of temperature change would increase the temperature gradient over the country, which would have dynamic effects on the wind pattern. For example, it will increase the speed of the monsoon flow, which transports moisture into the country.

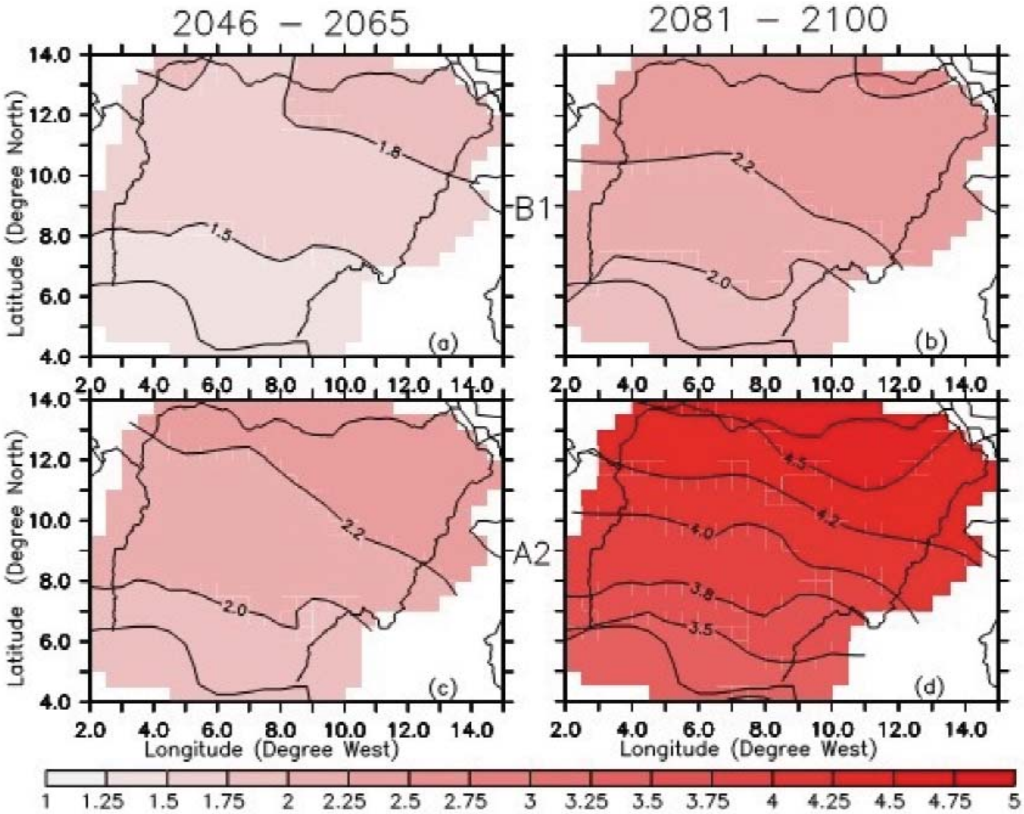


Figure 11 Projected changes in maximum temperature for Nigeria in the future (2046-2065 and 2081-2100) for B1 and A2 scenarios.

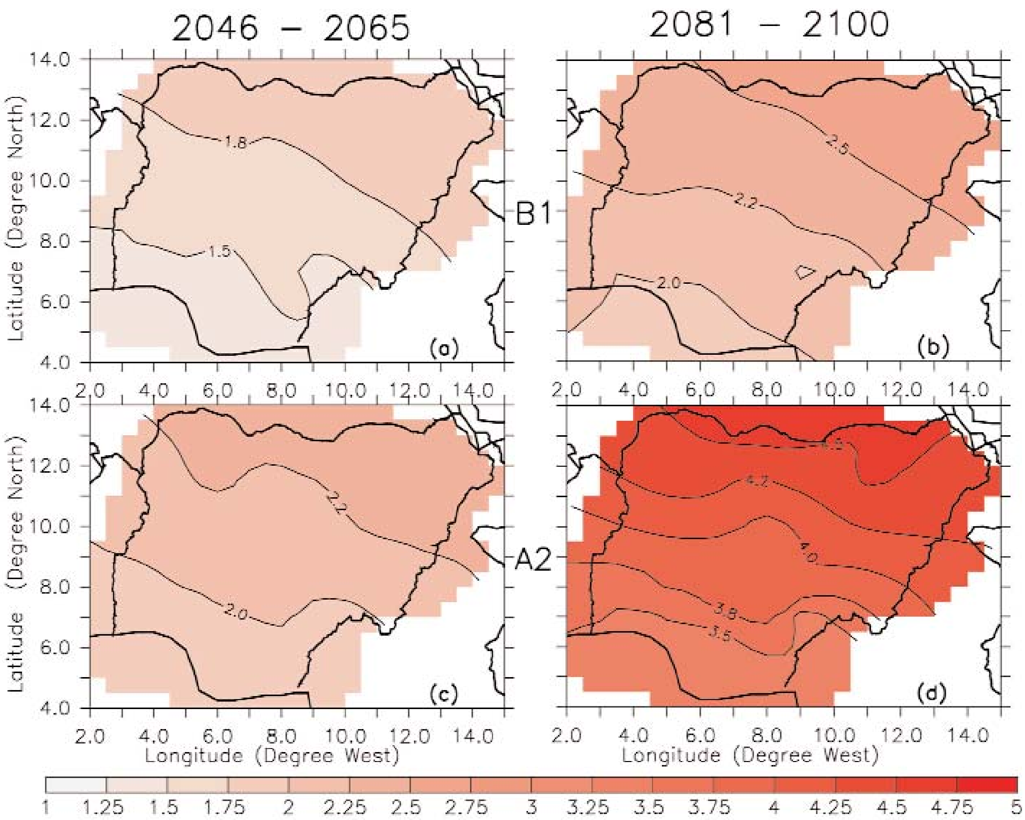
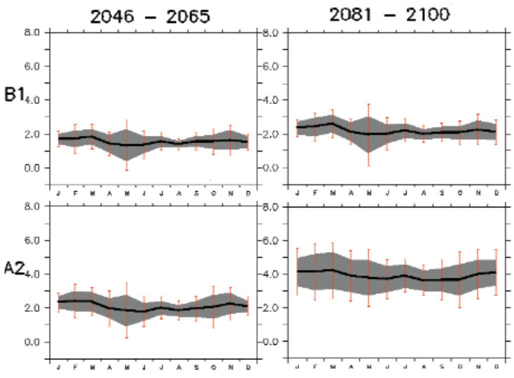
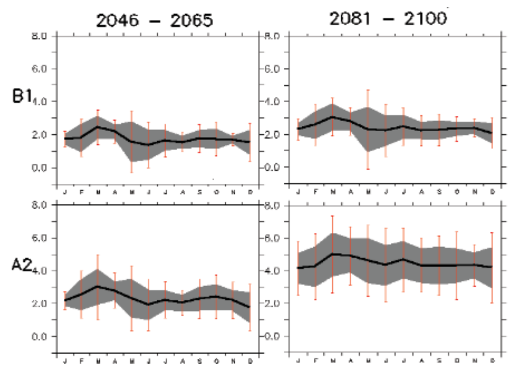


Figure 12 Projected changes in minimum temperature over Nigeria in future (2046-2065 and 2081-2100) for B1 and A2 scenarios.

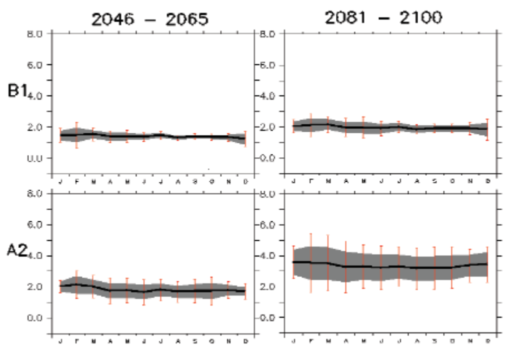
Figures 13 and 14 present changes in the seasonal variation of temperature for four of the ecological zones. The full line shows the models' average, while the shaded region represents the area of a standard deviation away from the mean. The line bars indicate the maximum and minimum values from models' values. The temperature change is uniform throughout the year in the Mangrove and Rainforest zones, but has a tendency to be higher in February and March over the Savanna (Tall Grass and Short Grass) zones. However, over all zones, the projections of the models show a wider spread (i.e. larger variance) in A2 than in B1 scenario. This means that there are larger uncertainties in the A2 projections than in the B1 projections and these uncertainties are lower in the late-century than in mid-century.



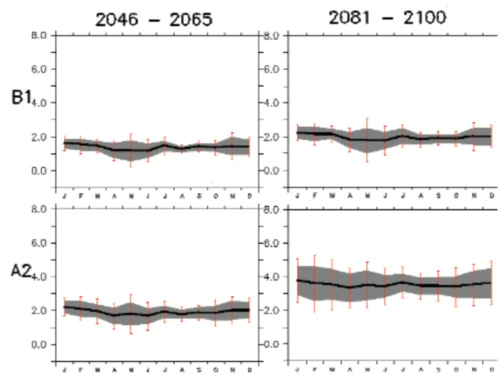
(c)Tall Grass Savanna



(d) Short Grass Savanna



(a) Mangrove



(b) Rainforest

Figure 13 Projected changes in seasonal variation of maximum temperature in future using B1 and A2 scenarios for the ecological zones in Nigeria.

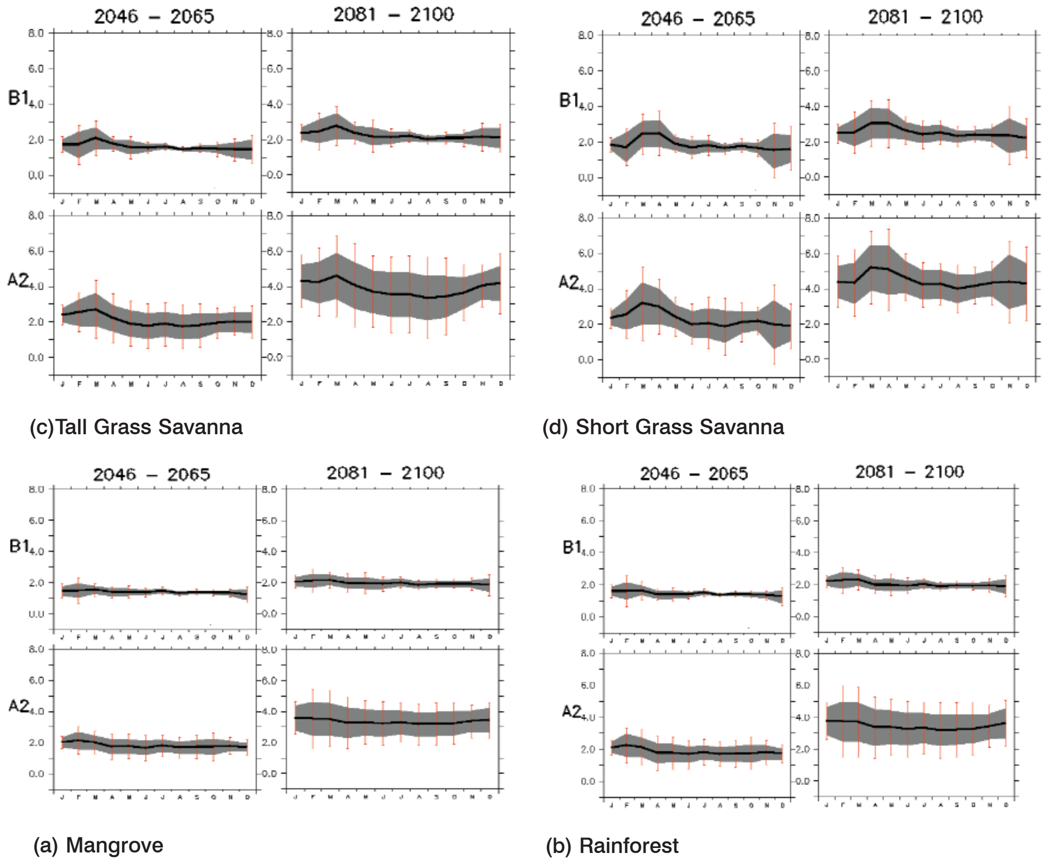


Figure 14 Projected changes in seasonal variation of maximum temperature in future using B1 and A2 scenarios over the ecological zones in Nigeria

Figures 15 and 16 present the frequency distribution of the projected temperature changes in each of the four ecological zones. This distribution is obtained from changes across all the weather stations within the zone, all the models and all the months. The figures show that, over the zones, the distribution shifts towards the positive sign (i.e. warming), and the most probable event is increase in temperature, with increasing magnitudes in future periods. In addition, it suggests that a temperature change of +6°C is possible in the Short Grass Savanna zone in the late-century (2081-2100), under the A2 scenario.

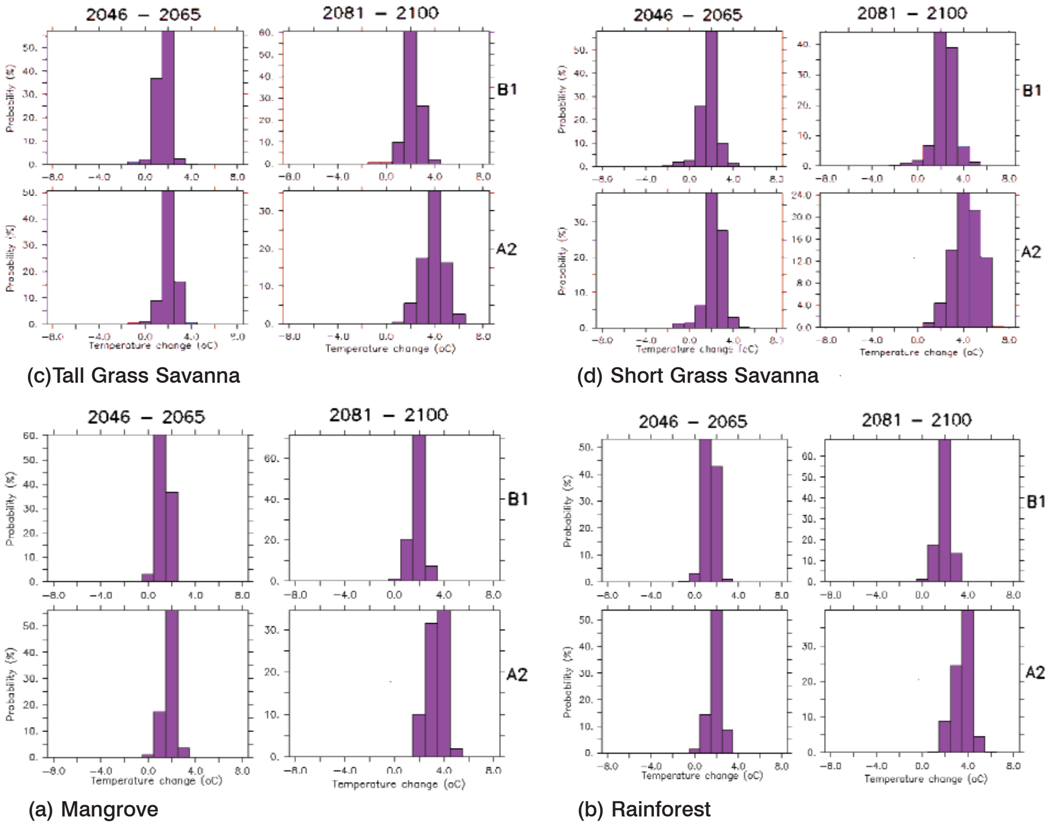


Figure 15 The frequency distribution of changes in maximum temperature in future for B1 and A2 scenarios for four of the ecological zones in Nigeria.

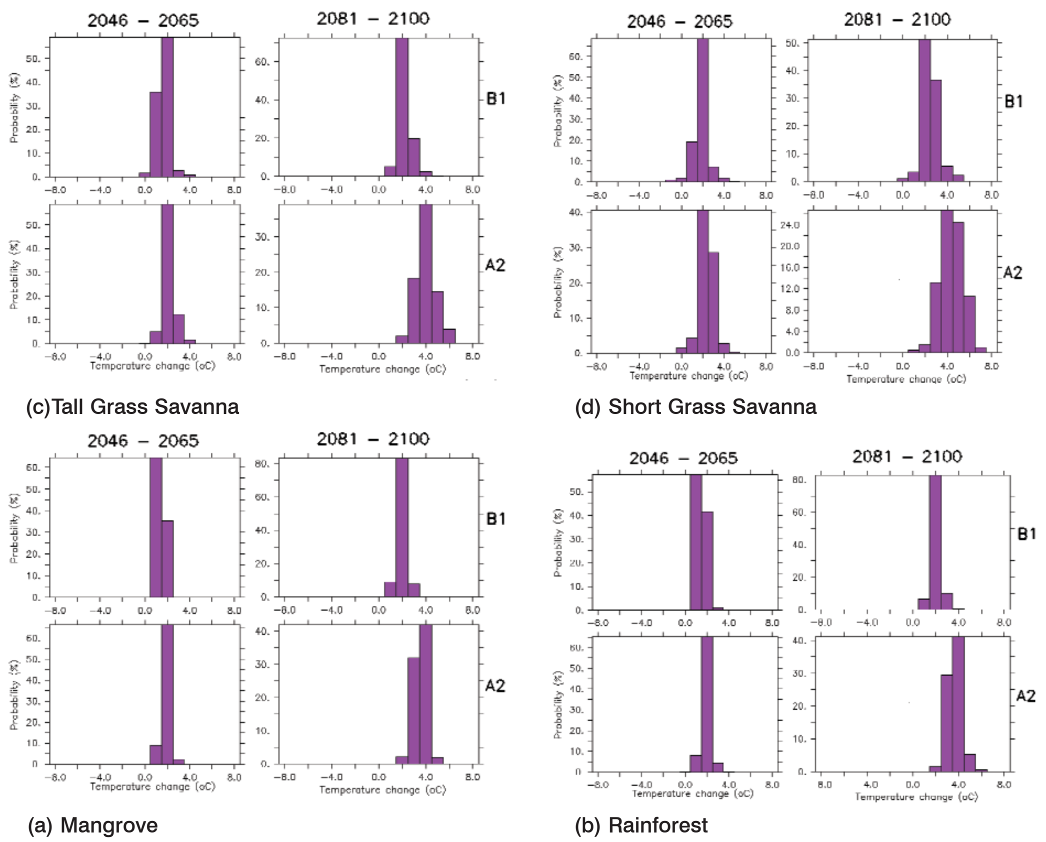


Figure 16 The frequency distribution of changes in minimum temperature in future for B1 and A2 scenarios for four of the ecological zones in Nigeria.

4.2 Rainfall

Figure 17 presents the time series of rainfall changes averaged for Nigeria for both B1 and A2 scenarios. The anomalies are calculated with respect to the means of the present-day climate. In the figure, the full line represents the models' average, while the shaded region represents the area of a standard deviation away from the mean. The figure demonstrates that there is no specific trend in future rainfall anomalies.

