



# A Review on Intergovernmental Panel on Climate Change (IPCC) 1<sup>st</sup> to 6<sup>th</sup> Report

B. J. Ekah <sup>a\*</sup>, J. U. Akwagiobe <sup>a</sup>, S. O. Udo <sup>a</sup> and I. O. Ewona <sup>a</sup>

<sup>a</sup> Department of Physics, University of Calabar, Calabar, Nigeria.

## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

This article reviews the first to sixth report of the Inter-Governmental Panel on Climate Change (IPCC). The types of greenhouse gases, sources of greenhouse gases and the impact of climate change on man, animals and the environment has been identified. The strategies to combat climate change has been studied in these reports. A review of these reports are necessary and it is an obligatory document required to combat the adverse effects of climate change and global warming.

Keywords: IPCC report; global warming; climate change.

## 1. INTRODUCTION

Greenhouse gases are those gaseous constituents of the atmosphere produced both naturally or by human activities. These greenhouse gases trap energy from the sun

within the atmosphere, making it to warm the earth [1]. Water vapour ( $H_2O$ ), Carbon dioxide ( $CO_2$ ), Nitrous oxide ( $NO_2$ ), Methane ( $CH_4$ ), and Ozone ( $O_3$ ) are the primary greenhouse gases in the earth's atmosphere [1,2] while Hexafluoride ( $SF_6$ ), Hydrofluorocarbons (HFCs), and

\*Corresponding author: E-mail: simpleseke@gmail.com;

Perfluorocarbons (PFCs) are also of concern. Moreover, the Halocarbons and other Chlorine and Bromine containing substances are regarded as human made greenhouse gases. The depletion of the Ozone layer in the stratosphere results in a decrease in radiative forcing due to the presence and magnitude of Chlorofluorocarbons (CFCS) released into the atmosphere over decades. The release of Sulphur was assumed to cause a cooling effect within the Northern Hemisphere overtime; however, it was later noted that Sulphur emissions were responsible for acid rain and other environmental issues. The need to carry out further researches in this area was raised for the improvement and clarity of uncertainties [2].

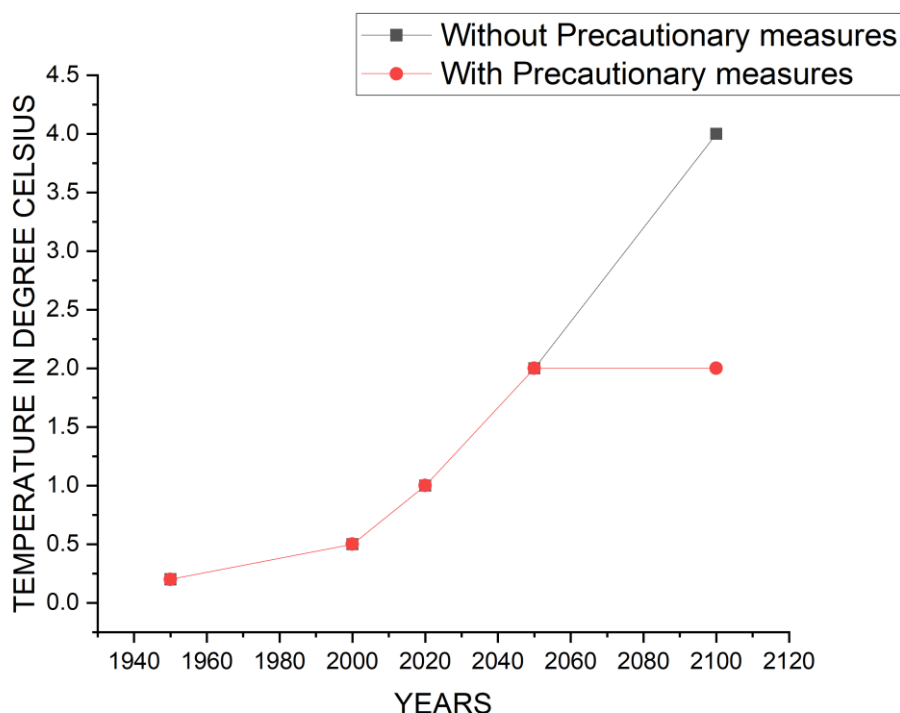
## 2. THE IPCC WORKING ASSESSMENT REPORTS

