International Journal of Academic and Applied Research (IJAAR)
ISSN: 2643-9603
Vol. 6 Issue 8, August - 2022, Pages: 107-116

Rethinking Africa's Contribution to Climate Change and Variability: An Assessment of the Impacts and Adaptive Capacity

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Abstract: *Currently, climate variability and change have been recognized as the greatest challenges facing human beings and their socio-economic activities. Africa has experienced climate variability and change, which has declined agricultural productivity and resulted in decreased national and household food security. To adapt to the changing climate, farmers need a transformation in their farming practices and to adopt various practices that sustainably increase agricultural productivity as well as their resilience. The main goal of this study was to rethink Africa's contribution to climate change and variability in Africa. This study was guided by the specific objectives, namely; assessing the impacts of climate change and variability on agriculture, mitigation strategies towards climate change, and the adaptive capacity employed by the local people to reduce climate change and variability in Africa. It was found that factors like institutional, environmental, energy, and culture enhance climate change and variability. It was also noted that sea level rises, temperature increases, extreme weather events, and changes in precipitation all lead to climate change. Public education, training, and awareness campaigns mitigate climate change. According to this study, it was concluded that the contributions of Africans to climate change can be described in a variety of disciplines, including agriculture, technology, health, government institutions, the environment, and other disciplines. In terms of Africa's contribution to climate change, the problematic issues are poverty, a lack of climate-smart agriculture, an excessive reliance on aquatic resources for irrigation, fishing, and pollution, population expansion, and over-exploitation of coastal resources. According to the study, it is therefore preferable to deploy climate-smart agriculture, effective government structures, and as many of the national and international mitigation programs as is practical.*

Keywords: Climate change, climate variability, adaptive capacity, mitigation, rethinking, African, socio-economic activities, climate-smart agriculture, Greenhouse gas emissions, smallholder agricultural systems

1. INTRODUCTION

Livestock is responsible for about 18% of emissions, making it 65 percent of cattle's total emissions. Thus, due to the farmers' limited ability to adjust to the changes, climate change continues to pose a severe danger to smallholder agricultural systems and the state of food security. The ecosystem, farmers' livelihoods, agricultural output, and income have all been significantly impacted by climate change. As a result, especially for vulnerable African communities, climate change poses a serious threat to the viability of food production and other subsistence practices. In an effort to lessen the susceptibility of smallholder farmers, who are most affected by climatic changes, numerous solutions have been proposed to mitigate these detrimental negative effects of climate change (UNFCCC, 2007).