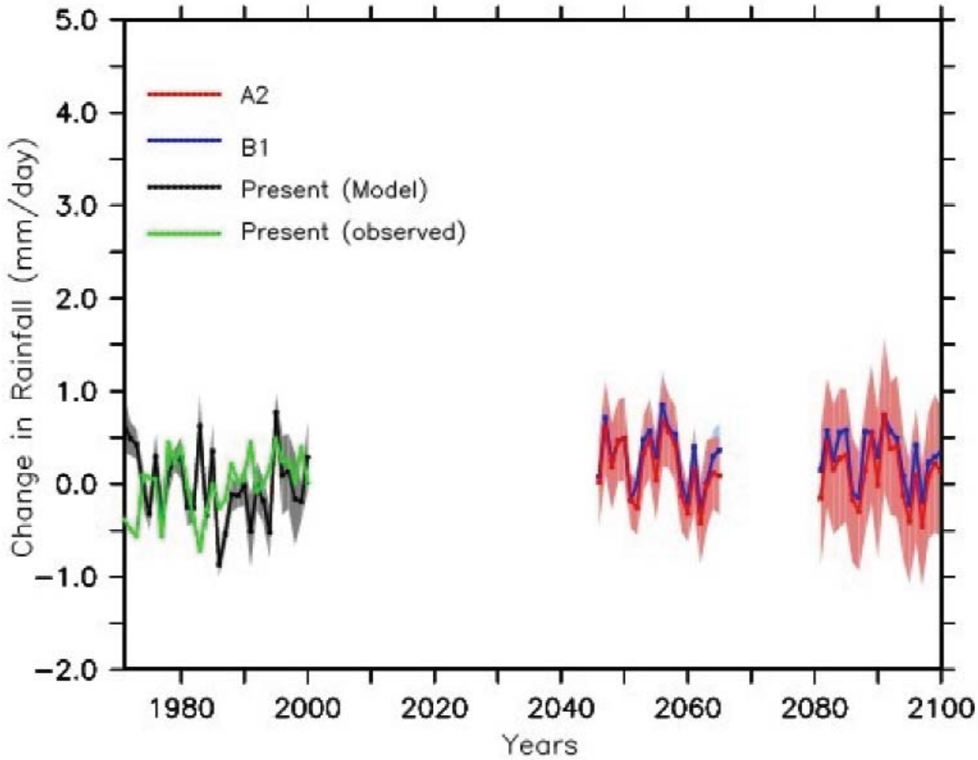


Figure 17 Time series of changes in rainfall (mm/day) for present-day and future climate of Nigeria under B1 and A2 scenarios. The dashed show station observation; the lines represent the models mean, while the shaded regions are areas of a standard deviation away from the mean.

Figure 18 presents the spatial distribution of the changes in rainfall patterns. The values are relative to the present-day climate. With B1 scenario, the models suggest a wetter climate over the entire country, with the highest increase (mm/day) in the coastal region and the lowest (mm/day) value in the northeast region. The rainfall pattern does not change between the mid-century and late-century. With A2 scenario, the models suggest a wetter climate over most regions in the country, except in the northeast, where they predict a drier climate. They also show the possibility that the Jos plateau may have a drier climate in the late-century. The model results for both scenarios are consistent with changes in the temperature pattern. With the increase in the temperature predicted in Figures 11 and 12, the atmosphere will require more moisture to be saturated and give rainfall. Hence, the increase in temperature along the coast would lead to greater evaporation from the ocean atmosphere thereby producing more rainfall over the coastal region. On the other hand, the warmer temperature in the semi-arid northeast region would decrease the atmospheric humidity, thereby reducing the chance of cloud formation and rainfall. Consistent with this, the northeast would have a drier climate under A2 scenario than under B1 scenario, because the temperature is higher under A2 scenario.

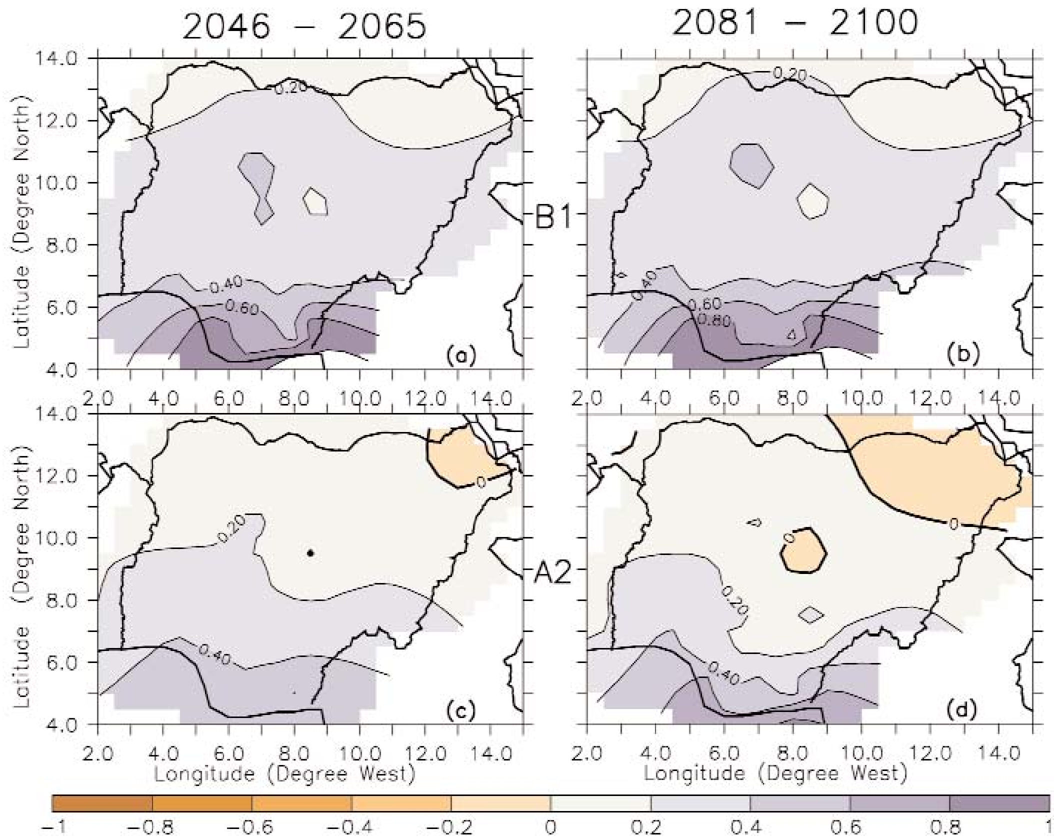


Figure 18 Projected changes in rainfall over Nigeria in future (2046-2065 and 2081-2100) for B1 and A2 scenarios.

Figure 19 presents the seasonal variation of rainfall and maximum and minimum temperature changes in each zone under B1 and A2 scenarios. The full line shows the models' average, while the shaded region represents the area of a standard deviation from the mean. The line bars indicate the maximum and minimum values from model values. Over each zone, the models suggests a peak increase of approximately 2 mm/day in August in the Mangrove and Rainforest zones and about 1 mm/day in the same month over Short Grass Savanna and Tall Grass Savanna zones. In general, the increase in temperature is uniform for all the months over the Mangrove and Rain forest, but shows a tendency to be higher in February and March in the Tall Grass Savanna and Short Grass Savanna.

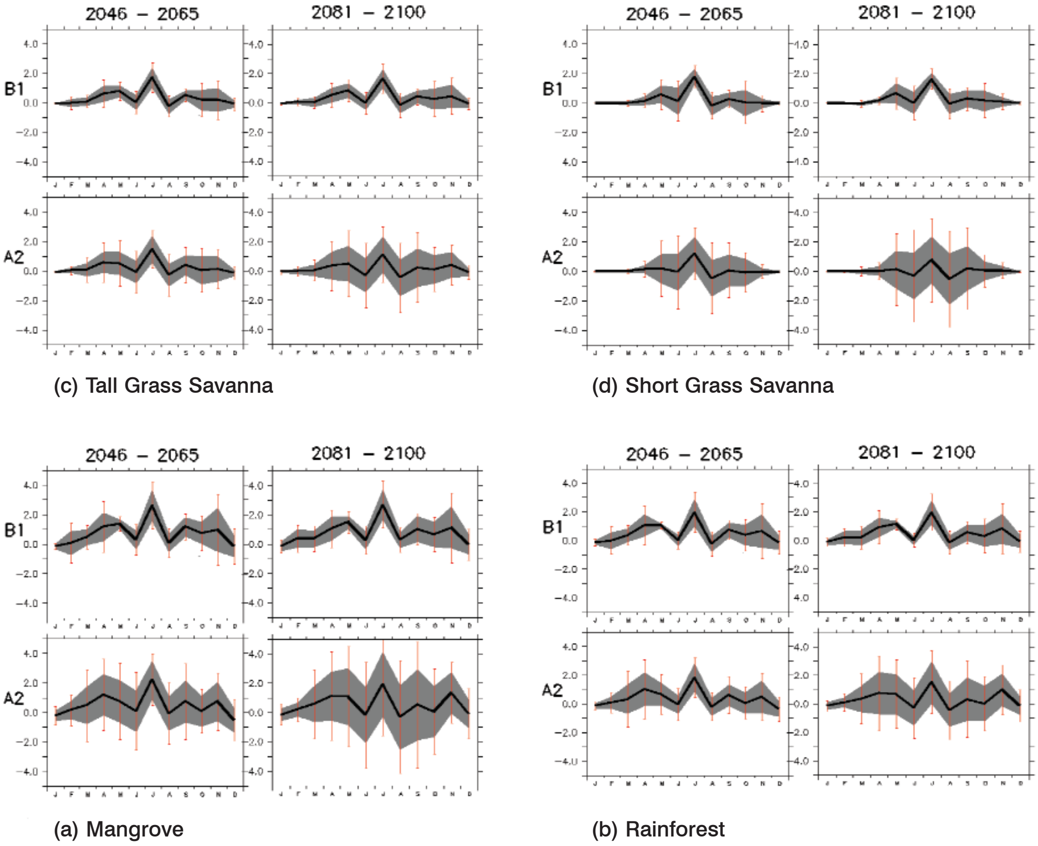
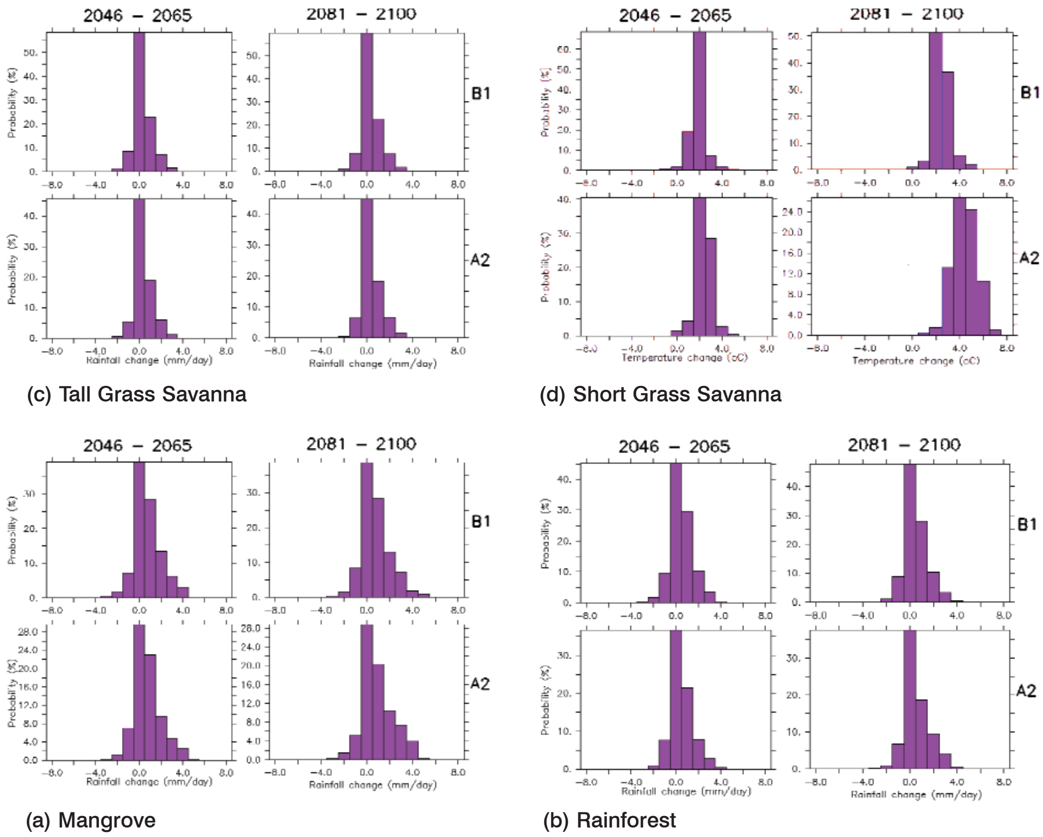


Figure 19 Projected changes in seasonal variation of rainfall in future using B1 and A2 scenarios in four of the ecological zones in Nigeria.

Figure 20 shows the frequency distribution of the projected changes in rainfall and minimum and maximum temperature for each ecological zone for both B1 and A2 scenarios in the two time periods. This distribution is obtained from changes across all the stations within the ecological zone, all models and all months. Over the zones, although the rainfall change of ±5 mm/day has the highest probability frequency, the distribution is skewed towards positive values. The distribution over the Mangrove and Rainforest zones suggest that an increase of 4 mm/day is possible in those zones.



(c) Tall Grass Savanna

(d) Short Grass Savanna

(a) Mangrove

(b) Rainforest

Figure 20 The frequency distribution of changes in maximum temperature in future for B1 and A2 scenarios over the ecological zones in Nigeria.

4.3 Extreme Temperature and Rainfall Events

The models project an increase in future occurrences of extreme temperature and rainfall events over all four of the ecological zones in Nigeria in both B1 and A2. In the mid-century (2046-2065), the number of days with temperatures greater than 38°C would increase by 3, 5, 33 and 67 days over Mangrove, Rain Forest, Short Grass Savanna, and Tall Grass Savanna, respectively under B1 scenario. Under the A2 scenario, the increases would be 7, 23, 40 and 82 days respectively. The number of days with heat waves would increase by 23, 32, 43 and 68 days respectively under the B1 scenario in mid-century, and by 39, 51, 60 and 85 days respectively according to the A2 scenario (Tables 3-6). These values are virtually doubled in late-century (2081-2100). The number of days with extreme rainfall (50 mm/day) increases by 1-2 days over all the ecological zones for both scenarios, except over the Savanna zones in the late-century when a decrease of one day is projected. The projected increase in extreme rainfall events is consistent with what is expected, especially in the coastal regions due to the increase in atmospheric evaporation following the predicted temperature increase. This would cause more water to be released during the rainfall events. Furthermore, both scenarios show an increase of 1-2 weeks in the length of the rainfall season over the zones in mid-century and late-century, except over the Short Grass savanna, where both scenarios project a decrease of less than one week. In most cases, the increase in the length of the rainfall season is due to the earlier onset of rain (see Tables 4-7). The earlier onset of the rainfall season is consistent with the projected increase in temperature gradient and the speed of monsoon flow, which would bring in moisture faster and initiate the onset of the rainfall season earlier over the country.

Table 4 Extreme Events in Mangrove zone.

Parameter	Extreme Event	Baseline Values	Changes with B1		Changes with A2	
		Baseline (1981-2000)	2046-2065	2081-2100	2046-2065	2081-2100
Rainfall (Intensity precipitation and drought)	Rainfall Onset Date (Julian day)	67.7	-7.3	-10.3	-9.7	-11.3
	Rainfall Cessation Date (Julian day)	314.6	7.0	6.0	5.7	5.9
	Length Rainfall Season (days/year)	247.3	14.5	15.4	15.6	16.5
	Number of rainfall event (days/year)	125.4	24.5	25.1	20.8	21.2
	Number of days with rainfall greater than 50 mm/day (days/year)	8.8	1.8	1.7	1.1	1.3
	Number of days with rainfall greater than 100 mm/day (days/year)	1.2	0.1	0.1	-0.1	0.0
Temperature (Heat waves and cold events)	Number of days with maximum temperature greater 35°C (days/year)	20.3	65.1	92.4	88.8	169.6
	Number of days with maximum temperature greater than 38°C (days/year)	0.3	2.5	7.7	7.1	46.4
	Number of days with minimum temperature less than 10°C (days/year)	1.6	-0.5	-0.5	-0.1	-0.1
	Number of days with minimum temperature less than 5°C (days/year)	1.6	-0.5	-0.5	-0.1	-0.1
	Number of days with heat waves (days/year)	1.8	22.7	42.4	39.4	108.6

Table 5 Extreme events in Guinea zone.

Parameter	Extreme Event	Baseline Values	Changes with B1		Changes with A2	
		Baseline (1981-2000)	2046-2065	2081-2100	2046-2065	2081-2100
Rainfall (Intensity precipitation and drought)	Rainfall Onset Date (Julian day)	77.5	-6.6	-8.7	-8.0	-8.6
	Rainfall Cessation Date (Julian day)	315.3	1.3	1.3	0.4	0.1
	Length Rainfall Season (days/year)	238.2	7.6	9.7	8.0	8.3
	Number of rainfall event (days/year)	118.3	9.8	10.6	6.2	4.9
	Number of days with rainfall greater than 50 mm/day (days/year)	5.4	0.9	0.9	0.7	0.6
	Number of days with rainfall greater than 100 mm/day (days/year)	0.4	0.2	0.2	0.1	0.1
Temperature (Heat waves and cold events)	Number of days with maximum temperature greater 35°C (days/year)	56.8	48.3	73.3	71.8	151.4
	Number of days with maximum temperature greater than 38°C (days/year)	4.6	12.4	25.0	22.9	69.7
	Number of days with minimum temperature less than 10°C (days/year)	1.7	-0.6	-0.6	-0.2	-0.2
	Number of days with minimum temperature less than 5°C (days/year)	1.7	-0.6	-0.6	-0.2	-0.2
	Number of days with heat waves (days/year)	13.9	31.6	54.1	51.3	119.7

Table 6 Extreme events in Tall Grass Savanna zone.

Parameter	Extreme Event	Baseline Values	Changes with B1		Changes with A2	
		Baseline (1981-2000)	2046-2065	2081-2100	2046-2065	2081-2100
Rainfall (Intensity precipitation and drought)	Rainfall Onset Date (Julian day)	118.0	-6.6	-9.7	-7.0	-4.1
	Rainfall Cessation Date (Julian day)	295.4	1.1	1.3	-1.7	0.1
	Length Rainfall Season (days/year)	177.7	11.3	10.8	5.1	4.2
	Number of rainfall event (days/year)	85.1	6.9	7.0	3.5	2.1
	Number of days with rainfall greater than 50 mm/day (days/year)	3.7	0.3	0.3	0.1	0.0
	Number of days with rainfall greater than 100 mm/day (days/year)	0.2	0.0	0.0	0.0	0.0
Temperature (Heat waves and cold events)	Number of days with maximum temperature greater 35°C (days/year)	100.5	47.6	68.9	66.9	137.3
	Number of days with maximum temperature greater than 38°C (days/year)	32.5	26.3	43.6	40.7	96.5
	Number of days with minimum temperature less than 10°C (days/year)	2.5	-1.3	-1.3	-0.9	-1.0
	Number of days with minimum temperature less than 5°C (days/year)	2.5	-1.3	-1.3	-0.9	-1.0
	Number of days with heat waves (days/year)	49.8	43.0	62.8	60.0	123.0

Table 7 Extreme events in Short Grass Savanna zone.