The current climatic state of the earth, the role played by human activities and how it is changing, has become an issue of global concern. A major contributor to the activities of these finding is the Intergovernmental Panel on Climate Change (IPCC), which was jointly established in 1988 by two organizations under the chairmanship of Professor Bert Bolin. The Intergovernmental Panel on Climate Change (IPCC) first working group report was setup to address and strengthen global response to the threat of Climate Change [2]. The IPCC first assessment further setup six tasks to address the issues of Climate Change. The first task was the assessment of net greenhouse gas emission, their sources and sinks of greenhouse gases. The second task had to do with predictions of climate change distributions across different regions, impact studies, model validation, and analyzing the sensitivity of the produced models. The third task analyzed the energy and industrial issues; the fourth task dealt with agriculture and forestry related issues; the fifth task dealt with vulnerability to sea level rise; the sixth task had to do with emission scenarios. From the findings of the working group, it concluded that emissions which resulted from human activities were substantially increasing atmospheric concentration of greenhouse gases such as: Carbon dioxide, Chlorofluorocarbons, Methane and Nitrous oxide. The designed model predicted the sensitivity analysis and observations indicated that global average surface temperature would double the amount of  $CO_2$  in

the atmosphere. Moreover, the IPCC working group also predicted that the range of value between of temperatures to be  $1.5^{\circ}C - 4.5^{\circ}C$ . The working group also had many uncertainties in predictions due to limited information in most areas and continents. The global average air temperature was increased by  $0.3^{\circ}C$  to  $0.6^{\circ}C$  over the past 100 years [2]. Fig. 1 below illustrates global surface temperature changes with and without anthropogenic greenhouse gas emission and future temperature projection from the year 1950 to 2100. Global average temperature will increase if greenhouse gases are released into the atmosphere owing to human activities and will decrease if precautionary measures are implemented. The IPCC further setup different working groups to handle issues of climate change globally [2].

The second report of the Intergovernmental Panel on Climate Change (IPCC) was setup to review the state of knowledge concerning the impacts of climate change on ecological and physical systems, human health, socio-economic sectors and appraising available information on the technical and economic feasibility of a range of potential adaptation and mitigation strategies. To provide scientific, technical and economic information which can be used in evaluating whether projected range of plausible impact constitutes dangerous anthropogenic interference with the climate system. It has been a challenge that human activities have increased the atmospheric concentrations of greenhouse gases which tend to warm the atmosphere and, in some areas or regions, aerosols released is assumed to warm the planet as well. These changes in greenhouse gases and aerosols are projected to lead to regional and global changes in climate and climate-related parameters such as temperature, precipitation, soil moisture and sea level (Adger, et al., 2014; [3-5]; Shradhanand et al., 2015; [6].

The third assessment report of the Intergovernmental Panel on Climate Change (IPCC) considers former assessments and merges new results from the previous years of research on climate change. It is confirmed that the earth's climatic system has changed both at the global and regional scales. The IPCC third assessment further reports that there is a stronger confirmation that warming is mostly attributed to human activities.



**Fig. 1. Global surface temperature °C anomaly relative to 1950-2100**

The global average surface temperature (air temperature over land and sea) over the 20<sup>th</sup> century has increased at the rate of 0.6°C. The 1990s was observed to be the warmest years right from inception when compared with other data collected. New proxy data for the northern hemisphere suggests an increase in temperature in the 20th century when compared with previous data of about 1000 years. With the available data, the global increase in temperature from surface satellites at a height of 8km is  $0.05 \pm 0.10^{\circ}\text{C}$  per decade. Factors such as atmospheric aerosols, ozone depletion and El Nino phenomenon is said to have influenced the atmosphere. Global sea level has also risen at the rate of 0.1m and 0.2m since 1950s while snow cover and ice have decreased at 10% - 15% since 1950 within the northern hemisphere. Cloud cover increases by 2%, rainfall rate has increased at about 0.2 to 0.3 % per decade within the tropics. Rainfall rate decreases over the Northern Hemisphere sub-tropics at about 0.3% per decade. Other areas/regions experience changes in the amount of precipitation; such as changes in atmospheric moisture and thunderstorm. Regions like Asia and Africa are experiencing an increasing level of the intensity of droughts in recent decades while in most areas, intensive rainfall and flooding is experienced.