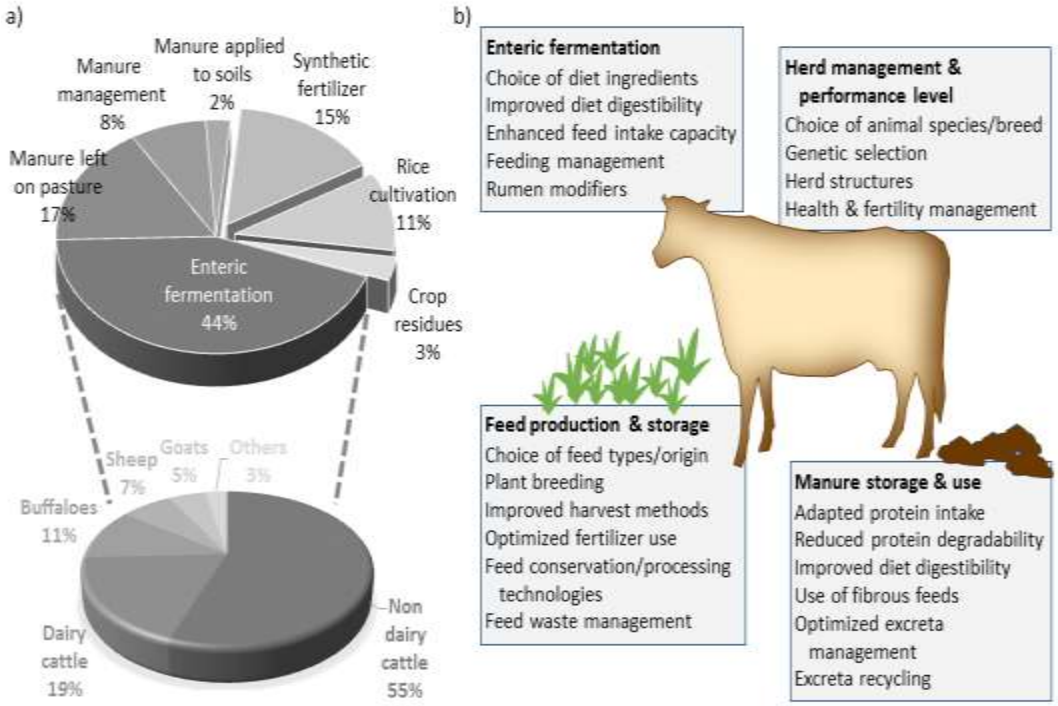

Figure 1: Livestock emissions
Source: (Dickhoefer et al., 2014).

According to UNFCCC (2007) as cited in Pörtner et al. (2022), climate change is currently acknowledged as one of the most damaging hazards that has hampered global communities' socioeconomic activity, health, and way of life. Climate change has numerous significant effects on developing nations, including decreased family and national food security and a fall in agricultural production (Gomez-Zavaglia et al., 2020). However, because to variances in exposures, sensitivities, and adaptive capacities, the degree of unfavorable consequences differs across nations, regions, and socio-demographic groups (Ali, 2019). Although the effects of climate variability and change are wide-ranging, the repercussions on agriculture are among the most significant due to changes in temperature, rainfall, and hydrological cycle patterns.

Agriculture and climate change are intertwined in that agriculture directly influences climate through emissions of greenhouse gases (Istudor et al., 2019), while climate change indirectly influences agriculture through variations in temperature and rainfall. According to Campbell et al. (2017), agriculture is a major contributor to 30% of global emissions overall. In addition, many agricultural communities continue to experience major negative effects from climate change, especially poor smallholder farmers who have limited ability to respond to adverse shocks, aggravating global poverty and food insecurity (Zeleke et al., 2021).

According to Water and Infrastructure (2017) report, Africa is already a climate-stressed continent that is extremely sensitive to the effects of climate change. On seasonal and decadal time frames (Benson & Ayiga, 2022), several parts of Africa are known to have some of the world's most unpredictable climates. Within months of one another, rainfall variability occurs in the same region (Kassegn & Endris, 2021). These occurrences have the potential to cause widespread socioeconomic unrest and hunger. For instance, according to estimates, 220 million people in Africa experience drought every year and a third of the continent's population already resides in drought-prone areas (Ramin & McMichael, 2009).

Since almost all of Africa's 50 river basins are transboundary, the continent will experience increasing water stress and scarcity, which could lead to a rise in water disputes (Link et al., 2016). In many African nations, especially for subsistence farmers and in sub-Saharan Africa, agricultural production, which depends mostly on rainfall for irrigation, would be seriously hampered (Amjath-Babu et al., 2016). Due to climate change, there will be a significant loss of agricultural area, shorter growing seasons, and reduced yields (Mahato, 2014).

Africa is vulnerable to a number of climate sensitive diseases including malaria, tuberculosis and diarrhea. As a result of climate change, disease vectors are moving to new regions and higher altitudes, changing their geographic distribution (Guernier et al., 2004). For instance, Boko et al. (2007) mentioned that the malaria mosquito's migration to higher altitudes will expose a significant number of previously uninfected people to infection in the densely populated east African highlands.