Parameter	Extreme Event	Baseline Values	Changes with B1		Changes with A2	
		Baseline (1981-2000)	2046-2065	2081-2100	2046-2065	2081-2100
Rainfall (Intensity precipitation and drought)	Rainfall Onset Date (Julian day)	150.2	-4.2	-5.1	0.7	3.4
	Rainfall Cessation Date (Julian day)	272.5	-5.0	-4.2	-6.1	-3.6
	Length Rainfall Season (days/year)	122.8	-0.7	0.8	-6.3	-5.5
	Number of rainfall event (days/year)	57.3	0.4	0.4	-3.1	-3.7
	Number of days with rainfall greater than 50 mm/day (days/year)	2.7	0.1	0.2	-0.2	-0.3
	Number of days with rainfall greater than 100 mm/day (days/year)	0.1	0.0	0.0	0.0	-0.1
Temperature (Heat waves and cold events)	Number of days with maximum temperature greater 35°C (days/year)	153.0	75.6	98.3	92.8	154.6
	Number of days with maximum temperature greater than 38°C (days/year)	68.0	66.7	87.5	82.2	151.6
	Number of days with minimum temperature less than 10°C (days/year)	3.5	-2.1	-2.1	-1.5	-1.9
	Number of days with minimum temperature less than 5°C (days/year)	3.5	-2.1	-2.1	-1.5	-1.9
	Number of days with heat waves (days/year)	89.7	68.3	90.6	85.1	163.0

5. Biophysical Impacts of Climate Change in Nigeria

As outlined in the introduction of this report, the projected climate change will have impacts on biophysical sectors. In the following section, a description of the impacts of the predicted climate change on two major sectors: (i) agriculture and (ii) human health is provided.

5.1 Agriculture

In Nigeria, improved food production and food security could be pursued through either greater *intensification* of agricultural practices (i.e. increased use of chemical fertilizers and pesticides, changes in irrigation practices and improved seed stock) or conversely through *extensification* (i.e. less-intensive farming methods that require fewer inputs). A major problem with less-intensive farming methods is the growing population and the constraining land tenure system. This implies that enhancing food security in the country will rely more on intensification of farming activities. However, intensification of agriculture cannot be successful without an adequate knowledge of the climate-crop relationships. To assess the impact of climate on agriculture, we focus on the influence of climate on maize yields, as this is a common crop across all the ecological zones, making it a good index for crop productivity in Nigeria. Almost all the ethnic groups in Nigeria consume maize, either fresh or processed. Maize is also a vital ingredient for infant food, brewery, sugar, syrup and poultry feed industries (Sowumi and Akintola, 2010).

While the effects of climatic fluctuations on maize have been well recognized for a long time at the global level, they are inadequately studied and understood in West and Central Africa (Fakorede *et al.*, 2003). It is noted that the vulnerability and risk of crop production due to weather fluctuations and climate variability can be minimized if future weather variations are adequately predicted and a suitable process-based eco-physiological crop yield forecasting model be identified to produce real-time yield forecasts (Lansigan *et al*., 2000). There is a negative relationship between the number of rain days during the *early vegetative stage* of maize and the resulting yield (Fakorede *et al*., 2003). In other words, the greater the number of rain days during this early growth stage, the lower the eventual grain yield. Conversely, the higher the occurrence of drought during this early growth stage, the higher the yield. The ability to predict these events will help in planning for appropriate investments and interventions in the agriculture sector in the country.

In this study, the Agriculture Production Systems Simulator Model (APSIM) is used to simulate maize yields under past and future climates (Keating *et al*., 2002). APSIM has been well validated for West Africa (Akponikpe *et al*., 2010). The results of climate change scenarios were used in the crop model to assess the response of maize productivity to the changes in climate. The maize yield simulation for 1981 to 2000 provides the baseline simulation for assessing changes in crop yield in the future.

5.1.1 Baseline Simulation of Maize Yield

Figure 21 presents the simulated mean annual maize yield in Nigeria indicating that the highest crop yields occur over the Tall Grass and Short Grass Savanna zones. The result is consistent with a previous observational study (Madiyazhagan *et al*., 2004). The highest maize production occurs in the Savanna because these zones have the most favorable climate and soil for maize production in Nigeria. The zones (also known as "middle-belts") are usually referred to as the food basket of Nigeria, because the highest food production is recorded in these zones.

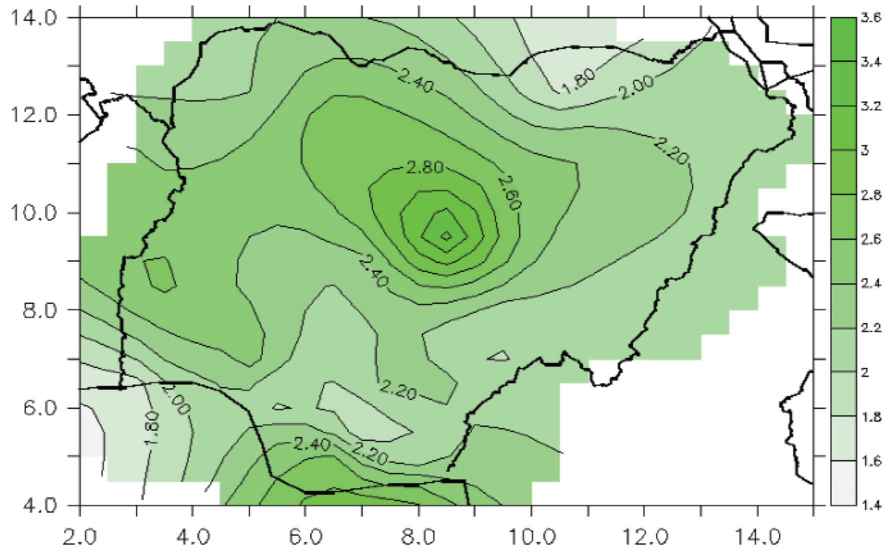


Figure 21 The simulated mean (1971-2000) annual yield of Maize (x 1000 tonnes per hectare).

5.1.2 Impact of Climate Change on Maize Yield

The projected climate change would cause a decrease in maize production over the entire country, as illustrated in Figure 22. However, the magnitude of the decrease varies by region and depends on whether scenario A2 or B1 is adopted. In general, the A2 scenario has higher impacts than the B1. In the mid-century, according to B1 scenario, maize production decreases by more than 10% over the entire country, except over the Jos Plateau, where a lower percentage is shown. According to the A2 scenario, the decrease in maize yield is more than 30% in the north-east region and approximately 20% south of 12°N. In the late-century, the percentage decrease at the northeast is approximately 30% and 60% for B1 and A2 scenarios respectively. In summary, the results indicate that the projected climate change would have negative impacts on maize production with the highest impact occurring in the northeast and decreasing in the southern regions.

The projected decline in crop productivity in Nigeria can be attributed mainly to the increase in temperature. Firstly, with the increased temperature, the optimum temperature for many crops would be exceeded in some zones. For example, although maize is a hot season crop, with optimum productivity in the temperature range of 21-30°C, the temperature range for maize would be exceeded in some zones in Nigeria, especially in Short Grass Savanna, where the temperature may be more than 38°C in the mid-century under A2 scenario. Madiyazhagan et al. (2004) observed that high temperature (greater than 30°C) compounded by water stress occurring at the same time decreases maize kernel planted in dry land environments. The results in this study agree with the WMO (1996) report that the global rising temperature would diminish the yield of some crops, especially if night time temperature increases. A higher night time temperature might increase dark respiration of plants, diminishing net biomass production. Secondly, the increase in air temperature without a corresponding increase in air moisture would lower the atmospheric humidity resulting in an increase in water stress. Thirdly, the increase in temperature without a corresponding increase in rainfall will lead to an increase in the rate of evapotranspiration leading to soil depletion. The increase in extreme events such as heat waves, for example would also contribute to lower crop production (Oweis *et al*., 2000).

Some previous studies have shown that temperature increase can have both a positive and negative effect on crop yields. Increased temperatures within a few degrees can positively affect the rate of plant development (vegetative growth) and hence enhance annual crops growth rate through the developmental process. In addition, higher temperature increases can reduce the yields and quality of many crops. For example, high temperatures shorten the life cycle of grain crops, resulting in a shorter grain filling period. This means that the plants produce smaller and lighter grains, culminating in lower crop yields and potentially poorer grain quality (Wolfe, 1995; Adams *et al.*, 1998). This is because temperature increases are associated with higher respiration rates, shorter periods of seed formation and consequently lower biomass production (Molua and Lambi, 2006). Rosenzweig et al. (1993) reported positive crop yield responses to temperature increases of 2°C but yield reductions are observed with a 4°C increase. They also found that reductions in crop yields are more significant in lower latitudes compared with higher latitudes, particularly with respect to wheat and maize yields. Soil warming may further led to a decline in net primary productivity (NPP) as warming encourages microbial activity and can thus reduce the carbon stocks in soils (Oechel et al., 1993; Schimel *et al*., 1994).

The simulations generated in the current study consider all of the above impacts and conclude that the overall net effect of the temperature increase on crop yield in Nigeria will be negative.

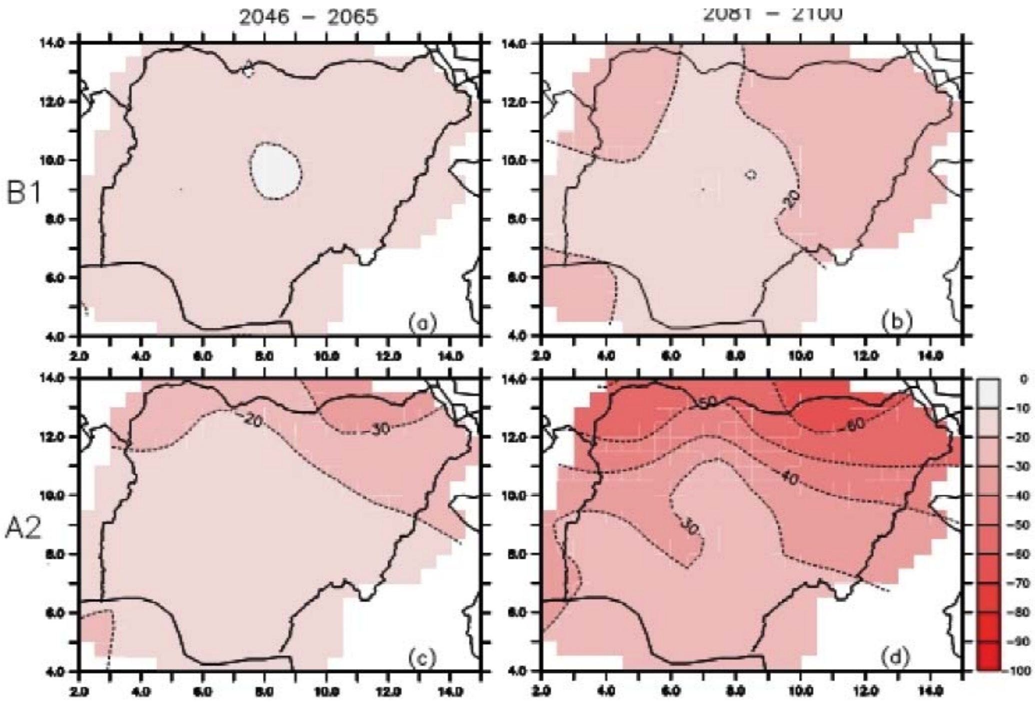


Figure 22 Impact of climate change on maize yields for Nigeria in the future.

5.2 Human Health

To assess the impact of climate change on health, the focus in this study is on the malaria epidemic as it is the most prominent disease throughout the nation. The impacts are evaluated using the downscaled climate change data in a model for malaria developed by Githeko and Ndegwa (2001). This model has been successfully tested and applied over East Africa (Githeko and Ndegwa, 2001) but has not been validated over Nigeria. In this study, we compared the model simulation of malaria epidemics over three cities (Akure, Ibadan and Lagos), for which we have observed malaria data.

Using simulated past and future climate data as inputs into the malaria model, the malaria epidemic is simulated for the past climate (1981-2000) and the two future periods (2046-2065 and 2081-2100) according to scenarios B1 and A2. An assessment was then made of the potential impacts of climate change on malaria epidemics based on a consideration of the difference between the past and future epidemics.

5.2.1 Baseline simulation of Malaria Epidemics

Figure 23 presents the simulated annual mean of malaria epidemic risk in percentage (%) and the number of months with malaria epidemic risk, for the baseline period of 1981-2000. The figures show a high epidemic risk (defined as greater than 30%) south of 7°N with the highest risk being in the Mangrove zone. The zones north of 7°N have a lower risk. The high risk of malaria south of 7°N can be attributed to higher relative humidity and rainfall experienced over the region which increases the number of breeding sites for mosquitoes (*Anopheles* sp). The figures demonstrate that rainfall is a factor in malaria transmission since rainfall decreases further inland, as the malaria risk also decreases. This means that rainfall has a positive correlation with increases in malaria incidence.

Furthermore, relative humidity in the coastal area is sometimes higher than 60%, which is high enough to increase the incidence of malaria throughout the year. High relative humidity lengthens the life of the mosquito and helps the parasite to complete the necessary life cycle required to transmit the infection. When relative humidity drops below 60%, it is believed that malaria transmission cannot occur because of the reduced lifespan of mosquitoes (Pampana, 1969) which is the major reason why the other latitudes have lower risk.

High temperatures and low seasonal variation in temperature also favour the development of the mosquito. Biologically, temperature affects three aspects of malaria transmission; the survival and reproduction rates of the mosquito, the intensity, particularly the biting rate, of mosquito activity and the development, survival, and reproduction rates of the *Plasmodium* parasite within the mosquito. Both the lowest and highest temperatures favour the development of mosquitoes (Githeko and Ndegwa, 2001). However, at times the minimum temperature is too low and the maximum temperature is too high for their survival. This is another reason why Nigeria's coastal region has the highest number of malaria risk months, because of fewer such temperature extremes.

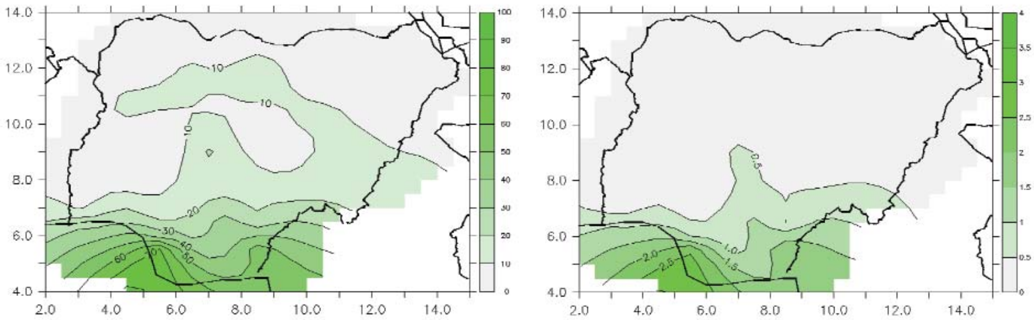


Figure 23 Simulated Annual mean of Malaria epidemic risks (%; right panel), and the number of occurrences (month; right panel) per year.

5.2.2 Impacts of Climate Change on Malaria Epidemics

Figure 24 presents the projected changes in malaria epidemic risk and the projected number of months with malaria epidemics. The highest increase in the malaria epidemics is projected to occur in the southern region of Nigeria where a hotter and wetter climate is expected. The results show a greater increase in malaria epidemics when the A2 scenario is applied compared with the B1 scenario. Specifically, the B1 scenario predicts a greater than 40% increase in malaria epidemics in the Mangrove zone between 2081 and 2100. For the same period, the A2 scenario predicts approximately a 100% increase. According to the A2 scenario, the number of months with malaria epidemics would increase by three-four months in the Mangrove zone.

In summary, according to both the B1 and the A2 scenarios, the malaria risk and number of malaria epidemic months are expected to increase in future. This can be attributed to an increase in the minimum temperature to a level that is optimal for the development of mosquitoes, especially in the northern part of the country. Previously, the minimum temperature has been too low for their survival. With these shifts in weather and climatic factors, the malaria risk will be greater due to more favourable conditions for the *Anopheles* mosquito.

However it should be noted that this study did not consider other factors, such as land cover changes and public health intervention measures, which may have influenced malaria incidence in the past. Because of the lack of historical data, it was not possible to take these factors into consideration in the analysis for this study.

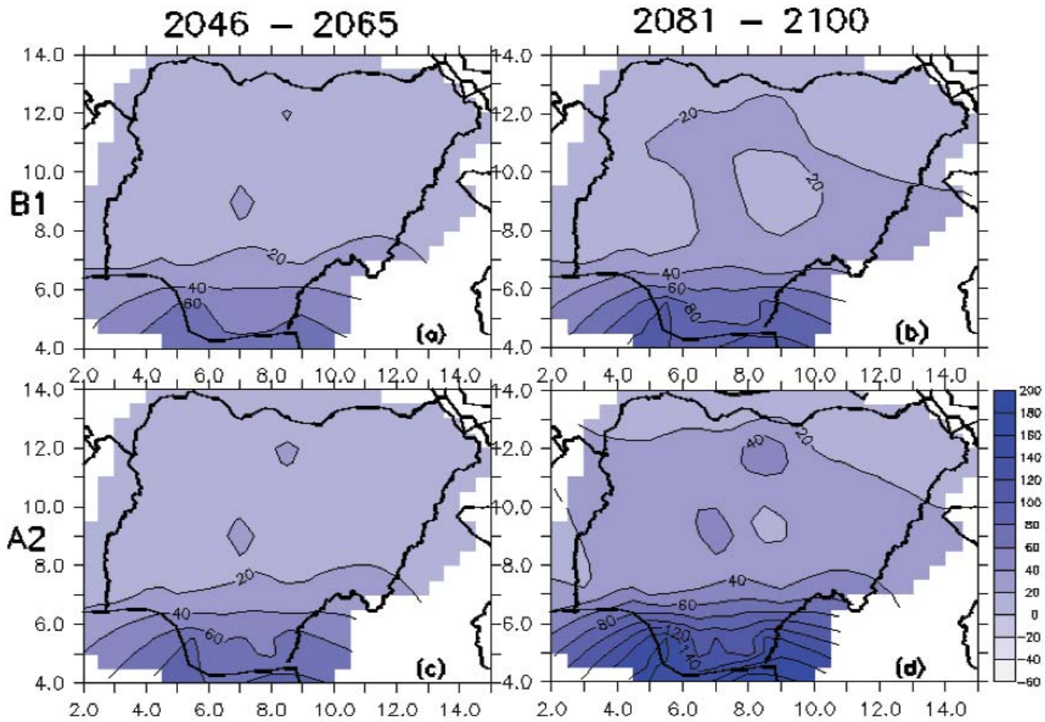


Figure 24 Impact of climate change on malaria epidemic risk (%) for Nigeria in the future.