It is explained by the policymakers that external factors also influence climate. Radiative forcing is a measure of the influence a factor has in altering the balance of incoming and outgoing energy budget in the earth's atmospheric system and it is an index of importance of the factor as a potential climatic change mechanism. It is expressed in Watts per square metre ( $\text{wm}^{-2}$ ). Radiative forcing could be either positive (warming) or negative (cooling). A positive radiative forcing is produced by raising the concentration of greenhouse gases which in turn warms the earth planet while a negative radiative forcing leads to cooling of the earth's surface by the release of airborne particles or aerosols. Aerosols could be released from factors such as volcanic activities, human activities such as industrialization, burning of fossil fuels, to mention but a few. Atmospheric concentration of carbon dioxide  $\text{CO}_2$  has been increasing right from 1750 at the rate of 31% at about 1.5ppm over the past two decades. The increase in  $\text{CO}_2$  is attributed to the use of fossil fuels, land-use change, deforestation (Alber et al., 2008; [7-9]. The third assessment confirms that more than half of the atmospheric concentration of methane ( $\text{CH}_4$ ) is anthropogenic (fossil fuels, cattle, rice agriculture and landfills) evolving from the use of carbon monoxide. Nitrous oxide  $\text{N}_2\text{O}$

concentration has increased by (17%) 46ppm since the year 1750 and its emission is confirmed to be anthropogenic. Halocarbon gases are still anthropogenic and was evolved into the atmosphere since 1995. The Halocarbons are gases which are responsible for ozone depletion. Examples are  $CFCL_3$  and  $CF_2CL_2$ . The stratospheric ozone ( $O_3$ ) layer has been observed to be depleting since 1979 to 2000 and it is estimated to be the cause of negative radiative forcing ( $-0.15 \text{ wmm}^{-2}$ ). The troposphere, Ozone  $O_3$  is estimated to have increased at 36% right from the year 1750 and produces a positive radiative forcing of  $0.35 \text{ wmm}^{-2}$  (Alber, et al., 2008; [7-14].

IPCC fourth assessment report observed changes in climate, effects and their causes. It was reported that 89% of data obtained confirms that global warming and climate change is existing. Changes observed within the continents include; ocean basin scales, intense rainfall in some areas and draught in others, cold extremes, less frequencies, heat waves and more frequencies in some landed areas. The Forth IPCC assessment report observed that precipitation increased at a higher degree in: eastern parts of North and South America, Northern and Central Asia, Northern Europe, while precipitation decreased in: Sahel, Mediterranean, Southern Africa and part of southern Asia since 1900 – 2005. Other effects include; Intense tropical cyclone activities around Northern Atlantic, high precipitation events, occurrences of natural systems such as; ice glacial, snow, lakes, alteration in water quality in terms of temperature, salinity, ice cover changes, circulation shift, changes in phyto plankton, changes in algal, migration of animals both on land and sea. Main drivers of climate change and global warming include; both natural and anthropogenic activities. Global atmospheric concentrations of  $CO_2$ ,  $CH_4$  and  $N_2O$  have increased markedly due to industrialization (Human Activities). Atmospheric concentrations of  $CO_2$  and  $CH_4$  in 2005 exceeds the natural range over the last 650,000 years. IPCC had identified some relevant areas of concern as temperature changes. The IPCC assessment group further concluded that large-scale warming approximately  $3.5^\circ\text{C}$  and above, will increase the likelihood of rigorous, pervasive and irreversible impacts which will be difficult for people to adapt. Risks such as; insufficient water, reduced agricultural productivity, food insecurity, increased rate of loss of livelihood in the rural areas, extreme weather events which may result

in breakdown of infrastructures in areas of power supply, network, health and other services. The IPCC further predicts that rising temperature in African will exceed other continents if precautionary measures are not taken [15,16].