Brauch et al. (2011) mentioned that Sub-Saharan Africa (SSA) is one of the area's most susceptible to the effects of climate change and its dangers and this is also in line with Turyasingura, Mwanjalolo, et al. (2022) who noted that like other developing nations, SSA is marked by rapid population expansion and a heavy reliance on agriculture that is fed by the rain, which plays a significant role in economic growth. The community is especially vulnerable because agriculture accounts for 80% of agriculture production, employs around 65% of the active population, and is run by smallholder farmers, depending on how they have adapted to climate change (Abegunde et al., 2019), and farmers have shown to be resilient, but climate change is still harming their ability to cope right now and this is as a result of climate change systems as shown in (**Figure 2**).

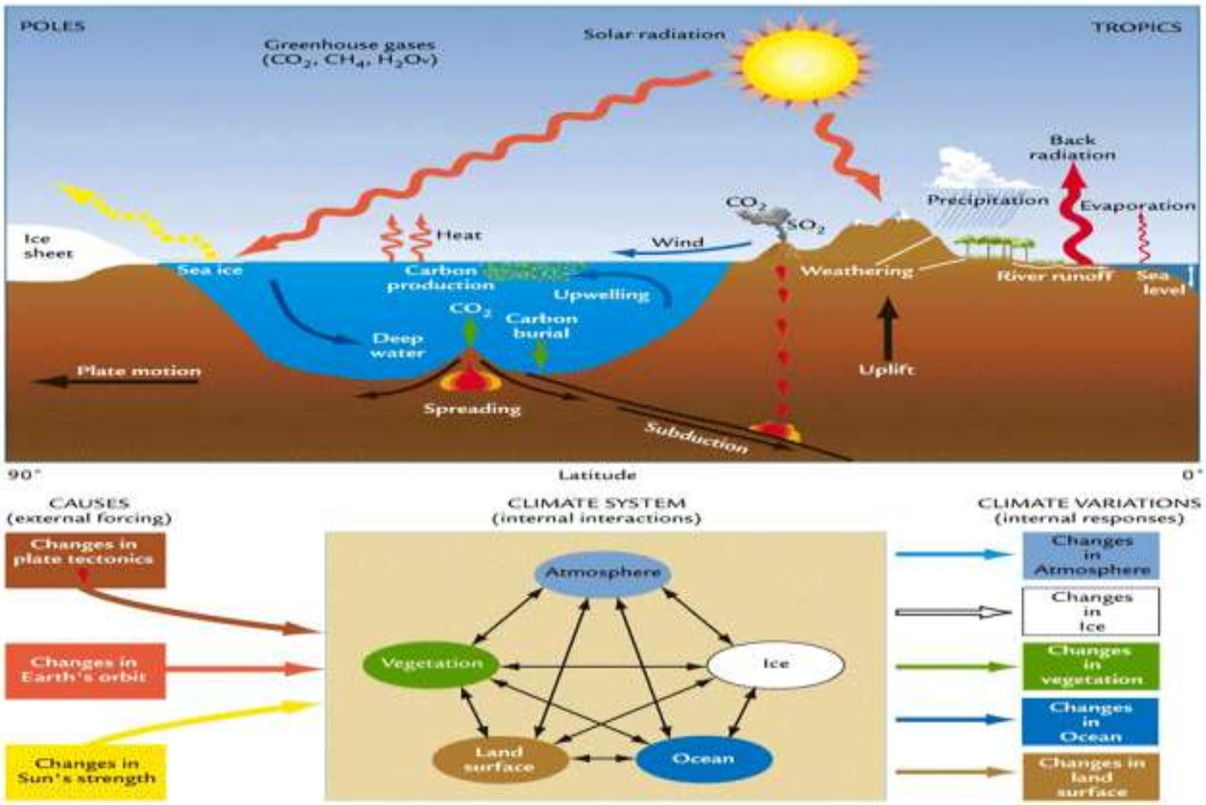

Figure 2: Earth's climate systems

The main goal of this study was to rethink Africa's contribution to climate change and variability in Africa. This study was guided by the specific objectives, namely; assessing the impacts of climate change and variability on agriculture, mitigation strategies towards climate change, and the adaptive capacity employed by the local people to reduce climate change and variability in Africa.