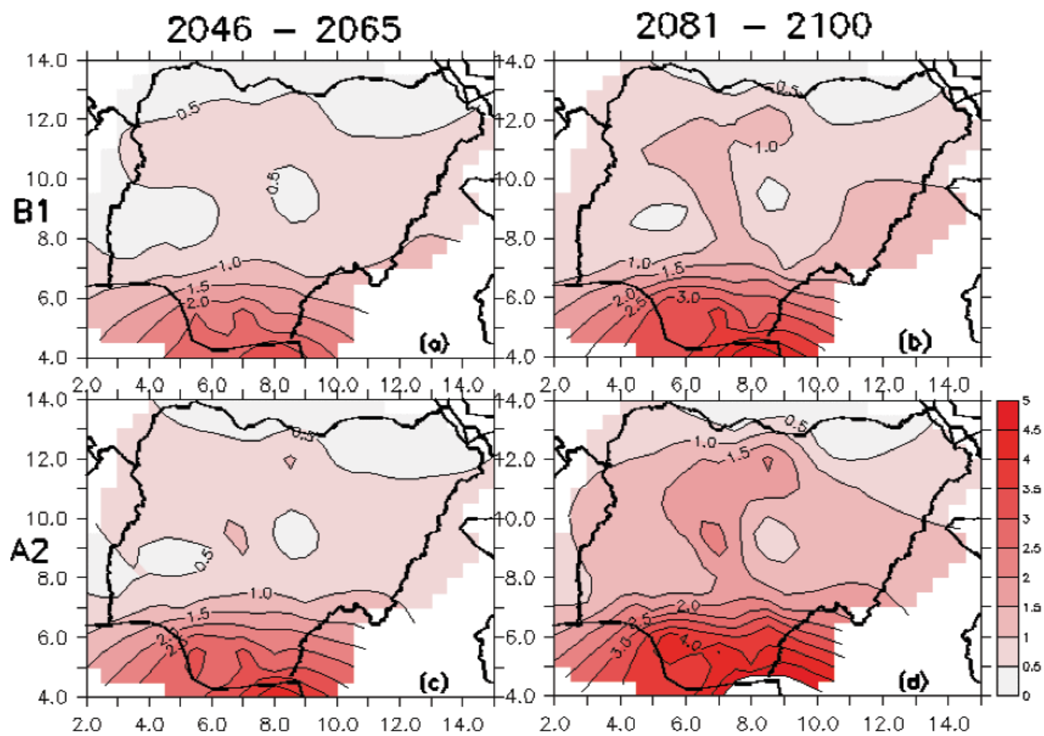


Figure 25 Impact of climate change on occurrence malaria epidemic for Nigeria in the future.

6. Climate Change Adaptation

6.1 Climate Change Adaptation Strategy for Nigeria

The major challenge that climate change presents for Nigeria is an increase in air temperature over the entire country, leading to flooding around the coastal areas and drought in the Short Grass Savanna zone. The major adaptation option against this impact is reforestation which would reduce or lower the rate of warming, reduce runoff (i.e. flooding) over coastal regions, preserve soil moisture and enhance rainfall over the Savanna zones. It is recommended that the Nigerian government embark on reforestation efforts throughout the country. An important question for further research to consider is which zones should be focused on so as to optimize the advantages of reforestation.

In addition, since the emphasis of the present study is far future projection, future studies should aim to develop scenarios of near-term climate change based on the existing trends and knowledge of how climate may change in the next twenty to thirty years. Information from such studies may be more relevant for Nigerian policymakers. However, the projection should be developed as scenarios rather than using CGMs to model the future climate.

6.2 Agriculture

The agricultural sector is particularly prone to the influence of climate change due to its reliance on rainfall and temperature. Given the significance of agriculture for both food and livelihood security in Nigeria, changes in this sector can have a great impact on human quality of life. Further, climate change impacts agriculture and food security in complex ways which can be observed in the variation of changes according to different agro-ecological conditions. For example, the IPCC projects that climate change will increase water stress throughout Africa but more so in eastern and western Africa (Easterling *et al*., 2007). Specific to Nigeria, the present study shows that climate change will affect crop productivity. Currently, Nigeria is a net importer of food and it is expected that there will be a significant increase in the demand for agricultural production as a result of the growing population. Therefore, unless drastic and sustained measures at expanding and improving the agricultural sector are taken over the next several decades, Nigeria is likely to experience serious food shortages. Unless appropriate adaptation strategies are put in place in a timely manner, these predictable outcome scenarios will be further compounded by the negative impacts of climate change as indicated by the results of this study.

The following technologies are recommended in order to reduce the negative impacts of climate change on the agricultural sector:

- Early warning systems put into place;
- Distribution of appropriate crop varieties specifically bred for adaptation to the anticipated changes in climate. This would include the development of early vegetative stage drought tolerant and early maturing crops;
- Careful and timely application of organic fertilizers, such as the practice of cover cropping and other organic soil amendment practices;
- Adoption of agroforestry techniques to simultaneously improve soil structure and fertility status; and
- Strengthening of extension services.

6.3 Human Health

Our study has shown that climate change will contribute to increased malaria epidemics throughout the country, with the highest impact in the Mangrove and Rainforest zones. It should be noted that these zones have the highest population density in Nigeria, indicating population-based vulnerability in these regions. This implies that climate change would further strain the already poor public health resources in Nigeria, especially in the cities located in the Mangrove and Rainforest zones. We suggest that this might heighten the conflict in the Niger Delta region. Hence, we propose adaptation options that would improve public health facilities and services. There should more medical emergency response institutions, and they should be well equipped. There should be more research activities, focusing on how to control vector-borne and water-borne deceases. Such activities should be organised by government agencies (federal, state and local), academia, the private sector, and non-governmental organizations, but engage and empower local communities, through advocacy and awareness, on how to reduce the risk of disease epidemics.

In addition, there is need for a health early-warning system in Nigeria. The system would coordinate disease observation, use a climate-health model to provide seasonal forecasts on disease outbreaks and broadcast the information to the public. Such information is even more crucial following the occurrence of climate-extreme events, such as heat-waves and flooding, which are precursors for malaria epidemics. This would help in reducing the risk of disease epidemics, and increase the adaptive capacity of vulnerable communities.

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Appendices

Table A1 Rainfall: Annual mean (baseline) and the future changes. The climate change values are given in the format: Minimum (Central Range) Maximum; Central Range shows the values between ± one standard deviation.

Zones	Stations	Baseline mean (mm/day) 1971-2000	Changes with B1 scenario (mm/day)		Changes with A2 scenario (mm/day)	
			2046 - 2065	2081-2100	2046 - 2065	2081-2100
Mangrove	Ikeja	3.5	-0.8 (-0.37 to 1.0) 1.2	-0.64 (-0.29 to 1.0) 1.1	-1.0 (-0.5 to 1.2) 1.5	-1.6 (-0.7 to 1.3) 1.5
	P. Harcourt	5.9	-0.5 (-0.06 to 1.5) 1.7	-0.35 (-0.03 to 1.5) 2.0	-2.1 (-0.8 to 1.7) 2.0	-3.7 (-1.4 to 2.3) 2.1
	Calabar	7.5	-0.5 (-0.02 to 1.9) 2.4	-0.42 (-0.04 to 1.9) 2.4	-2.7 (-1.1 to 2.1) 2.6	-3.9 (-1.4 to 2.7) 3.0
	Warri	7.3	-0.7 (-0.06 to 1.9) 2.3	-0.43 (-0.01 to 2.0) 2.5	-2.4 (-0.9 to 2.1) 2.5	-4.1 (-1.5 to 2.8) 2.8
	Abeokuta	2.9	-0.5 (-0.13 to 0.9) 1.1	-0.33 (-0.09 to 0.9) 1.1	-0.7 (-0.3 to 0.8) 1.0	-1.3 (-0.6 to 1.0) 1.2
Rainforest	Akure	3.8	-0.8 (-0.38 to 0.8) 1.1	-0.59 (-0.29 to 0.8) 1.0	-0.8 (-0.4 to 1.1) 1.4	-1.3 (-0.6 to 1.1) 1.4
	Benin	5.7	-0.7 (-0.20 to 1.3) 1.5	-0.61 (-0.24 to 1.3) 1.7	-1.6 (-0.6 to 1.5) 1.8	-3.0 (-1.2 to 1.9) 1.9
	Ibadan	3.4	-0.6 (-0.21 to 0.9) 1.1	-0.56 (-0.20 to 0.9) 1.1	-0.7 (-0.3 to 1.0) 1.3	-1.1 (-0.4 to 1.0) 1.3
	Ijebu_Ode	4.1	-0.8 (-0.38 to 1.0) 1.1	-0.69 (-0.36 to 0.9) 1.2	-1.1 (-0.5 to 1.1) 1.4	-1.8 (-0.9 to 1.2) 1.3
	Ondo	4	-0.6 (-0.25 to 1.1) 1.3	-0.45 (-0.15 to 1.1) 1.3	-0.8 (-0.4 to 1.1) 1.4	-1.3 (-0.5 to 1.3) 1.6
	Owerri	6.2	-0.7 (-0.18 to 1.6) 2.0	-0.45 (-0.06 to 1.6) 2.1	-2.0 (-0.8 to 1.7) 2.1	-3.2 (-1.3 to 2.2) 2.3
	Lagos	4.2	-1.0 (-0.44 to 1.3) 1.6	-0.98 (-0.46 to 1.1) 1.3	-1.4 (-0.7 to 1.4) 1.8	-2.1 (-0.9 to 1.6) 1.8
	Ikom	6.3	-0.6 (-0.04 to 1.7) 1.8	-0.42 (0.06 to 1.7) 2.0	-1.8 (-0.7 to 1.7) 2.0	-3.4 (-1.3 to 2.3) 2.2
	Oshogbo	3.5	-0.5 (-0.16 to 0.9) 1.0	-0.38 (-0.13 to 0.9) 1.1	-0.7 (-0.3 to 0.9) 1.1	-1.4 (-0.6 to 1.1) 1.2
	Onitsha	5	-0.5 (-0.10 to 1.4) 1.7	-0.39 (-0.06 to 1.3) 1.6	-1.6 (-0.6 to 1.4) 1.7	-3.4 (-1.4 to 1.8) 1.8
	Uyo	5.8	-0.7 (-0.28 to 1.3) 1.7	-0.52 (-0.20 to 1.3) 1.7	-1.7 (-0.7 to 1.5) 1.9	-2.9 (-1.2 to 1.8) 2.0
Tall Grass Savanna	Enugu	4.8	-0.8 (-0.32 to 1.2) 1.4	-0.60 (-0.24 to 1.2) 1.4	-1.4 (-0.6 to 1.3) 1.6	-2.8 (-1.2 to 1.6) 1.6
	Ibi	2.7	-0.6 (-0.32 to 0.7) 0.9	-0.60 (-0.29 to 0.8) 1.0	-0.8 (-0.4 to 0.8) 1.0	-1.5 (-0.7 to 1.0) 1.0
	Ogoja	4.9	-0.7 (-0.27 to 1.2) 1.4	-0.65 (-0.26 to 1.3) 1.5	-1.4 (-0.6 to 1.3) 1.5	-3.2 (-1.4 to 1.7) 1.5
	Iseyin	3	-0.5 (-0.28 to 0.8) 1.0	-0.50 (-0.28 to 0.8) 1.0	-0.7 (-0.3 to 0.9) 1.2	-1.1 (-0.5 to 0.9) 1.2
	Makurdi	3.2	-0.5 (-0.23 to 0.9) 1.0	-0.50 (-0.25 to 0.9) 1.1	-0.9 (-0.4 to 1.0) 1.2	-1.4 (-0.6 to 1.1) 1.2
	Lokoja	3	-0.5 (-0.19 to 0.8) 1.0	-0.44 (-0.20 to 0.8) 1.0	-0.9 (-0.4 to 0.9) 1.1	-1.4 (-0.6 to 1.0) 1.1
	Ilorin	2.9	-0.6 (-0.25 to 0.8) 0.9	-0.52 (-0.22 to 0.9) 1.0	-0.6 (-0.3 to 1.0) 1.2	-1.0 (-0.5 to 1.1) 1.3
	Abuja	4	-0.5 (-0.24 to 1.1) 1.4	-0.59 (-0.31 to 1.1) 1.4	-1.8 (-0.8 to 1.2) 1.4	-2.6 (-1.3 to 1.4) 1.4
	Bauchi	2.8	-0.5 (-0.31 to 1.0) 1.2	-0.44 (-0.31 to 0.9) 1.2	-1.2 (-0.6 to 0.9) 1.0	-1.9 (-0.9 to 1.2) 1.2
	Kaduna	3.1	-0.3 (-0.06 to 1.0) 1.1	-0.25 (-0.05 to 1.0) 1.2	-1.2 (-0.6 to 1.0) 1.0	-1.7 (-0.8 to 1.1) 1.1
	Minna	3.2	-0.5 (-0.25 to 0.8) 1.0	-0.48 (-0.28 to 0.9) 1.1	-1.1 (-0.5 to 1.0) 1.1	-1.9 (-0.9 to 1.1) 1.1
	Shaki	2.9	-0.4 (-0.19 to 0.7) 0.9	-0.47 (-0.20 to 0.8) 1.0	-0.6 (-0.3 to 0.8) 1.1	-0.9 (-0.4 to 0.9) 1.1
	Yelwa	2.7	-0.5 (-0.28 to 0.8) 0.9	-0.47 (-0.26 to 0.7) 0.9	-1.6 (-0.8 to 1.0) 1.1	-2.1 (-1.1 to 1.2) 1.2
	Jos	2.1	-0.5 (-0.51 to 0.8) 1.0	-0.55 (-0.50 to 0.7) 1.0	-1.7 (-1.0 to 1.0) 1.1	-2.5 (-1.4 to 1.2) 1.2
	Bida	2.7	-0.5 (-0.20 to 0.7) 0.8	-0.37 (-0.17 to 0.7) 0.9	-0.9 (-0.4 to 0.8) 0.9	-1.5 (-0.7 to 1.0) 1.0
Short Grass Savanna	Zaria	3	-0.5 (-0.27 to 0.9) 1.1	-0.30 (-0.17 to 0.9) 1.1	-1.3 (-0.7 to 1.0) 1.1	-2.0 (-1.0 to 1.1) 1.2
	Nguru	1.2	-0.3 (-0.28 to 0.5) 0.6	-0.26 (-0.24 to 0.5) 0.6	-1.0 (-0.6 to 0.6) 0.6	-1.4 (-0.8 to 0.8) 0.8
	Yola	2.6	-0.5 (-0.19 to 0.8) 0.9	-0.37 (-0.15 to 0.8) 1.0	-0.8 (-0.4 to 0.7) 0.8	-1.1 (-0.6 to 0.8) 0.8
	Kano	3.2	-0.6 (-0.54 to 1.2) 1.4	-0.51 (-0.45 to 1.0) 1.3	-2.4 (-1.3 to 1.4) 1.3	-2.8 (-1.5 to 1.6) 1.6
	Katsina	1.6	-0.3 (-0.26 to 0.7) 0.8	-0.29 (-0.22 to 0.7) 0.8	-0.8 (-0.5 to 0.7) 0.7	-1.4 (-0.8 to 0.9) 0.8
	Maiduguri	1.9	-0.4 (-0.38 to 0.8) 0.9	-0.41 (-0.32 to 0.7) 0.9	-1.6 (-0.9 to 0.9) 0.9	-2.2 (-1.3 to 1.1) 1.0
	Potiskum	2.1	-0.5 (-0.41 to 0.8) 0.9	-0.48 (-0.38 to 0.7) 0.9	-1.5 (-0.8 to 0.9) 0.9	-2.3 (-1.3 to 1.2) 1.0
	Sokoto	1.9	-0.4 (-0.33 to 0.7) 0.8	-0.32 (-0.28 to 0.7) 0.8	-1.3 (-0.7 to 0.9) 0.9	-1.8 (-1.0 to 1.1) 0.9
	Gusau	2.7	-0.4 (-0.26 to 0.8) 1.0	-0.38 (-0.21 to 0.9) 1.0	-1.4 (-0.7 to 1.0) 1.0	-2.2 (-1.1 to 1.3) 1.1

Table A2 Maximum Temperature: Annual mean (baseline) and the future changes. The climate change values are given in the format: Minimum (Central Range) Maximum; Central Range shows the values between ± one standard deviation.