The fifth IPCC report group focuses mainly on the effects of climate change and global warming only in African continent. The fifth reports that further predicts that climate change may occur if measures are not being put in place and these will hinder the growth and development of the continent [17]. The assessment report further recommended mitigation and adaptation of climate change as strategies to combat climate change. Mitigation is the process of reducing emissions or enhancing sinks of greenhouse gases (GHGs), so as to limit future climate change. Adaptation is simply a process of adjustment to actual or expected climate and its effects in order to either lessen or avoid harm or exploit beneficial opportunities. Adaptation and Mitigation are both strategies suggested to reduce and manage the risks of climate change impacts in Africa.

The fifth assessment report still confirmed that the earth's climate is still warming since 1950s and African continent will experience a widespread impacts and changes in its environment such as; changing rainfall or melting snow, ice altering freshwater systems, results in poor water quality and quantity, [17,18]. The IPCC validates that 95% certainty to climate change and global warming is as a result of the concentration of greenhouse gases in the atmosphere emanating from human activities. It has been projected that the impact of climate change will affect water availability in some areas, food production and human health in Africa which will as well impede economic development, food chain, trading investment, human security and economic growth [19]. Strong evidence of global warming is presented by the fifth assessment report over Africa for the past 50 to 100 years as surface temperature is already increasing at the rate of  $0.5$  to  $2.0^\circ\text{C}$  and the warming is very likely to keep its pace. Temperature changes play a major role, increasing the rate of diseases like; malaria in eastern Africa and has affected farmers in southern Africa. Increased annual rainfall is experienced in some parts of Africa to be between 5mm to 50mm for each decade and rainfall trend varies for different locations. There could be heavy rainfall in some regions which may result in flooding while reduced rainfall may cause draught in order regions. The impact of

extreme weather makes the following vulnerable; ecosystem, freshwater, terrestrial and marine species. Humans most especially women and children may experience a higher vulnerability risk as a result of susceptibility to infectious diseases and death. The elderly is likely to experience physical harm and death due to heat stress, droughts and wildfires (large destructive fire that spreads quickly). Most humans may tend to migrate while other face psychological and emotional stress, reduction of food consumption and negative health outcome. These variations make it necessary to put adaptation measures in order to manage the risk of changing rainfall on forestry. Effective adaptation will help; strengthen human security, livelihood, improve health services and wellbeing of the African continent and will reduce high level of poverty. IPCC confirms that adaptation is the only way to reduce risk of greenhouse gases. It is the responsibility of the African governments to promote global actions on climate change mitigation and to avoid delay on adaptation as it will end up increasing cost, creating difficulties in eliminating global emission of carbon. The fifth assessment report on carbon budget states that: For the average global warming to be limited, world emission should be less than 2°C of its total emissions from human activities and should not exceed the range of 800–1,000 Gigatons of carbon dioxide. Presently, the world's carbon dioxide emission is about 500 Gigatons. The bone of contention for the IPCC fifth assessment is to limit warming below 2 °C in Africa as warming beyond such rate will hinder economic growth and human development. The rate of warming appropriate for African continent is 1.5°C. It is certain that human influence has warmed the atmosphere, ocean and land. There are rapid changes in the atmosphere, ocean, cryosphere and biosphere. Recent changes are occurring across the climate system over centuries to thousands of years. There are evidences of observed changes in extreme weather events such as; heavy precipitation, droughts, heat waves and tropical cyclones and it is attributed to human activities [20-26,17].