Zones	Stations	Baseline mean (°C)) 1971-2000	Changes with B1 scenario (°C)		Changes with A2 scenario (°C)	
			2046 - 2065	2081-2100	2046 - 2065	2081-2100
Mangrove	Ikeja	31.6	0.81 (1.0 to 1.8) 1.8	1.3 (1.6 to 2.4) 2.5	1.1 (1.4 to 2.3) 2.5	2.1 (2.7 to 4.2) 4.5
	P. Harcourt	31.9	0.74 (0.9 to 1.6) 1.7	1.2 (1.4 to 2.3) 2.5	1.2 (1.4 to 2.2) 2.3	2.1 (2.7 to 4.0) 4.2
	Calabar	31.3	0.72 (0.9 to 1.7) 1.8	1.1 (1.4 to 2.3) 2.6	1.2 (1.5 to 2.2) 2.3	2.1 (2.7 to 4.0) 4.2
	Warri	32.0	0.70 (0.9 to 1.6) 1.7	1.1 (1.4 to 2.3) 2.4	1.1 (1.4 to 2.3) 2.5	2.1 (2.6 to 4.1) 4.4
	Abeokuta	32.9	0.71 (1.0 to 1.9) 1.9	1.2 (1.5 to 2.5) 2.6	1.0 (1.4 to 2.5) 2.7	2.2 (2.8 to 4.5) 4.8
Rainforest	Akure	31.6	0.74 (1.0 to 1.8) 1.9	1.3 (1.5 to 2.4) 2.6	1.1 (1.4 to 2.5) 2.6	2.1 (2.7 to 4.4) 4.7
	Benin	32.1	0.68 (0.9 to 1.7) 1.8	1.2 (1.4 to 2.4) 2.5	1.1 (1.4 to 2.4) 2.5	1.8 (2.6 to 4.3) 4.4
	Ibadan	32.0	0.69 (0.9 to 1.8) 1.9	1.2 (1.5 to 2.4) 2.6	1.1 (1.4 to 2.5) 2.7	2.2 (2.8 to 4.4) 4.7
	Ijebu_Ode	31.9	0.74 (1.0 to 1.7) 1.8	1.2 (1.5 to 2.4) 2.5	1.1 (1.4 to 2.3) 2.6	2.2 (2.8 to 4.2) 4.5
	Ondo	31.3	0.71 (1.0 to 1.8) 1.9	1.2 (1.5 to 2.4) 2.6	1.0 (1.4 to 2.4) 2.7	2.0 (2.7 to 4.3) 4.6
	Owerri	32.5	0.78 (1.0 to 1.7) 1.8	1.2 (1.5 to 2.4) 2.5	1.2 (1.5 to 2.3) 2.4	1.9 (2.6 to 4.2) 4.3
	Lagos	30.7	0.87 (1.1 to 1.7) 1.8	1.3 (1.6 to 2.3) 2.5	1.0 (1.4 to 2.3) 2.5	2.0 (2.7 to 4.3) 4.5
	Ikom	32.5	0.73 (0.9 to 1.7) 1.9	1.2 (1.5 to 2.4) 2.6	1.2 (1.5 to 2.4) 2.5	2.3 (2.8 to 4.3) 4.5
	Oshogbo	31.7	0.74 (1.0 to 1.9) 2.0	1.3 (1.6 to 2.6) 2.7	1.1 (1.5 to 2.5) 2.7	2.3 (2.9 to 4.5) 4.8
	Onitsha	32.8	0.73 (0.9 to 1.7) 1.8	1.2 (1.4 to 2.4) 2.5	1.1 (1.4 to 2.4) 2.5	1.9 (2.6 to 4.3) 4.5
	Uyo	31.8	0.75 (1.0 to 1.7) 1.8	1.2 (1.5 to 2.4) 2.5	1.2 (1.5 to 2.3) 2.4	2.1 (2.7 to 4.1) 4.3
Tall Grass Savanna	Enugu	32.6	0.77 (1.0 to 1.8) 1.9	1.3 (1.6 to 2.5) 2.6	1.1 (1.5 to 2.4) 2.6	2.3 (2.8 to 4.4) 4.7
	Ibi	33.8	0.75 (1.1 to 2.1) 2.2	1.3 (1.6 to 2.8) 3.1	1.1 (1.5 to 2.8) 3.0	2.4 (3.0 to 4.8) 5.1
	Ogoja	33.2	0.75 (1.0 to 1.9) 2.0	1.2 (1.5 to 2.6) 2.8	1.2 (1.5 to 2.5) 2.6	2.3 (2.9 to 4.5) 4.7
	Iseyin	31.9	0.72 (1.0 to 2.0) 2.0	1.3 (1.6 to 2.6) 2.8	1.0 (1.4 to 2.6) 2.8	2.2 (2.8 to 4.7) 5.0
	Makurdi	33.6	0.70 (1.0 to 2.0) 2.1	1.2 (1.6 to 2.7) 2.9	1.1 (1.5 to 2.6) 2.8	2.4 (3.0 to 4.7) 5.0
	Lokoja	33.8	0.69 (1.0 to 1.9) 2.0	1.2 (1.6 to 2.6) 2.8	1.1 (1.5 to 2.6) 2.7	2.4 (2.9 to 4.6) 4.9
	Ilorin	32.6	0.76 (1.0 to 2.0) 2.1	1.3 (1.6 to 2.6) 2.8	1.0 (1.4 to 2.6) 2.9	2.2 (2.8 to 4.7) 5.1
	Abuja	33.1	0.67 (1.0 to 2.1) 2.2	1.2 (1.6 to 2.8) 3.0	1.0 (1.4 to 2.7) 2.9	2.4 (3.0 to 4.8) 5.2
	Bauchi	33.1	0.65 (1.1 to 2.2) 2.4	1.3 (1.6 to 3.0) 3.3	1.0 (1.6 to 2.9) 3.1	2.5 (3.2 to 5.2) 5.7
	Kaduna	32.0	0.71 (1.0 to 2.2) 2.4	1.3 (1.6 to 2.9) 3.1	1.0 (1.5 to 2.8) 3.1	2.4 (3.1 to 5.0) 5.6
	Minna	33.6	0.63 (1.0 to 2.1) 2.3	1.2 (1.6 to 2.8) 3.0	1.0 (1.5 to 2.8) 3.0	2.4 (3.1 to 4.9) 5.4
	Shaki	31.4	0.64 (1.0 to 2.0) 2.1	1.2 (1.6 to 2.7) 2.9	1.0 (1.4 to 2.6) 2.9	2.2 (2.8 to 4.8) 5.2
	Yelwa	34.7	0.76 (1.0 to 2.2) 2.3	1.3 (1.7 to 2.8) 3.0	0.7 (1.3 to 2.8) 3.1	2.3 (3.0 to 5.1) 5.7
	Jos	27.8	0.72 (1.1 to 2.1) 2.3	1.3 (1.6 to 2.9) 3.1	1.1 (1.5 to 2.7) 2.9	2.5 (3.1 to 4.9) 5.3
	Bida	33.9	0.70 (1.0 to 2.0) 2.2	1.2 (1.6 to 2.7) 2.9	1.1 (1.5 to 2.7) 3.0	2.3 (3.0 to 4.8) 5.3
Short Grass Savanna	Zaria	32.0	0.67 (1.1 to 2.3) 2.4	1.2 (1.6 to 3.0) 3.2	0.7 (1.4 to 3.0) 3.3	2.4 (3.1 to 5.2) 5.8
	Nguru	35.5	0.56 (1.1 to 2.5) 2.7	1.2 (1.7 to 3.3) 3.6	0.8 (1.5 to 3.3) 3.8	2.4 (3.2 to 6.0) 7.2
	Yola	35.1	0.78 (1.1 to 2.3) 2.5	1.5 (1.7 to 3.1) 3.4	1.1 (1.6 to 2.9) 3.2	2.6 (3.3 to 5.2) 5.6
	Kano	33.7	0.53 (1.0 to 2.5) 2.7	1.1 (1.6 to 3.2) 3.5	0.8 (1.5 to 3.2) 3.6	2.4 (3.3 to 5.7) 6.5
	Katsina	34.1	0.42 (1.0 to 2.5) 2.6	1.0 (1.6 to 3.2) 3.4	0.7 (1.4 to 3.2) 3.6	2.3 (3.2 to 5.8) 6.7
	Maiduguri	35.5	0.59 (1.1 to 2.5) 2.6	1.2 (1.7 to 3.3) 3.6	0.8 (1.5 to 3.2) 3.6	2.4 (3.3 to 5.6) 6.3
	Potiskum	34.7	0.54 (1.0 to 2.5) 2.6	1.2 (1.7 to 3.3) 3.6	0.9 (1.5 to 3.2) 3.6	2.4 (3.3 to 5.9) 6.9
	Sokoto	35.5	0.48 (1.0 to 2.5) 2.6	1.1 (1.7 to 3.2) 3.3	0.8 (1.4 to 3.1) 3.5	2.4 (3.3 to 5.6) 6.3
	Gusau	34.0	0.48 (1.0 to 2.4) 2.5	1.0 (1.6 to 3.1) 3.3	0.8 (1.4 to 3.1) 3.4	2.3 (3.2 to 5.5) 6.2

Table A3 Minimum Temperature: Annual mean (baseline) and the future changes. The climate change values are given in the format: Minimum (Central Range) Maximum; Central Range shows the values between ± one standard deviation.

Zones	Stations	Baseline mean (°C)) 1971-2000	Changes with B1 scenario (°C)		Changes with A2 scenario (°C)	
			2046 - 2065	2081-2100	2046 - 2065	2081-2100
Mangrove	Ikeja	24.15	1.0 (1.2 to 1.7) 1.8	1.5 (1.7 to 2.3) 2.5	0.82 (1.3 to 2.3) 2.5	1.3 (2.4 to 4.4) 4.6
	P. Harcourt	23.3	1.0 (1.1 to 1.6) 1.7	1.5 (1.6 to 2.3) 2.5	0.85 (1.4 to 2.2) 2.3	1.4 (2.4 to 4.2) 4.3
	Calabar	23.71	1.0 (1.1 to 1.7) 1.8	1.4 (1.6 to 2.3) 2.5	0.92 (1.4 to 2.2) 2.3	1.4 (2.4 to 4.2) 4.2
	Warri	24.02	1.0 (1.1 to 1.6) 1.7	1.4 (1.6 to 2.2) 2.4	0.97 (1.4 to 2.2) 2.3	1.9 (2.6 to 4.1) 4.3
	Abeokuta	24.07	1.0 (1.1 to 1.7) 1.8	1.5 (1.7 to 2.4) 2.5	0.73 (1.3 to 2.4) 2.6	1.6 (2.6 to 4.5) 4.9
Rainforest	Akure	21.92	0.9 (1.1 to 1.8) 1.9	1.6 (1.7 to 2.5) 2.6	0.71 (1.3 to 2.5) 2.6	1.2 (2.5 to 4.6) 4.9
	Benin	23.89	0.9 (1.1 to 1.6) 1.7	1.4 (1.6 to 2.3) 2.4	0.74 (1.3 to 2.3) 2.3	1.1 (2.3 to 4.3) 4.4
	Ibadan	23.13	1.0 (1.1 to 1.7) 1.8	1.5 (1.7 to 2.4) 2.5	0.84 (1.3 to 2.4) 2.5	1.3 (2.5 to 4.5) 4.8
	Ijebu_Ode	23.66	1.0 (1.1 to 1.6) 1.7	1.5 (1.7 to 2.3) 2.4	0.78 (1.3 to 2.3) 2.4	1.4 (2.4 to 4.3) 4.6
	Ondo	22.73	1.0 (1.2 to 1.7) 1.8	1.6 (1.7 to 2.4) 2.5	0.62 (1.3 to 2.4) 2.5	1.1 (2.4 to 4.5) 4.7
	Owerri	23.92	1.0 (1.2 to 1.7) 1.8	1.5 (1.6 to 2.3) 2.5	0.84 (1.4 to 2.3) 2.3	0.9 (2.3 to 4.4) 4.4
	Lagos	25.59	1.0 (1.2 to 1.7) 1.8	1.5 (1.7 to 2.3) 2.4	0.65 (1.3 to 2.4) 2.5	0.9 (2.3 to 4.4) 4.7
	Ikom	22.94	1.1 (1.2 to 1.8) 1.9	1.6 (1.7 to 2.5) 2.7	0.40 (1.2 to 2.5) 2.5	0.8 (2.3 to 4.6) 4.6
	Oshogbo	21.79	1.0 (1.1 to 1.9) 2.0	1.5 (1.7 to 2.5) 2.7	0.59 (1.3 to 2.6) 2.8	1.4 (2.6 to 4.8) 5.1
	Onitsha	24.20	1.0 (1.1 to 1.7) 1.8	1.5 (1.6 to 2.3) 2.5	0.64 (1.3 to 2.3) 2.4	0.8 (2.2 to 4.4) 4.5
	Uyo	23.50	1.0 (1.2 to 1.7) 1.8	1.5 (1.7 to 2.4) 2.6	0.85 (1.4 to 2.3) 2.3	1.2 (2.4 to 4.3) 4.3
Tall Grass Savanna	Enugu	23.18	1.0 (1.2 to 1.8) 1.9	1.5 (1.7 to 2.5) 2.8	0.61 (1.3 to 2.5) 2.6	1.1 (2.5 to 4.7) 4.8
	Ibi	23.17	1.0 (1.2 to 2.0) 2.2	1.6 (1.7 to 2.7) 3.0	0.74 (1.4 to 2.8) 3.0	1.4 (2.8 to 5.1) 5.2
	Ogoja	22.89	1.1 (1.2 to 1.9) 1.9	1.7 (1.8 to 2.6) 2.8	0.61 (1.3 to 2.6) 2.6	0.9 (2.4 to 4.8) 4.9
	Iseyin	22.21	1.0 (1.2 to 1.8) 1.9	1.6 (1.8 to 2.5) 2.6	0.51 (1.3 to 2.6) 2.7	1.1 (2.5 to 4.8) 5.1
	Makurdi	23.19	0.9 (1.1 to 2.0) 2.1	1.5 (1.6 to 2.7) 3.0	0.82 (1.4 to 2.8) 3.1	1.6 (2.7 to 5.1) 5.5
	Lokoja	23.59	0.9 (1.0 to 1.9) 2.0	1.4 (1.6 to 2.6) 2.9	0.87 (1.4 to 2.7) 3.0	1.6 (2.7 to 4.9) 5.4
	Ilorin	22.22	1.0 (1.2 to 1.9) 2.0	1.6 (1.8 to 2.5) 2.7	0.66 (1.3 to 2.6) 2.8	1.1 (2.5 to 4.9) 5.3
	Abuja	21.83	1.0 (1.2 to 2.0) 2.1	1.6 (1.8 to 2.7) 2.9	0.55 (1.3 to 2.8) 2.9	1.4 (2.7 to 5.0) 5.3
	Bauchi	20.21	1.0 (1.2 to 2.3) 2.4	1.6 (1.8 to 3.0) 3.3	0.64 (1.4 to 3.0) 3.2	1.7 (2.9 to 5.3) 5.7
	Kaduna	19.81	1.1 (1.3 to 2.2) 2.3	1.7 (1.9 to 2.9) 3.1	0.64 (1.4 to 2.9) 3.1	1.7 (2.9 to 5.3) 5.7
	Minna	22.82	1.0 (1.2 to 2.0) 2.1	1.6 (1.8 to 2.7) 2.9	0.75 (1.4 to 2.8) 3.0	1.6 (2.8 to 5.1) 5.4
	Shaki	21.63	1.0 (1.2 to 1.8) 1.9	1.6 (1.7 to 2.5) 2.7	0.56 (1.3 to 2.6) 2.8	1.0 (2.5 to 4.9) 5.2
	Yelwa	21.96	0.9 (1.2 to 2.3) 2.4	1.5 (1.8 to 2.9) 3.2	0.10 (1.2 to 3.2) 3.4	1.5 (2.8 to 5.5) 6.0
	Jos	16.15	1.0 (1.2 to 2.1) 2.2	1.6 (1.8 to 2.8) 3.1	0.29 (1.2 to 2.9) 2.9	1.3 (2.7 to 5.1) 5.4
	Bida	23.56	1.0 (1.1 to 1.9) 2.0	1.5 (1.7 to 2.6) 2.8	0.89 (1.5 to 2.7) 3.0	1.6 (2.8 to 5.0) 5.4
Short Grass Savanna	Zaria	19.95	1.0 (1.2 to 2.2) 2.3	1.6 (1.8 to 2.9) 3.2	0.10 (1.2 to 3.1) 3.2	1.6 (2.8 to 5.3) 5.7
	Nguru	21.41	1.1 (1.3 to 2.5) 2.6	1.7 (1.9 to 3.2) 3.6	0.70 (1.4 to 3.2) 3.6	3.0 (3.4 to 5.5) 6.2
	Yola	23.12	1.2 (1.3 to 2.3) 2.4	1.8 (1.9 to 3.0) 3.3	0.75 (1.5 to 3.0) 3.2	1.8 (3.0 to 5.3) 5.6
	Kano	20.77	0.9 (1.2 to 2.4) 2.5	1.6 (1.8 to 3.1) 3.4	0.85 (1.4 to 3.1) 3.5	2.9 (3.4 to 5.5) 6.1
	Katsina	20.38	0.9 (1.2 to 2.5) 2.6	1.5 (1.8 to 3.2) 3.5	0.76 (1.4 to 3.3) 3.7	2.9 (3.4 to 5.7) 6.3
	Maiduguri	21.10	1.0 (1.2 to 2.6) 2.8	1.6 (1.9 to 3.3) 3.7	0.42 (1.3 to 3.3) 3.7	2.4 (3.3 to 5.6) 6.3
	Potiskum	20.89	0.9 (1.2 to 2.5) 2.7	1.6 (1.8 to 3.3) 3.7	0.81 (1.4 to 3.2) 3.6	3.0 (3.4 to 5.6) 6.2
	Sokoto	23.13	0.8 (1.2 to 2.3) 2.5	1.4 (1.8 to 3.1) 3.3	0.69 (1.4 to 3.1) 3.5	2.8 (3.4 to 5.5) 6.1
	Gusau	20.58	1.0 (1.2 to 2.3) 2.4	1.6 (1.9 to 3.0) 3.3	0.86 (1.5 to 3.1) 3.5	2.8 (3.4 to 5.5) 6.2

Table A4 Observed and simulated extreme daily rainfall with return period of 10 and 20 years at 40 stations in Nigeria.

Stations	Observed	10-year event			Observed	20-year event		
		Simulated				Simulated		
		Min.	Median	Max.		Min.	Median	Max.
Ikeja	153.2	134.5	142.4	185.2	172.8	150.6	160.6	214.1
P. Harcourt	124.0	121.5	130.2	143.9	133.3	130.6	140.3	158.7
Calabar	161.8	133.6	148.7	156.0	175.8	142.8	159.3	168.8
Warri	149.2	134.2	146.1	158.4	161.0	142.3	159.6	172.1
Abeokuta	101.2	84.6	96.0	115.4	110.9	89.6	103.9	128.1
Akure	112.6	84.7	116.7	127.1	124.2	88.4	130.2	143.2
Benin	133.3	113.8	118.2	133.8	144.2	120.5	126.2	145.9
Ibadan	90.5	98.2	139.8	179.9	97.1	107.8	161.5	213.4
Ijebu_Ode	128.6	101.5	123.6	130.8	140.8	109.3	133.2	144.4
Ondo	138.4	93.8	110.6	178.5	158.3	100.9	122.0	210.8
Owerri	142.3	137.1	148.9	156.7	153.7	148.1	163.1	171.6
Lagos	187.2	134.4	166.0	208.9	211.2	145.5	183.8	240.5
Ikom	132.7	111.5	133.0	151.9	144.9	118.7	147.3	170.8
Oshogbo	89.0	67.9	78.9	88.0	97.5	71.2	85.2	96.3
Onitsha	134.6	102.0	119.3	128.4	148.6	108.4	131.5	140.5
Uyo	112.9	102.1	114.7	130.7	120.1	107.5	122.9	141.7
Enugu	127.0	119.4	133.0	155.4	140.1	130.3	147.7	174.2
Ibi	113.0	102.8	114.4	128.0	123.0	112.8	125.6	142.0
Ogoja	132.8	92.9	117.1	130.0	146.9	97.2	128.8	144.9
Iseyin	110.9	98.1	109.8	118.2	123.0	107.6	123.7	129.5
Makurdi	104.3	97.9	103.4	109.6	113.0	105.6	111.9	118.7
Lokoja	93.2	85.3	92.0	95.9	99.5	90.8	97.9	102.0
Ilorin	109.1	78.2	100.1	115.2	120.0	82.9	110.3	125.9
Abuja	125.8	100.6	128.1	153.7	143.4	110.6	141.3	174.8
Bauchi	92.8	82.7	87.0	97.6	101.2	87.5	94.9	105.8
Kaduna	97.5	74.7	97.8	113.5	108.9	80.5	109.4	127.5
Minna	92.3	92.4	94.7	102.0	99.5	99.5	101.1	113.5
Shaki	91.2	84.3	88.0	93.7	99.3	91.9	95.5	102.6
Yelwa	88.5	77.7	92.6	94.9	95.2	86.1	98.0	100.7
Jos	78.3	71.8	94.1	119.7	84.3	79.7	103.3	133.6
Bida	100.0	89.3	102.0	109.7	110.6	96.9	113.6	122.1
Zaria	87.8	74.6	99.5	103.8	95.6	81.0	106.8	111.7
Nguru	76.6	59.4	74.8	78.2	85.1	66.4	83.5	87.2
Yola	85.7	64.9	75.1	79.4	93.2	68.5	79.6	85.6
Kano	108.1	101.7	117.0	140.5	118.3	107.3	126.9	160.7
Katsina	59.7	67.4	88.6	101.2	64.8	75.0	100.1	116.2
Maiduguri	80.5	76.9	87.5	115.5	88.8	84.9	94.0	129.1
Potiskum	97.8	82.0	96.7	98.7	109.1	90.7	107.5	108.9
Sokoto	89.8	86.0	110.3	127.7	100.5	95.6	124.8	146.6
Gusau	97.1	71.7	99.5	112.0	107.4	77.3	108.4	121.5

Table A5 Observed and simulated extreme daily rainfall with return period of 50 and 100 years at 40 stations in Nigeria.

Stations	Observed	50-year event			Observed	100-year event		
		Simulated				Simulated		
		Min.	Median	Max.		Min.	Median	Max.
Ikeja	198.1	169.6	183.6	251.5	217.1	183.3	200.7	279.5
P. Harcourt	145.3	142.3	153.3	177.8	154.2	151.1	163.0	192.1
Calabar	193.9	154.7	173.1	185.3	207.5	163.7	183.5	197.7
Warri	176.3	152.9	173.9	189.8	187.7	160.8	184.5	203.1
Abeokuta	123.5	96.0	114.2	144.4	133.0	100.9	121.8	156.6
Akure	139.2	93.1	147.8	164.0	150.5	96.7	160.9	179.5
Benin	158.3	128.3	136.7	162.3	168.9	134.2	144.5	174.5
Ibadan	105.6	120.2	189.4	256.6	111.9	129.6	210.4	289.1
Ijebu_Ode	156.6	119.3	145.6	164.7	168.4	126.9	155.0	179.9
Ondo	184.1	110.2	136.7	252.7	203.5	117.1	147.7	284.0
Owerri	168.4	161.8	181.6	193.1	179.5	171.7	195.4	209.2
Lagos	242.4	158.2	206.8	281.4	265.7	167.8	224.1	312.1
Ikom	160.6	128.1	165.8	195.4	172.4	135.1	179.7	213.8
Oshogbo	108.4	75.4	93.3	107.0	116.6	78.6	99.5	115.0
Onitsha	166.8	116.7	145.8	156.2	180.4	122.9	156.5	168.0
Uyo	129.5	114.6	133.6	155.8	136.5	119.9	141.6	166.5
Enugu	156.9	144.5	165.4	198.4	169.6	155.0	178.7	216.6
Ibi	136.0	125.8	140.1	160.2	145.7	135.5	151.0	173.8
Ogoja	165.1	102.6	143.9	164.1	178.8	106.7	155.2	178.6
Iseyin	138.6	119.2	141.5	144.2	150.3	127.6	153.2	156.4
Makurdi	124.3	115.6	123.3	130.5	132.8	123.1	131.8	139.3
Lokoja	107.7	97.9	105.6	110.2	113.8	103.2	111.3	117.1
Ilorin	134.1	89.0	123.5	139.8	144.6	93.6	133.1	150.3
Abuja	166.1	123.6	158.5	202.3	183.1	133.4	171.4	222.8
Bauchi	112.2	93.8	106.1	116.4	120.4	98.4	113.5	124.3
Kaduna	123.8	88.0	124.5	145.6	134.9	93.6	135.8	159.2
Minna	108.8	108.7	109.8	128.3	115.8	115.6	116.5	139.5
Shaki	109.8	101.6	105.1	114.8	117.6	108.9	112.4	124.1
Yelwa	103.8	96.9	104.0	111.2	110.3	105.0	109.1	119.0
Jos	92.0	90.1	115.2	151.5	97.9	97.8	124.0	165.0
Bida	124.4	106.7	129.2	138.1	134.8	114.0	140.2	150.1
Zaria	105.7	89.3	116.4	121.8	113.3	95.5	123.5	129.5
Nguru	96.0	75.5	93.9	98.9	104.3	82.3	101.3	107.7
Yola	102.9	73.2	85.4	93.7	110.2	76.8	89.8	99.8
Kano	131.4	114.6	139.7	186.8	141.2	120.0	149.3	206.4
Katsina	71.3	84.8	115.3	135.6	76.1	92.1	126.7	150.1
Maiduguri	99.7	95.3	102.3	146.6	107.8	103.1	109.3	159.8
Potiskum	123.7	101.9	121.4	122.5	134.6	110.3	131.9	133.4
Sokoto	114.2	108.1	143.5	170.9	124.5	117.4	157.6	189.2
Gusau	120.7	84.6	119.9	133.7	130.8	90.1	128.6	142.8

Table A6 Observed and simulated extreme 3-day accumulated rainfall with return period of 10 and 20 years at 40 stations in Nigeria.

Stations	Observed	10-year event			Observed	20-year event		
		Simulated				Simulated		
		Min.	Median	Max.		Min.	Median	Max.
Ikeja	203.5	138.1	165.0	198.2	233.2	151.5	182.9	225.4
P. Harcourt	151.1	150.5	170.9	178.2	161.9	159.0	184.5	195.7
Calabar	208.9	180.3	197.1	207.2	224.5	193.1	211.7	226.1
Warri	194.1	186.0	199.8	208.0	205.6	202.3	218.6	226.0
Abeokuta	135.4	100.3	114.8	126.1	150.6	106.8	125.2	136.9
Akure	128.5	108.5	132.5	143.9	138.8	115.0	145.0	160.7
Benin	173.6	148.1	153.6	160.6	189.9	157.1	163.6	171.8
Ibadan	101.0	118.5	151.4	195.5	106.6	129.5	171.7	226.7
Ijebu_Ode	142.2	116.0	145.9	167.6	153.3	122.0	157.4	183.1
Ondo	150.3	119.3	141.4	196.6	167.7	128.4	155.4	225.9
Owerri	189.4	173.7	185.8	187.6	206.2	187.7	201.2	205.1
Lagos	235.2	146.9	192.5	231.9	264.7	158.1	214.0	263.8
Ikom	163.5	152.1	162.2	176.0	175.8	163.4	175.3	191.8
Oshogbo	107.3	98.7	105.4	117.5	117.0	107.4	114.2	128.6
Onitsha	153.5	135.4	150.5	177.7	166.1	144.1	163.7	199.7
Uyo	156.0	149.4	153.7	167.7	167.7	160.2	165.3	181.0
Enugu	175.4	144.6	160.5	181.0	195.4	154.0	176.8	199.3
Ibi	122.9	119.8	132.7	139.0	133.7	129.6	144.4	151.6
Ogoja	158.2	144.3	157.1	162.6	170.8	154.0	171.0	177.1
Iseyin	129.9	116.3	126.9	135.0	142.4	125.7	141.2	147.8
Makurdi	131.1	121.8	130.1	140.9	144.5	132.5	140.4	154.5
Lokoja	113.4	113.6	117.3	121.2	122.6	121.6	125.8	130.9
Ilorin	120.6	106.1	114.3	132.7	130.3	115.2	124.2	145.6
Abuja	146.5	118.9	157.4	175.1	164.5	128.3	172.2	194.8
Bauchi	112.7	111.3	119.8	128.7	121.7	122.9	129.5	140.6
Kaduna	122.9	98.7	123.2	135.8	134.9	106.3	133.3	150.3
Minna	114.6	114.0	123.2	127.4	124.1	121.4	132.9	138.3
Shaki	104.9	100.9	108.6	116.5	113.4	109.7	117.6	128.4
Yelwa	129.8	92.7	121.2	131.0	145.5	100.4	132.2	142.7
Jos	109.9	83.8	120.5	131.9	120.6	91.8	133.4	142.1
Bida	115.2	115.1	123.2	133.3	126.3	126.2	137.5	147.0
Zaria	102.8	95.0	124.4	138.4	109.8	103.2	133.2	149.9
Nguru	92.5	68.9	88.3	96.0	104.0	76.7	97.6	105.1
Yola	105.5	89.7	102.3	110.7	114.8	96.5	110.0	121.1
Kano	127.1	151.0	158.3	172.7	137.7	162.9	172.9	191.9
Katsina	66.3	82.2	104.6	112.6	71.4	91.9	116.6	125.1
Maiduguri	95.5	90.9	114.3	124.1	106.1	100.5	127.1	135.0
Potiskum	111.5	92.4	118.4	124.0	123.4	101.3	129.0	138.1
Sokoto	120.5	92.6	127.9	148.0	138.6	101.5	141.9	168.0
Gusau	127.7	99.8	123.9	132.3	142.5	108.2	135.6	142.9

Table A7 Observed and simulated extreme 3-day accumulated rainfall with return period of 50 and 100 years at six stations in Nigeria.

Stations	50-year event				100-year event			
	Observed	Simulated			Observed	Simulated		
		Min.	Median	Max.		Min.	Median	Max.
Ikeja	271.7	168.9	206.0	260.5	300.5	181.8	223.3	286.8
P. Harcourt	175.9	169.9	202.1	218.7	186.4	178.1	215.3	236.0
Calabar	244.7	209.8	229.8	250.6	259.8	222.2	243.3	269.0
Warri	220.4	222.0	240.8	249.4	231.4	236.6	256.1	266.9
Abeokuta	170.3	115.3	137.5	150.8	185.1	121.6	146.0	161.3
Akure	152.2	123.4	161.1	182.5	162.2	129.7	172.6	198.8
Benin	210.9	168.8	176.4	186.8	226.7	177.6	186.0	198.6
Ibadan	113.9	143.9	198.0	267.2	119.4	154.6	217.7	297.6
Ijebu_Ode	167.6	129.9	172.2	203.0	178.4	135.7	183.3	218.0
Ondo	190.2	140.2	173.4	263.7	207.1	149.0	187.0	292.1
Owerri	228.1	205.8	220.5	227.9	244.4	219.4	235.0	245.4
Lagos	302.9	172.5	241.7	305.1	331.5	183.4	262.6	336.0
Ikom	191.8	178.1	192.1	212.3	203.7	189.0	204.8	227.6
Oshogbo	129.4	118.5	125.6	142.9	138.8	126.3	134.1	153.7
Onitsha	182.5	155.3	180.8	228.3	194.8	163.8	193.6	249.7
Uyo	182.9	174.2	180.6	198.3	194.3	183.8	192.1	211.2
Enugu	221.3	166.2	195.3	223.0	240.7	175.3	208.6	240.7
Ibi	147.6	142.2	159.5	170.0	158.1	151.6	170.8	183.8
Ogoja	187.2	166.6	188.2	195.9	199.5	176.1	201.1	209.9
Iseyin	158.5	137.9	158.9	164.3	170.7	147.0	171.6	177.0
Makurdi	161.9	146.5	153.6	172.1	174.9	156.9	163.6	185.3
Lokoja	134.4	132.0	137.7	143.7	143.3	139.8	146.7	153.7
Ilorin	142.8	125.7	135.8	162.3	152.1	133.3	144.7	174.8
Abuja	187.8	140.5	192.0	220.4	205.2	149.5	208.4	239.5
Bauchi	133.3	136.2	142.2	156.0	142.1	143.8	151.7	167.5
Kaduna	150.5	116.0	149.6	170.8	162.2	123.3	160.7	186.2
Minna	136.4	130.9	145.0	152.4	145.6	138.0	153.1	163.0
Shaki	124.4	121.0	129.4	143.8	132.6	129.4	138.2	155.3
Yelwa	165.9	110.5	146.5	157.9	181.2	118.0	157.3	169.3
Jos	134.4	102.3	147.2	155.3	144.7	110.1	157.5	165.1
Bida	140.5	140.6	156.0	167.3	151.2	151.3	168.5	182.5
Zaria	118.8	113.8	145.8	164.7	125.6	121.7	156.3	175.8
Nguru	118.9	86.8	109.6	117.0	130.1	94.3	118.6	126.5
Yola	126.9	105.3	119.9	134.5	135.9	111.9	127.3	144.5
Kano	151.4	178.3	190.5	216.6	161.7	189.8	204.2	235.2
Katsina	77.9	104.4	132.1	141.3	82.9	113.8	143.7	153.5
Maiduguri	119.7	112.9	139.5	149.3	129.9	122.1	148.7	159.9
Potiskum	138.8	112.7	142.8	156.2	150.4	121.3	153.2	169.9
Sokoto	162.2	113.0	161.0	193.9	179.8	121.6	175.8	213.2
Gusau	161.7	119.1	150.0	156.6	176.1	127.3	160.7	166.8

Table A8 Projected changes in extreme daily rainfall with return period of 10, 20, 50 and 100 years at 40 stations in Nigeria, using B1 scenario for future period (2046-2065).

Stations	10-year event			20-year event			50-year event			100-year event		
	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.
Ikeja	-27.5	6.2	23.2	-30.0	5.4	26.3	-32.4	4.1	29.5	-33.8	3.4	31.5
P. Harcourt	-18.0	-2.4	14.6	-20.4	-3.5	18.7	-22.9	-4.4	23.2	-24.5	-4.8	26.2
Calabar	-9.7	6.9	20.2	-9.9	8.0	20.7	-10.1	8.5	21.3	-10.3	8.3	21.6
Warri	-7.6	0.9	4.4	-8.9	1.1	4.2	-10.4	0.4	4.1	-11.4	-0.3	4.0
Abeokuta	-8.5	6.9	24.7	-9.2	7.5	29.0	-10.1	8.1	33.9	-10.6	8.5	37.2
Akure	-19.1	-4.5	10.7	-23.0	-5.0	16.5	-26.9	-5.4	23.2	-29.2	-5.7	27.9
Benin	-9.2	8.3	14.7	-10.7	8.6	17.9	-12.3	8.8	21.6	-13.3	9.0	24.1
Ibadan	-41.0	-3.2	48.5	-44.6	-4.8	53.3	-47.8	-6.4	58.0	-49.6	-7.4	60.6
Ijebu_Ode	-21.9	-4.2	13.5	-25.0	-4.3	16.0	-28.8	-4.4	18.7	-31.1	-4.5	20.5
Ondo	-33.7	0.6	36.6	-36.3	-0.1	44.0	-38.8	-0.9	51.7	-40.3	-1.4	56.5
Owerri	-10.4	1.0	18.6	-12.1	0.4	20.2	-14.0	-0.1	21.9	-15.1	-0.5	23.0
Lagos	-15.8	12.1	58.6	-17.2	13.6	67.4	-18.6	15.1	77.1	-19.4	16.1	83.5
Ikom	-14.8	-2.5	29.6	-16.3	-2.4	32.7	-17.8	-2.3	36.1	-18.8	-2.2	38.4
Oshogbo	-6.2	6.1	23.8	-7.3	6.6	27.8	-8.5	7.1	32.6	-9.2	7.4	35.8
Onitsha	-2.8	10.2	18.7	-4.9	9.6	19.7	-7.2	8.9	20.8	-8.6	8.5	21.5
Uyo	-7.2	4.9	18.8	-7.8	6.1	22.2	-8.5	7.5	26.0	-9.0	7.7	28.6
Enugu	-4.3	4.0	11.8	-5.8	2.4	11.7	-7.4	0.7	12.4	-8.4	-0.4	13.7
Ibi	-20.2	-3.4	14.7	-20.8	-3.9	14.3	-21.4	-4.4	13.8	-21.7	-4.7	13.6
Ogoja	-10.0	2.4	49.3	-11.4	2.0	59.7	-12.8	1.6	72.0	-13.7	1.4	80.4
Iseyin	-25.2	-9.2	-1.1	-28.4	-11.4	-1.6	-31.7	-13.3	-2.1	-33.8	-14.4	-2.4
Makurdi	-7.6	-4.0	5.7	-9.6	-5.2	5.6	-11.8	-7.2	5.5	-13.3	-8.4	5.4
Lokoja	-5.0	1.1	6.1	-5.4	0.8	6.1	-6.1	0.4	6.0	-7.3	0.2	6.1
Ilorin	-8.8	2.6	19.2	-9.3	3.1	23.4	-10.5	3.5	28.3	-11.2	3.8	31.4
Abuja	-15.7	-0.4	23.9	-18.3	-1.1	27.7	-21.0	-1.9	31.7	-22.6	-2.3	34.2
Bauchi	-7.2	4.3	17.3	-7.8	1.9	19.4	-8.4	1.5	21.8	-8.8	1.2	23.4
Kaduna	-10.1	8.0	16.1	-11.2	9.5	15.1	-12.2	9.0	14.0	-12.8	8.7	15.9
Minna	-19.3	-1.6	2.0	-22.0	-2.4	2.5	-24.8	-3.3	3.0	-26.5	-3.8	3.4
Shaki	-8.3	-2.8	3.6	-9.8	-4.2	3.2	-11.4	-5.7	4.0	-12.4	-6.6	4.6
Yelwa	-3.9	0.8	8.6	-3.9	0.4	8.6	-4.0	-0.3	8.7	-4.7	-0.7	8.7
Jos	-19.3	-4.8	10.9	-20.8	-5.1	11.4	-22.4	-7.8	11.9	-23.3	-9.3	12.2
Bida	-19.2	-13.5	-1.2	-20.8	-15.0	-1.2	-22.5	-16.5	-1.2	-23.6	-17.4	-1.2
Zaria	-2.3	6.3	11.8	-1.9	6.0	12.0	-1.6	7.9	12.2	-1.3	7.8	12.5
Nguru	-4.5	3.7	18.2	-5.7	2.3	17.0	-7.4	0.8	15.8	-8.4	0.0	15.0
Yola	-6.0	-1.1	31.0	-8.1	-2.0	35.8	-10.4	-1.2	41.3	-11.9	-0.6	44.9
Kano	-30.1	10.4	41.4	-35.3	11.5	48.4	-40.3	12.8	56.5	-43.2	13.6	61.9
Katsina	-26.6	-16.1	21.5	-30.7	-17.9	24.1	-34.7	-19.6	26.8	-37.1	-20.6	28.5
Maiduguri	-18.8	13.8	35.7	-20.4	11.7	42.9	-22.1	9.6	50.8	-23.1	8.3	55.9
Potiskum	-21.3	-1.3	29.8	-25.6	-0.1	33.0	-30.2	1.2	36.4	-33.0	2.0	38.5
Sokoto	-20.1	-13.6	4.2	-23.4	-14.6	4.3	-26.7	-15.5	4.5	-28.7	-16.1	4.6
Gusau	-11.1	-0.6	16.1	-9.5	-1.1	17.1	-7.8	0.1	18.5	-6.7	0.8	19.5

Table A9 Projected changes in extreme daily rainfall with return period of 10, 20, 50 and 100 years at 40 stations in Nigeria, using B1 scenario for future period (2080-2100).

Stations	10-year event			20-year event			50-year event			100-year event		
	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.
Ikeja	-24.5	3.9	25.1	-27.3	3.5	28.5	-30.1	3.1	31.9	-31.7	2.8	34.0
P. Harcourt	-12.7	1.9	6.0	-14.5	1.5	6.4	-16.4	1.1	7.3	-17.6	0.8	8.0
Calabar	-8.1	7.4	9.3	-8.8	7.6	9.1	-9.5	7.3	10.6	-10.0	6.6	11.6
Warri	-6.3	0.2	9.4	-8.7	-0.5	11.6	-11.3	-1.2	14.1	-12.9	-1.7	15.7
Abeokuta	-19.8	1.7	9.3	-21.1	2.0	11.1	-22.6	2.4	13.1	-23.5	2.6	14.5
Akure	-19.1	2.1	27.2	-22.9	0.6	31.2	-26.7	-0.9	40.7	-29.0	-1.9	47.7
Benin	-11.2	4.2	15.2	-13.2	3.9	17.4	-15.3	3.6	19.9	-16.6	3.4	21.5
Ibadan	-24.2	18.6	28.6	-27.2	18.6	33.7	-29.9	18.6	40.3	-31.5	18.6	44.4
Ijebu_Ode	-14.1	-3.3	6.2	-15.8	-4.6	7.6	-17.7	-6.1	9.2	-18.8	-7.0	10.2
Ondo	-30.5	-0.3	16.8	-33.8	-1.4	20.1	-37.0	-2.5	23.8	-38.8	-3.2	26.1
Owerri	-4.7	1.3	11.8	-6.5	-0.1	12.4	-8.5	-0.6	13.0	-9.8	-0.3	13.4
Lagos	-21.8	-7.8	18.9	-24.1	-9.8	20.9	-26.3	-11.8	23.0	-27.6	-13.2	24.4
Ikom	-17.9	-2.5	34.5	-21.9	-4.7	39.3	-26.0	-6.2	44.7	-28.4	-6.4	48.3
Oshogbo	-2.9	6.1	26.0	-3.2	6.8	28.5	-3.5	7.6	32.4	-3.7	8.1	35.2
Onitsha	0.8	4.3	28.2	-0.6	5.5	29.9	-2.0	6.8	31.8	-2.9	7.6	33.0
Uyo	-6.7	5.4	25.2	-6.7	7.1	29.1	-6.8	9.0	33.5	-6.9	9.4	36.5
Enugu	-12.6	5.1	12.4	-15.4	5.5	13.7	-18.3	5.9	15.1	-20.0	6.1	16.0
Ibi	-13.2	0.6	19.8	-13.4	0.6	20.7	-13.6	0.7	21.6	-13.7	0.7	22.1
Ogoja	-12.3	-0.3	25.9	-15.3	0.0	30.9	-18.5	0.4	36.8	-20.5	0.6	40.8
Iseyin	-21.1	-6.1	13.2	-23.5	-7.3	13.9	-26.0	-8.5	14.7	-27.6	-9.2	15.2
Makurdi	-8.3	-0.6	1.7	-10.1	-2.7	1.9	-12.0	-4.9	2.0	-13.2	-6.3	2.2
Lokoja	-5.8	2.6	12.5	-7.5	2.0	13.2	-9.4	2.3	13.9	-10.7	2.7	14.4
Ilorin	-5.0	-3.0	15.4	-6.2	-3.3	16.4	-8.6	-1.9	17.5	-10.1	-0.9	18.2
Abuja	-13.8	-5.8	17.0	-14.5	-6.9	17.0	-15.3	-8.1	19.3	-15.7	-8.8	20.7
Bauchi	-9.8	2.4	15.8	-11.7	2.9	18.2	-13.8	3.4	20.9	-15.1	3.7	22.7
Kaduna	1.4	7.6	39.6	1.1	7.9	43.3	0.8	8.3	47.4	0.6	8.5	50.0
Minna	-17.0	-4.0	0.6	-21.2	-5.4	-0.1	-25.6	-6.9	-0.6	-28.2	-8.0	-0.7
Shaki	-4.4	8.5	19.6	-4.8	9.4	20.6	-5.3	10.4	21.6	-5.7	11.0	22.2
Yelwa	-2.9	1.1	20.3	-2.2	0.9	18.6	-2.7	-0.7	16.8	-3.8	-0.8	15.7
Jos	-19.6	-8.3	13.2	-23.0	-9.6	11.0	-26.6	-11.0	9.9	-28.9	-11.9	10.5
Bida	-14.5	-10.3	6.6	-16.7	-11.1	8.2	-18.9	-11.8	10.0	-20.3	-12.3	11.1
Zaria	-4.4	2.7	18.2	-5.2	4.3	19.5	-6.1	3.7	20.9	-6.6	3.4	21.7
Nguru	-0.5	7.6	21.4	-0.9	6.0	20.9	-1.3	6.1	20.3	-1.6	6.1	19.9
Yola	-5.1	5.6	21.1	-6.1	7.1	24.8	-7.2	7.3	29.0	-8.0	7.2	31.8
Kano	-11.2	8.4	33.2	-13.6	9.3	38.4	-15.9	10.2	44.4	-17.3	10.8	48.5
Katsina	-31.4	-10.5	14.3	-35.0	-12.6	16.7	-38.4	-14.8	19.2	-40.4	-16.1	20.8
Maiduguri	-17.9	16.5	34.3	-20.6	19.6	41.5	-23.5	23.1	49.5	-25.2	25.3	54.6
Potiskum	-21.3	4.8	26.8	-23.7	6.2	29.2	-26.2	7.7	31.7	-27.7	8.0	33.3
Sokoto	-23.8	-14.5	-0.9	-25.6	-16.8	-1.4	-27.4	-19.1	-1.9	-28.4	-20.5	-2.2
Gusau	-15.6	-2.4	34.4	-16.6	-3.2	38.8	-17.5	-4.0	43.6	-18.1	-4.5	46.7

Table A10 Projected changes in extreme daily rainfall with return period of 10, 20, 50 and 100 years at 40 stations in Nigeria, using B1 scenario for future period (2080-2100).