The sixth assessment report confirms that West Africa is already experiencing widespread losses and damages from climate change. Human activity has been the major reason behind it. The report attest that most African countries have contributed to global greenhouse gas emissions causing climate change. Currently, West Africa is already facing loss of lives and impacts on human health, reduced economic growth, water

shortages, reduced food production, biodiversity loss, and adverse impacts on human settlements and infrastructure. It is predicted that the average annual surface temperatures in West Africa will be higher than the global average. In West Africa, the potentially lethal heat days has increased to 50–150 per year at 1.6°C warming and 100–250 per year at 2.5°C warming, the highest in coastal regions and it is likely to affect children born in 2020 within the average temperature value of 1.5°C warming. Over the tropics of West Africa mortality risk from heat waves is 6–9 times higher than the 1950–2005 average at 2°C global warming (IPCC, 2014). Rainfall is forecasted to decrease in western Africa and increase in the east and vice versa. A reduction in length of the rainy season is projected over the western Sahel by 4 to 6 days at warming of 1.5°C and 2°C. Extreme rainfall events will become more frequent, intense with very high emissions, increasing exposure to flooding (high confidence). At 2°C global warming, West Africa is projected to experience a dry, more drought and insufficient rainfall in most areas, especially in the last decades of the 21st century. It is expected that future climate change is projected to have a very large negative effect on African countries and their economy. The IPCC's sixth assessment report identifies mitigation and adaptation as key areas to support sustainable development [27,28]. Adaptation options include; improving approach to climate information, developing agroforestry systems and conservation agriculture, agricultural diversification and growing of drought resistant crop varieties. Agriculture techniques like; drip irrigation, pits planting and erosion control techniques can improve soil fertility, increase yield, food security and increase farmers' strength [29]. Table 1 is the Rundown of review discussed above.

### 3. DISCUSSION

From historical data, the IPCC observed that average global surface temperature has been increasing cumulatively since 1850–2019 as a function of Carbon dioxide, Chlorofluorocarbons, Methane and Nitrous oxide. Increase in magnitude and the global temperature of the earth may amount to 4.5 °C if precautionary measures are not adequately implemented. The Intergovernmental Panel on Climate Change (IPCC) confirms that greenhouse gases in the atmosphere are due to human activities (deforestation, land-use-change, use of fossil fuels, industrialization and others). The

Intergovernmental Panel on Climate Change (IPCC) provides a summary of the current state of the climate, the changes occurring, the role of human influence, provides knowledge about possible climatic effects (heavy rainfall, flooding or draught, extreme weather, ecosystem, freshwater, terrestrial and marine species extension, vulnerability risk as a result of susceptibility to infectious diseases, psychological and emotional stress, reduction of food consumption, negative health outcome, death). Relevant information about regions and possible ways of combating climate change were discussed. Mitigation and adaptation methods

were suggested as possible ways to combat climate change. It was outlined that both methods could be effective if applied simultaneously rather than applying them individually. Effective adaptation would strengthen human security, livelihood, improve health services and wellbeing of the African continent and will reduce high level of poverty. The sixth assessment report on climate change attest that African countries are also contributors to climate change and it predicts that the level of temperature increase in Africa may exceed 3°C, except mitigation and adaptation measures are adopted.

**Table 1. Rundown of review**

<b>IPCC Reports</b>	<b>Summary</b>
<b>First Report</b>	<ul style="list-style-type: none"> <li>❖ Identifying sources and sinks of greenhouse gases handled.</li> <li>❖ Predictions of climate change distributions across different regions, impact studies, model validation, and analyzing the sensitivity of the produced models was considered.</li> <li>❖ Energy and industrial issues were addressed.</li> <li>❖ Agriculture and forestry related issues were addressed.</li> <li>❖ Vulnerability to sea level rise and gaseous emission was considered.</li> </ul>
<b>Second Report</b>	<ul style="list-style-type: none"> <li>❖ Reviewed the science concerning the impacts of climate change on ecological and physical systems, human health, socio-economic sectors and appraising available information on the technical and economic feasibility of a range of potential adaptation and mitigation strategies.</li> </ul>
<b>Third Report</b>	<ul style="list-style-type: none"> <li>❖ In the third IPCC report, the first and second assessments reports were merged together and new results were obtained from the previous years research on climate change.</li> <li>❖ The third assessment further reports that there is a stronger confirmation that the earth average temperature is increasing and it is generally connected with human activities. Example; the global average surface temperature has increased, there is decrease in ice and snow cover, global sea level rise has occurred, there is an increase and decrease in cloud cover, increased and decreased rainfall rate, flooding and increased intensity of draught in some countries.</li> </ul>
<b>Fourth Report</b>	<ul style="list-style-type: none"> <li>❖ The fourth assessment report observed changes in climate, effects and their causes. About 89% of data obtained from measurements confirmed that global warming and climate change is real and changes are observed within the continents including ocean basin scales, intense rainfall in some areas and draught in others, cold extremes, less frequencies, heat waves. Other effects include; Intense tropical cyclone activities around Northern Atlantic, High Precipitation events, occurrences of Natural systems such as ice glacial, snow, lakes, alteration in water quality in terms of temperature, salinity, ice cover changes, circulation shift, changes in phyto plankton, changes in algal, migration of animals both on land and sea.</li> <li>❖ The group further concludes that severe warming approximately 3.5°C and above, will increase the likelihood of harsh, penetrating and constant impacts of natural occurrences which will be difficult for people to adapt and can result in effects such as; limited access to good water, decreased agricultural productivity, food scarcity, ill-health, extreme weather and death.</li> </ul>