Stations	10-year event			20-year event			50-year event			100-year event		
	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.
Ikeja	-12.5	-1.2	15.4	-14.3	-1.3	15.9	-16.1	-1.4	16.5	-17.2	-1.4	16.8
P. Harcourt	-10.8	-5.3	5.7	-11.8	-6.3	4.5	-13.0	-7.1	3.3	-13.7	-7.0	2.5
Calabar	-2.6	6.9	10.1	-3.0	6.7	11.7	-3.5	8.3	13.8	-3.8	9.4	15.2
Warri	-13.7	-0.4	7.6	-15.5	-0.5	7.5	-17.5	-0.7	7.7	-18.8	-0.8	7.9
Abeokuta	-14.2	1.2	8.2	-15.8	1.3	9.6	-17.5	1.4	11.2	-18.5	1.4	12.2
Akure	-23.3	-6.6	20.5	-26.3	-7.2	28.5	-29.4	-7.8	37.9	-31.7	-8.1	44.4
Benin	-7.5	5.5	13.6	-9.7	5.8	15.0	-12.1	6.1	16.5	-14.1	6.4	17.6
Ibadan	-36.5	-6.1	47.2	-40.9	-5.9	55.5	-45.1	-7.6	64.3	-47.4	-9.0	69.8
Ijebu_Ode	-21.6	1.9	9.0	-23.5	1.7	7.9	-25.5	2.5	6.8	-26.8	1.9	6.1
Ondo	-34.8	-11.8	28.3	-38.2	-12.6	34.9	-41.6	-13.4	42.2	-43.5	-13.9	46.7
Owerri	-7.1	4.2	12.6	-9.8	2.8	14.6	-12.6	0.6	17.7	-14.4	-0.5	19.6
Lagos	-28.5	3.7	22.5	-31.8	2.8	24.9	-35.1	1.7	27.4	-37.2	1.1	29.1
Ikom	-12.9	-4.3	19.8	-15.7	-6.1	23.2	-18.6	-7.4	26.9	-20.4	-7.8	29.4
Oshogbo	-1.6	11.6	20.2	-1.8	13.4	23.3	-2.0	15.4	27.0	-2.1	16.8	29.5
Onitsha	-9.9	5.2	21.9	-10.7	5.8	25.4	-11.7	6.5	29.4	-12.2	6.9	32.0
Uyo	0.7	3.2	18.0	-0.2	2.9	20.6	-1.2	4.2	23.5	-1.9	4.5	25.4
Enugu	-9.4	9.7	14.9	-11.5	9.1	13.4	-13.5	8.5	12.4	-14.7	8.2	12.1
Ibi	-16.8	4.2	19.1	-20.3	4.1	19.2	-23.9	4.0	19.3	-26.1	3.9	19.4
Ogoja	-13.3	-3.7	28.6	-16.3	-4.4	35.5	-19.2	-5.1	43.7	-21.1	-5.6	49.3
Iseyin	-8.9	1.3	8.9	-9.6	0.1	10.0	-10.2	-1.2	11.1	-10.6	-2.0	11.9
Makurdi	-19.1	-4.0	13.7	-22.9	-6.7	14.0	-27.0	-9.7	14.3	-29.7	-11.6	14.5
Lokoja	-5.5	-0.9	12.9	-6.7	-1.8	15.2	-8.0	-2.8	17.8	-8.9	-3.5	19.5
Ilorin	-8.1	-1.1	17.0	-8.0	-2.0	19.1	-7.8	-2.9	21.5	-7.8	-3.0	23.0
Abuja	-18.1	8.4	25.1	-19.3	9.6	27.4	-20.5	8.6	29.8	-21.2	8.0	31.4
Bauchi	-11.4	3.4	11.3	-14.8	3.0	13.5	-18.3	2.5	16.1	-20.5	2.2	17.9
Kaduna	-2.0	5.8	11.5	-1.9	5.7	12.3	-1.8	5.7	13.1	-1.7	5.6	13.6
Minna	-23.4	-2.8	2.1	-27.2	-4.0	2.7	-31.0	-5.1	3.3	-33.3	-5.5	3.7
Shaki	-13.3	2.9	21.0	-17.2	3.6	22.1	-21.3	4.3	23.3	-23.9	4.8	24.1
Yelwa	-3.4	1.7	3.9	-5.3	0.4	1.5	-7.5	-1.7	0.8	-8.9	-3.2	0.5
Jos	-17.7	-5.6	3.7	-20.4	-6.2	3.7	-23.3	-6.7	3.7	-25.0	-7.1	3.7
Bida	-11.7	-2.2	19.3	-13.1	-3.2	21.2	-14.7	-4.2	23.3	-15.6	-4.8	24.6
Zaria	-0.8	1.2	6.8	-2.4	0.7	6.3	-4.6	2.1	5.7	-6.4	1.4	5.3
Nguru	2.2	6.9	16.8	0.9	5.9	14.7	-0.8	4.1	12.5	-1.9	3.0	11.2
Yola	-4.8	4.5	24.5	-5.5	5.2	28.0	-6.3	5.9	32.0	-6.9	6.4	34.7
Kano	-17.6	6.1	23.1	-21.5	7.6	26.2	-25.3	9.3	29.6	-27.5	10.4	31.9
Katsina	-11.5	-8.1	23.4	-13.1	-7.8	24.8	-15.7	-7.6	26.7	-17.2	-7.4	27.8
Maiduguri	-11.8	-4.7	12.3	-14.9	-4.3	14.2	-18.2	-4.0	16.3	-20.2	-3.8	17.6
Potiskum	-7.5	1.7	17.2	-8.9	1.1	17.1	-10.4	0.4	17.0	-11.3	0.0	16.9
Sokoto	-12.0	-6.2	29.4	-13.5	-6.9	30.0	-15.0	-7.6	30.6	-15.9	-8.0	31.0
Gusau	-3.1	5.0	19.7	-1.4	5.2	17.5	-0.2	5.4	17.4	0.1	5.5	18.1

Table A11 Projected changes in extreme daily rainfall with return period of 10, 20, 50 and 100 years at 40 stations in Nigeria, using A2 scenario for future period (2080-2100).

Stations	10-year event			20-year event			50-year event			100-year event		
	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.
Ikeja	-26.8	4.8	33.5	-30.0	6.8	39.1	-33.0	6.0	44.8	-34.7	5.4	48.4
P. Harcourt	-16.6	-0.3	1.2	-19.2	-1.2	1.6	-22.1	-1.6	2.7	-23.8	-1.7	3.5
Calabar	0.4	7.2	14.6	0.2	6.5	15.8	0.0	5.7	17.2	-0.1	5.2	18.2
Warri	-3.2	2.7	11.0	-3.6	3.0	10.6	-4.0	3.5	10.5	-4.3	3.9	11.4
Abeokuta	-9.0	-3.1	2.6	-9.6	-3.9	3.0	-10.5	-4.5	3.3	-11.6	-5.0	3.5
Akure	-20.3	-4.5	35.8	-22.8	-4.1	41.7	-25.4	-3.7	52.2	-26.9	-3.5	59.3
Benin	-7.7	2.5	17.9	-9.0	2.7	19.9	-10.5	2.9	22.1	-11.4	3.1	23.6
Ibadan	-48.2	-13.5	36.9	-52.7	-15.7	41.8	-56.8	-18.6	46.5	-59.1	-20.3	49.3
Ijebu_Ode	-9.5	0.5	18.4	-10.4	0.4	18.7	-11.5	0.3	19.1	-12.2	0.2	19.4
Ondo	-21.7	-8.1	30.2	-25.5	-8.8	38.5	-29.2	-9.6	47.6	-31.4	-10.1	53.4
Owerri	-21.8	10.8	16.5	-25.7	11.7	18.1	-29.8	12.7	19.9	-32.4	13.3	21.1
Lagos	4.3	11.9	50.6	5.0	12.6	58.9	5.6	14.3	68.1	6.0	15.5	74.0
Ikom	-10.0	-5.3	10.9	-12.4	-6.4	10.4	-15.0	-7.4	9.8	-16.5	-8.1	9.5
Oshogbo	-2.8	8.4	17.2	-3.4	7.9	18.7	-4.1	8.4	20.3	-4.6	9.3	21.3
Onitsha	-8.7	6.2	34.2	-10.1	6.8	38.2	-11.5	6.0	42.8	-12.4	5.3	45.8
Uyo	-2.3	11.5	24.3	-2.8	10.8	29.0	-3.4	10.0	34.4	-3.8	9.5	38.0
Enugu	-2.5	9.8	15.4	-6.1	10.4	13.8	-9.6	11.0	14.9	-11.8	11.2	16.0
Ibi	-15.7	-9.9	13.8	-18.2	-12.1	12.8	-21.4	-14.4	11.7	-23.3	-15.8	11.1
Ogoja	-6.7	5.9	18.5	-8.8	4.7	23.2	-11.0	3.6	28.8	-12.4	2.9	32.6
Iseyin	-16.6	4.7	17.9	-17.2	2.3	20.3	-18.0	-0.1	22.8	-18.4	-1.5	24.4
Makurdi	-2.5	3.3	15.9	-5.0	2.4	15.1	-7.7	1.4	14.2	-9.4	0.8	13.6
Lokoja	-6.4	3.4	6.6	-6.9	2.6	7.9	-7.5	1.6	9.5	-8.0	1.0	10.5
Ilorin	-14.2	-0.6	8.5	-16.3	-2.0	8.5	-18.6	-3.5	8.7	-20.0	-3.6	8.9
Abuja	-14.5	-4.0	15.7	-15.9	-4.0	18.0	-17.3	-4.0	20.5	-18.2	-4.0	22.0
Bauchi	-3.0	1.5	18.6	-4.1	1.3	22.0	-5.3	1.3	25.9	-6.0	1.3	28.5
Kaduna	-11.9	2.7	18.0	-14.0	2.6	19.6	-16.0	2.0	22.9	-17.3	1.7	25.1
Minna	-17.5	-3.1	2.1	-20.8	-4.0	2.4	-24.2	-5.1	2.8	-26.2	-5.8	3.1
Shaki	-7.9	7.2	14.6	-9.8	7.3	15.6	-11.8	5.8	16.7	-13.3	5.5	17.4
Yelwa	-4.8	0.3	4.7	-4.6	-1.3	3.4	-4.9	-3.3	6.3	-5.7	-3.5	8.2
Jos	-6.5	3.3	10.3	-6.9	3.7	10.9	-8.4	3.5	11.5	-10.8	3.9	11.9
Bida	-10.8	-6.5	33.4	-13.3	-8.7	35.4	-15.8	-9.5	37.5	-17.4	-10.0	38.9
Zaria	-10.1	-4.0	4.4	-10.3	-2.7	1.8	-10.6	-1.1	0.6	-10.8	-2.9	2.7
Nguru	-22.1	7.6	14.5	-24.1	6.9	11.5	-26.1	6.2	9.8	-27.4	5.8	9.5
Yola	-10.9	3.2	15.4	-13.9	4.2	17.5	-17.3	5.7	19.9	-19.4	6.7	21.5
Kano	-22.6	2.4	34.4	-26.6	2.4	41.4	-30.4	2.5	49.5	-32.6	2.5	54.9
Katsina	-22.0	-5.2	12.3	-25.2	-6.1	14.8	-28.3	-7.0	17.4	-30.1	-7.5	19.0
Maiduguri	-5.6	3.4	18.0	-4.3	3.1	19.5	-2.9	3.6	21.0	-2.0	4.6	22.1
Potiskum	-14.1	0.1	3.0	-16.9	-1.0	2.1	-19.7	-2.1	1.5	-21.4	-3.2	1.1
Sokoto	-23.2	-15.2	2.1	-24.9	-16.6	2.8	-26.5	-18.1	3.5	-27.5	-19.0	3.9
Gusau	-13.9	-2.5	22.8	-14.9	-2.3	19.8	-15.8	-3.2	16.9	-16.4	-3.9	17.7

Table A12 Projected changes in extreme 3-day accumulated rainfall with return period of 10, 20, 50 and 100 years at 40 stations in Nigeria, using B1 scenario for future period (2046-2065).

Stations	10-year event			20-year event			50-year event			100-year event		
	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.
Ikeja	-27.8	-0.2	19.4	-29.8	-2.1	22.6	-31.8	-4.1	26.1	-32.9	-5.3	28.2
P. Harcourt	-12.3	-0.5	2.9	-14.1	-0.5	2.6	-16.1	-0.5	2.8	-17.3	-0.4	3.4
Calabar	-11.3	4.5	16.6	-12.6	4.7	18.9	-14.0	4.9	21.5	-14.9	5.1	23.1
Warri	-6.6	-2.8	1.0	-8.3	-4.6	1.6	-10.1	-5.3	2.2	-11.2	-5.7	2.5
Abeokuta	-8.5	5.2	16.6	-8.5	5.6	19.0	-8.4	5.9	21.7	-8.3	6.2	23.5
Akure	-18.3	-6.0	4.8	-21.7	-5.7	7.9	-25.3	-5.3	11.5	-27.5	-5.1	13.9
Benin	-7.2	1.5	8.9	-7.9	2.1	9.5	-8.7	2.8	10.1	-9.3	3.2	10.5
Ibadan	-36.3	-1.8	42.9	-39.8	-1.8	48.0	-43.2	-1.9	53.0	-45.1	-1.9	56.0
Ijebu_Ode	-18.2	-3.7	13.6	-20.3	-3.7	17.0	-22.6	-4.5	21.1	-24.0	-5.0	23.8
Ondo	-27.9	-6.6	28.6	-30.0	-6.8	36.0	-32.0	-7.0	44.2	-33.2	-7.2	49.5
Owerri	-11.6	-0.7	3.1	-13.2	-1.1	2.9	-15.0	-1.5	2.7	-16.2	-1.7	2.6
Lagos	-16.1	-1.7	51.1	-17.3	-2.2	59.1	-18.4	-2.7	67.9	-19.1	-3.1	73.7
Ikom	-13.6	3.8	8.5	-16.0	3.2	8.2	-18.6	2.5	7.9	-20.3	2.0	7.8
Oshogbo	-12.7	0.4	7.9	-14.9	1.5	10.1	-17.3	2.7	12.6	-18.9	3.5	14.2
Onitsha	-12.8	-1.4	11.2	-16.4	-2.6	12.8	-20.1	-4.3	14.4	-22.2	-5.4	15.5
Uyo	-10.9	-4.3	1.8	-12.0	-5.9	2.1	-13.1	-7.7	2.8	-13.9	-8.7	3.3
Enugu	-12.3	0.5	3.5	-13.9	-0.4	3.8	-15.5	0.7	4.6	-16.6	1.5	5.1
Ibi	-14.7	-1.3	13.6	-14.7	-0.9	16.1	-14.7	-0.4	18.8	-14.7	-0.2	20.5
Ogoja	-13.5	-1.0	10.1	-15.4	-0.2	12.2	-17.5	0.1	14.5	-18.7	0.1	16.0
Iseyin	-21.5	-9.3	14.3	-22.4	-9.5	17.9	-24.4	-9.7	21.9	-25.8	-9.8	24.5
Makurdi	-9.8	-5.0	10.4	-11.2	-5.6	13.2	-12.7	-6.2	16.3	-13.7	-6.5	18.2
Lokoja	-9.2	-1.8	4.0	-11.0	-2.3	5.0	-13.0	-2.8	6.1	-14.3	-3.1	6.8
Ilorin	-12.2	-4.7	12.8	-15.2	-7.1	13.9	-18.5	-7.9	15.5	-20.5	-8.3	16.8
Abuja	-13.2	-1.5	17.8	-15.5	-1.7	19.9	-17.8	-1.9	22.3	-19.2	-2.0	23.8
Bauchi	-15.2	-4.4	7.2	-17.1	-4.7	7.2	-21.4	-5.0	7.2	-24.3	-5.3	7.2
Kaduna	-8.8	6.3	9.6	-12.2	6.1	11.3	-15.5	5.6	13.4	-17.6	4.7	14.8
Minna	-12.8	-6.4	9.3	-13.6	-6.3	12.2	-14.5	-6.3	15.5	-15.7	-6.2	17.7
Shaki	-9.4	-3.1	-1.0	-9.8	-3.8	-0.9	-10.2	-4.6	-0.8	-10.5	-5.1	-0.7
Yelwa	-10.8	-1.8	18.1	-12.6	-3.9	21.2	-14.5	-6.0	24.6	-15.7	-7.4	26.8
Jos	-15.4	-2.8	11.4	-17.5	-2.8	11.6	-19.7	-3.1	11.9	-21.1	-2.7	12.1
Bida	-22.8	-13.6	-0.8	-25.7	-15.6	0.6	-28.8	-17.7	2.0	-30.6	-19.0	2.9
Zaria	-15.3	-1.6	20.3	-16.5	-3.1	22.8	-17.8	-4.6	25.5	-18.7	-4.9	27.2
Nguru	-12.2	4.0	24.6	-12.7	4.5	28.3	-13.2	5.0	32.3	-13.5	4.4	34.8
Yola	-12.1	5.2	13.6	-14.2	5.0	15.5	-16.3	4.4	17.6	-17.7	4.0	19.0
Kano	-17.3	4.0	24.1	-21.2	5.5	26.8	-25.1	6.9	29.6	-27.4	7.7	31.4
Katsina	-27.9	-16.1	12.6	-30.9	-18.0	12.8	-33.9	-19.9	12.9	-35.7	-21.1	13.1
Maiduguri	-17.1	1.8	29.0	-18.7	2.0	35.6	-20.3	3.7	42.7	-21.3	4.8	47.4
Potiskum	-16.3	-5.4	20.3	-17.7	-4.1	23.6	-19.1	-2.6	27.2	-20.0	-1.8	29.5
Sokoto	-16.6	-9.8	-1.6	-19.9	-10.3	-2.7	-23.1	-11.0	-3.7	-25.1	-12.5	-4.3
Gusau	-13.9	-3.2	14.0	-15.8	-3.5	16.0	-17.9	-3.9	18.2	-19.2	-4.1	19.7

Table A13 Projected changes in extreme 3-day accumulated rainfall with return period of 10, 20, 50 and 100 years at 40 stations in Nigeria, using B1 scenario for future period (2080-2100).