IPCC Reports	Summary
Fifth Report	<ul style="list-style-type: none"> <li>❖ The IPCC further predicts that rising temperature in Africa will exceed other continents if precautionary measures are not observed.</li> <li>❖ In the fifth assessment report, the effects of climate change and global warming only in African continent and its implications were considered. The report further recommends that Mitigation and Adaptation of Climate Change are the recommended strategies to combat Climate Change. Mitigation is the process of reducing emissions or enhancing sinks of greenhouse gases (GHGs), so as to limit future climate change. Adaptation is simply a process of adjustment to actual or expected climate and its effects in order to either lessen or avoid harm or exploit beneficial opportunities. Adaptation and Mitigation are both strategies suggested to reduce and manage the risks of climate change impacts in Africa.</li> </ul>
Sixth Report	<ul style="list-style-type: none"> <li>❖ The sixth assessment report stresses on the fact that West Africa is already experiencing widespread losses and damages from climate change and these is attributed to human activities. Nowadays, West African countries are already facing loss of lives and impacts on human health, reduced economic growth, water shortages, reduced food production, biodiversity loss, and unfavourable impacts on human settlements and infrastructure owing to human-induced climate change, increase in temperature between 1.5°C and 3°C warming.</li> <li>❖ The IPCC report further predicts that the average annual surface temperatures in West Africa will be higher than the global average which may result in extreme heat and heat waves.</li> <li>❖ The IPCC's sixth assessment report pinpoints mitigation and adaptation as key areas to support sustainable development for all. Adaptation options include: improving opportunities to climate information, developing agroforestry systems and conservation agriculture, agricultural diversification and growing of drought resistant crop varieties. Agriculture techniques like; drip irrigation, pits planting and others.</li> </ul>

#### 4. SUMMARY AND CONCLUSION

The Intergovernmental Panel on Climate Change (IPCC) affirms that historical data and analysis reveals a steady increase in global surface temperature within the range of 0.5 to 2.0°C. Research has proven that human activities are major contributors to greenhouse gas emission and the average global temperature of the earth is eventually shifting towards a temperature of 4.5°C. For the average global warming to be limited, world emission should be less than 2°C. A summary of the current state of climate, changes occurring and the role of human influence, provides knowledge about possible climatic effects and it gives relevant information about different regions and possible ways of combating climate change. Possible control measures suggested by the IPCC include; mitigation and adaptation methods. The sixth assessment report on climate change attest that African countries have contributed to global warming and it predicts that the level of

temperature increase may exceed the range of 2°C and 3°C, if mitigation and adaptation strategies are not applied. The IPCC further recommend more research work in the following areas:

1. Estimation of future gaseous emissions.
2. Biogeochemical cycling (including sources and sinks) of greenhouse gases.
3. Aerosols and aerosol precursors.
4. Projections of future concentrations of greenhouse gases and radiative properties.
5. Presentation of climatic processes using models, particularly feedbacks associated with clouds, sea, ice, oceans and vegetation, to help improve patterns of climate change.
6. A collection of long-term proxy observations of climate system variables (e.g., hydrological cycles, solar output, atmospheric energy balance components, ocean characteristics and ecosystem changes) for model testing and for detection and attribution studies.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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