Stations	10-year event			20-year event			50-year event			100-year event		
	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.
Ikeja	-24.8	0.3	25.8	-26.9	-0.7	30.6	-29.0	-1.7	35.7	-30.2	-2.3	38.9
P. Harcourt	-13.1	-2.5	9.5	-15.4	-2.7	10.9	-17.9	-2.9	12.4	-19.4	-3.0	13.7
Calabar	-12.4	3.1	7.6	-14.8	2.5	8.6	-17.6	1.8	9.7	-19.4	1.3	10.4
Warri	-7.2	-0.9	0.3	-10.8	-2.2	0.7	-14.7	-2.7	1.3	-17.1	-3.2	1.7
Abeokuta	-16.0	-2.5	12.2	-16.4	-3.3	13.9	-16.9	-4.1	15.8	-17.3	-4.6	17.0
Akure	-11.2	0.2	15.1	-12.2	1.0	18.0	-13.3	1.9	21.2	-13.9	2.5	23.2
Benin	-6.4	-0.7	17.9	-6.2	-0.9	21.6	-6.0	-0.5	25.7	-5.8	-0.3	28.5
Ibadan	-29.0	16.0	24.0	-32.4	17.3	27.5	-35.6	18.7	31.0	-37.4	19.5	33.1
Ijebu_Ode	-9.2	-5.2	4.6	-10.6	-4.5	7.3	-12.0	-3.8	10.4	-13.0	-3.4	12.5
Ondo	-31.2	-6.7	6.6	-34.4	-7.0	10.3	-37.6	-7.3	14.3	-39.5	-7.4	16.9
Owerri	-5.8	-4.0	10.2	-7.1	-5.3	10.5	-9.0	-5.7	10.9	-10.5	-6.4	11.2
Lagos	-26.2	-7.1	24.3	-30.2	-7.9	28.3	-34.3	-8.9	32.6	-36.7	-9.5	35.5
Ikom	-13.4	-2.6	17.0	-15.3	-3.7	18.9	-17.4	-4.9	21.0	-18.7	-5.7	22.4
Oshogbo	-10.9	0.6	22.6	-12.3	-1.6	28.3	-13.9	-3.8	34.7	-14.9	-5.3	38.8
Onitsha	-14.6	-1.3	9.2	-18.4	-1.6	9.3	-22.3	-2.3	9.4	-24.6	-2.7	10.7
Uyo	-10.7	-5.2	4.0	-11.7	-7.0	4.4	-12.9	-8.0	4.9	-13.7	-8.1	5.3
Enugu	-17.3	-2.4	13.6	-19.9	-4.0	18.4	-22.5	-5.7	23.8	-24.2	-6.7	27.3
Ibi	-10.0	-3.6	14.9	-8.8	-3.9	17.8	-7.5	-4.3	20.9	-7.2	-4.6	22.9
Ogoja	-11.5	-2.2	12.3	-13.7	-1.7	16.2	-16.0	-1.1	20.6	-17.5	-0.7	23.4
Iseyin	-25.5	-10.3	22.8	-27.6	-11.6	26.8	-29.8	-11.6	31.1	-31.2	-11.5	33.9
Makurdi	-9.7	0.8	11.1	-11.7	0.1	14.2	-13.8	-0.6	17.6	-15.1	-1.0	19.9
Lokoja	-11.8	-0.7	5.4	-12.5	0.1	7.3	-13.4	1.1	9.4	-15.1	1.7	10.8
Ilorin	-9.8	-4.6	8.2	-12.5	-5.5	10.6	-15.3	-6.4	13.1	-17.1	-7.0	14.8
Abuja	-15.1	-10.1	23.5	-16.1	-10.1	26.6	-17.9	-10.1	29.9	-19.0	-10.1	32.1
Bauchi	-14.3	-11.3	7.9	-17.8	-12.6	8.5	-21.6	-14.0	9.2	-23.9	-14.9	9.7
Kaduna	-4.4	-1.7	24.1	-5.4	-2.0	25.8	-6.5	-1.5	27.7	-7.1	-1.2	28.9
Minna	-13.7	-5.6	4.2	-14.2	-4.9	6.8	-14.8	-4.2	9.8	-15.4	-3.7	11.8
Shaki	-8.9	3.0	12.8	-9.9	2.2	13.7	-11.0	1.3	14.7	-11.6	0.7	15.4
Yelwa	-9.8	-6.7	21.9	-12.0	-8.4	24.0	-14.4	-10.7	26.2	-15.9	-12.1	27.6
Jos	-15.4	-7.1	12.1	-16.8	-6.2	10.9	-18.3	-5.2	9.6	-19.3	-4.5	10.4
Bida	-19.7	-13.5	2.7	-22.5	-16.5	2.9	-25.3	-18.3	3.0	-27.1	-19.5	3.0
Zaria	-10.7	-4.2	17.5	-11.1	-5.0	17.3	-11.5	-5.3	17.1	-11.7	-5.6	17.0
Nguru	-3.0	6.5	16.4	-1.7	7.2	15.9	-0.4	4.5	15.3	-0.6	4.5	15.0
Yola	-14.4	1.5	13.1	-17.2	0.4	15.2	-20.2	-0.8	17.5	-22.0	-1.5	19.0
Kano	-9.2	1.3	7.0	-9.6	1.7	7.3	-10.0	2.0	7.7	-11.0	2.3	7.9
Katsina	-25.5	-14.2	6.4	-27.3	-15.5	6.7	-29.1	-16.9	6.9	-30.1	-17.7	7.1
Maiduguri	-17.1	-1.8	27.4	-19.2	-1.5	27.5	-21.4	0.2	27.6	-22.7	1.2	27.6
Potiskum	-11.2	-1.4	17.0	-10.1	-1.9	18.2	-8.9	-2.8	19.6	-8.1	-3.3	20.5
Sokoto	-22.5	-9.7	15.9	-23.9	-11.4	18.0	-25.6	-13.7	20.3	-26.8	-15.1	21.8
Gusau	-15.2	-2.8	19.9	-16.7	-3.1	21.6	-19.0	-3.4	23.4	-20.4	-3.6	24.5

Table A14 Projected changes in extreme 3-day accumulated rainfall with return period of 10, 20, 50 and 100 years at 40 stations in Nigeria, using A2 scenario for future period (2046-2056).

Stations	10-year event			20-year event			50-year event			100-year event		
	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.
Ikeja	-10.3	-4.5	30.2	-11.7	-4.1	35.9	-13.3	-3.7	41.7	-14.3	-3.5	45.3
P. Harcourt	-9.9	-4.7	5.6	-10.3	-5.2	5.7	-10.8	-5.0	5.9	-11.1	-4.9	6.0
Calabar	-3.6	0.0	5.0	-5.1	-2.0	5.6	-6.6	-3.4	6.3	-7.5	-3.5	6.8
Warri	-13.0	-4.5	5.0	-15.6	-5.7	5.3	-18.3	-7.0	5.6	-20.1	-7.8	5.9
Abeokuta	-11.9	-5.7	5.4	-12.0	-6.8	5.9	-13.5	-8.0	6.4	-14.4	-8.8	6.8
Akure	-14.6	-8.9	8.8	-15.7	-10.2	11.3	-16.9	-11.6	14.0	-17.7	-12.5	15.9
Benin	-2.8	-0.5	10.5	-3.6	-1.7	12.0	-4.6	-2.6	13.7	-5.2	-2.7	14.9
Ibadan	-39.3	-7.6	29.8	-44.0	-9.0	35.5	-48.6	-10.6	41.6	-51.2	-11.5	45.4
Ijebu_Ode	-19.5	0.3	3.7	-20.2	-0.1	5.0	-20.9	-1.4	6.5	-21.4	-2.2	7.5
Ondo	-34.5	-11.1	16.5	-38.5	-11.8	21.2	-42.5	-12.5	26.5	-44.8	-13.0	29.8
Owerri	-6.1	-3.3	9.6	-8.2	-2.9	11.0	-10.5	-3.8	12.6	-12.1	-3.5	13.6
Lagos	-27.3	-2.3	21.3	-30.7	-4.2	24.2	-34.2	-6.1	27.3	-36.3	-7.2	29.3
Ikom	-10.6	-0.7	6.5	-12.6	-2.9	8.0	-14.8	-5.3	9.6	-16.2	-6.7	10.7
Oshogbo	-9.4	1.9	15.0	-10.9	0.2	17.3	-12.5	1.2	19.7	-13.5	2.0	21.3
Onitsha	-10.9	-2.6	5.3	-13.2	-3.5	6.0	-15.5	-4.6	6.8	-16.8	-5.2	7.3
Uyo	-8.4	-3.1	2.5	-10.1	-2.3	2.4	-12.0	-1.4	2.3	-13.2	-0.9	2.2
Enugu	-8.3	3.6	13.6	-9.2	2.4	15.9	-10.2	2.0	18.5	-10.9	2.3	20.2
Ibi	-15.0	-0.9	12.8	-17.5	-1.3	14.4	-20.1	-1.6	16.1	-21.7	-1.9	17.3
Ogoja	-7.3	-2.9	7.5	-9.2	-2.6	9.5	-11.1	-2.2	11.7	-12.3	-2.0	13.1
Iseyin	-14.8	-1.5	11.1	-16.7	-2.0	13.8	-18.7	-2.6	16.7	-19.9	-2.9	18.6
Makurdi	-10.9	-7.2	3.3	-12.4	-8.8	2.8	-14.1	-10.6	2.3	-15.4	-11.6	2.0
Lokoja	-10.0	-3.6	-0.7	-11.8	-3.8	0.7	-13.8	-4.0	2.2	-15.1	-4.1	3.2
Ilorin	-13.3	0.6	10.9	-14.5	0.3	12.9	-15.8	0.0	15.0	-16.6	-0.2	16.3
Abuja	-14.0	-0.2	19.6	-15.3	0.1	20.1	-16.6	0.4	20.5	-17.4	0.5	20.8
Bauchi	-10.8	-1.1	8.0	-13.3	-1.4	8.9	-16.2	-1.7	9.9	-17.9	-1.9	10.5
Kaduna	-7.4	-3.2	8.8	-9.8	-5.0	9.7	-12.2	-5.1	10.7	-13.7	-5.1	11.4
Minna	-14.4	-11.2	14.2	-16.4	-12.2	18.8	-19.6	-13.1	24.1	-21.6	-13.8	27.5
Shaki	-10.8	2.4	14.3	-13.5	1.7	15.5	-16.4	0.9	16.9	-18.3	0.4	18.0
Yelwa	-12.1	3.5	13.9	-15.5	2.8	15.4	-19.1	2.1	17.1	-21.4	1.6	18.1
Jos	-5.3	0.8	4.3	-6.6	2.6	4.6	-7.9	4.1	4.9	-8.7	4.8	5.8
Bida	-12.8	-9.6	17.6	-15.5	-12.4	19.7	-18.3	-14.3	21.9	-20.0	-15.3	23.2
Zaria	-18.5	-4.0	2.7	-20.7	-4.9	1.9	-23.0	-5.8	1.1	-24.5	-6.3	0.6
Nguru	-11.3	2.6	8.8	-13.3	2.1	6.5	-15.4	0.3	5.2	-16.7	-0.7	6.1
Yola	-12.9	0.5	11.4	-14.6	0.4	11.8	-16.6	0.3	14.5	-17.8	0.3	16.3
Kano	-10.8	-0.5	5.2	-11.8	-0.6	5.6	-12.8	-0.7	5.9	-13.4	-0.8	6.2
Katsina	-11.7	-3.7	17.1	-14.2	-3.9	19.8	-16.7	-4.1	22.8	-18.3	-4.3	24.6
Maiduguri	-10.6	-3.5	8.6	-12.5	-3.2	9.3	-14.7	-2.8	10.0	-16.6	-2.6	10.4
Potiskum	-11.2	-0.9	18.2	-12.2	-0.9	21.0	-13.2	-0.9	24.0	-13.9	-0.9	25.9
Sokoto	-15.2	2.3	11.6	-16.1	2.8	10.8	-17.0	3.3	10.2	-17.5	3.6	11.7
Gusau	-9.0	2.8	12.1	-9.9	2.1	11.1	-11.2	1.3	9.9	-12.0	0.9	9.2

Table A15 Projected changes in extreme 3-day accumulated rainfall with return period of 10, 20, 50 and 100 years at 40 stations in Nigeria, using A2 scenario for future period (2080-2100).

Stations	10-year event			20-year event			50-year event			100-year event		
	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.	Min.	Median	Max.
Ikeja	-27.9	-1.5	22.7	-30.4	-0.5	26.9	-32.8	0.4	31.3	-34.3	1.0	34.0
P. Harcourt	-17.7	-5.1	1.8	-20.7	-7.3	2.7	-23.9	-8.3	3.9	-25.9	-8.2	4.6
Calabar	-6.4	4.5	12.0	-9.0	4.0	13.4	-11.9	3.4	15.0	-13.7	3.0	16.1
Warri	-11.1	-0.6	3.9	-12.8	-1.1	2.5	-14.7	-2.8	0.9	-15.8	-3.8	0.8
Abeokuta	-11.1	-5.6	0.6	-12.5	-6.1	0.9	-14.0	-7.7	1.3	-15.0	-8.7	1.5
Akure	-19.6	-5.2	19.8	-22.1	-5.0	24.2	-24.6	-4.8	29.0	-26.1	-4.7	32.1
Benin	-4.6	2.8	13.0	-4.8	4.2	15.9	-5.0	5.7	19.2	-5.2	6.8	21.4
Ibadan	-40.9	-15.4	28.4	-44.7	-17.1	33.3	-48.4	-18.8	38.2	-50.4	-19.9	41.2
Ijebu_Ode	-6.8	0.0	18.7	-7.8	0.5	22.5	-9.0	3.3	26.8	-9.7	5.1	29.7
Ondo	-21.1	-8.7	21.6	-21.3	-10.2	26.2	-23.1	-11.9	31.3	-24.7	-12.9	34.9
Owerri	-19.2	-4.0	15.0	-22.5	-5.0	16.9	-26.0	-6.2	19.1	-28.1	-6.9	20.4
Lagos	-2.9	16.2	43.8	-2.0	17.5	51.2	-1.1	18.7	59.5	-0.5	19.4	64.9
Ikom	-13.0	-2.0	9.4	-16.3	-3.4	10.2	-19.9	-3.4	11.1	-22.2	-3.6	11.6
Oshogbo	-12.8	-3.2	9.3	-14.3	-3.8	11.3	-16.0	-4.3	13.5	-17.1	-4.3	14.9
Onitsha	-22.5	-0.1	22.9	-26.4	0.1	26.1	-30.2	0.3	29.8	-32.5	0.4	32.2
Uyo	-4.7	-1.0	7.9	-6.6	-1.4	10.3	-9.3	-1.8	13.0	-11.1	-2.1	14.8
Enugu	-4.5	8.9	12.8	-6.5	7.5	16.6	-8.6	5.9	20.8	-9.9	5.4	23.6
Ibi	-17.6	-5.8	6.2	-21.0	-6.2	6.9	-24.5	-6.7	7.5	-26.6	-7.0	8.0
Ogoja	-8.5	0.0	9.6	-9.2	-0.2	12.9	-11.2	-0.2	16.7	-12.5	-0.2	19.2
Iseyin	-13.6	-0.2	16.6	-14.3	-1.7	19.6	-15.1	-3.2	22.9	-15.6	-4.1	25.1
Makurdi	-8.6	-1.4	2.5	-10.5	-1.3	1.1	-12.5	-3.6	-0.2	-13.8	-5.3	0.2
Lokoja	-9.8	-3.3	7.9	-9.8	-3.7	9.5	-9.8	-4.1	11.2	-9.8	-4.3	12.3
Ilorin	-21.3	-6.1	13.6	-24.7	-6.5	14.7	-28.3	-7.0	15.9	-30.5	-7.4	17.6
Abuja	-14.1	2.9	10.8	-14.9	3.5	13.7	-15.7	3.2	16.8	-16.2	3.0	18.9
Bauchi	-16.8	-5.0	15.6	-19.2	-6.9	17.6	-21.7	-8.5	19.9	-23.4	-8.9	21.4
Kaduna	-14.0	-7.2	8.2	-17.6	-7.5	9.3	-21.4	-7.9	10.5	-23.8	-8.1	11.3
Minna	-18.9	-6.7	10.3	-20.3	-6.9	12.9	-21.7	-7.1	15.8	-22.7	-7.3	17.8
Shaki	-6.5	-0.5	8.6	-9.2	-2.2	9.6	-12.1	-3.4	10.6	-13.8	-5.1	11.3
Yelwa	-19.0	2.6	12.8	-21.7	3.5	12.0	-24.7	4.5	11.2	-26.5	5.1	10.9
Jos	-15.4	-2.3	9.0	-16.0	-3.2	11.0	-16.6	-2.6	13.0	-17.0	-2.3	14.3
Bida	-22.4	-4.6	21.5	-26.6	-5.6	21.9	-30.8	-6.7	22.3	-33.3	-7.4	22.5
Zaria	-23.2	-5.3	10.9	-24.8	-6.4	13.4	-26.6	-6.9	16.2	-27.7	-7.0	18.0
Nguru	-22.8	1.9	21.3	-23.6	1.3	20.0	-24.5	0.6	18.8	-25.1	0.1	18.0
Yola	-8.6	0.9	9.3	-10.6	1.3	11.2	-12.6	1.6	13.4	-13.9	1.8	14.8
Kano	-16.8	-1.0	9.0	-18.4	-1.2	10.8	-20.1	-1.4	12.9	-21.2	-1.6	14.2
Katsina	-21.6	-3.8	13.2	-23.6	-5.0	16.5	-25.7	-6.2	20.0	-27.0	-7.5	22.2
Maiduguri	-25.4	-3.0	17.7	-26.5	-4.2	19.3	-27.8	-4.0	21.1	-28.6	-3.5	22.3
Potiskum	-20.0	-5.2	10.0	-21.2	-4.7	10.3	-22.4	-4.2	10.7	-23.2	-3.8	10.9
Sokoto	-23.0	-16.0	9.9	-25.0	-18.1	8.6	-26.9	-20.4	7.2	-28.1	-21.7	6.5
Gusau	-18.4	-3.6	23.8	-20.2	-4.6	24.8	-22.2	-5.6	25.8	-23.4	-6.3	26.4