2 LITERATURE REVIEW

2.1. African contribution to Climate Change and variability

Environmental considerations: The distinct vegetation zones and the wild life they sustain may move due to climate change, and any changes in the woods are likely to be made worse by human competition for land. Five "biological hot spots," or regions with exceptionally high species richness and endemism, are found in Africa (Turyasingura, et al., 2022). The fauna and flora of the continent are abundant and diversified. A fifth of all known species of plants, animals, and birds, as well as a sixth of all amphibians and reptiles, are all found there. The largest ecosystem in Africa is found in savannahs, which are the richest grasslands on earth (Benson et al., 2020).

Environmental factors

Sub-Saharan Africa and other dry and drought-affected regions will have less rainfall and 10–30% dryness Nooni et al. (2021); Shiferaw et al. (2014). The majority of the 19 countries in the globe that are currently considered to be water-stressed are located in Africa. Independent of climate change, this figure is anticipated to rise due to factors like population growth-related increases in demand, deterioration of watersheds brought on by changes in land use, and siltation of river basins. Around 480 million Africans are anticipated to experience water scarcity by 2025. Environmental activates has led to the greenhouse gases as shown (**Table 1)** below;

International Journal of Academic and Applied Research (IJAAR)
ISSN: 2643-9603
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Table 1: Greenhouse Gases and their chemical formulas

Greenhouse Gas	Chemical Formula	Anthropogenic Sources	Atmospheric Lifetime (years)	GWP (100 Year Time Horizon)
Carbon Dioxide	CO_2	Fossil-fuel combustion, Land-use conversion, Cement Production	~100	1
Methane	CH_4	Fossil fuels, Rice paddies, Waste dumps	12	25
Nitrous Oxide	N_2O	Fertilizer, Industrial processes, Combustion	114	300
Tropospheric Ozone	O_3	Fossil fuel combustion, Industrial emissions, Chemical solvents	hours-days	N.A.
CFC-12	CCL_2F_2	Liquid coolants, Foams	100	10,900
HCFC-22	CCl_2F_2	Refrigerants	12	1,810
Sulfur Hexaflouride	SF_6	Dielectric fluid	3,200	22,800

Socio-Cultural Factors

Everyone is impacted by climate change, but women are particularly at risk. In underdeveloped nations, rural women are still mostly in charge of obtaining food, water, and energy for cooking, etc. According to (Benson & Ayiga, 2022). Women will have to put in more effort to obtain these resources as a result of drought deforestation and variable rainfall. As a result, women have less time to earn a living.

Energy Factors

Energy production and consumption may be impacted by changes in precipitation, for instance, increased temperatures and humidity implications could have a substantial impact on energy demand, increasing the need for air conditioning during the day. Strong, gusty winds and thunderstorms may also cause damage to electrical poles and lines. The production of hydroelectric power and other forms of energy would be negatively impacted by decreased precipitation. Sea level rise might cause harm to infrastructure in Africa's coastal regions, including power plants and oil and gas producing facilities.

Institutional Factors

The performance of national and local economies is hampered by ineffective and disorganized governmental institutions, which also reduces the amount of domestic funding available for climate action. However, the world economy is comparatively strong, and there are external sources of climate money, such as international funds and the private sector. Although small-scale renewable energy production, water resource projects, and sustainable farming and forestry techniques are widely adopted, activity is disorganized, and the full advantages of investments in climate change mitigation and resilience are frequently not realized.

2.2. Impact of Climate Variability and Change on Agriculture in Africa

Due to its importance in determining food security, agriculture in Sub-Saharan Africa (SSA) is prioritized in the production of inexpensive and sufficient food for its population. Despite its promise, it is more susceptible to the effects of climatic variability and change, and many developing countries' protection measures for the sector are still insufficient and flimsy. As a result, if nothing is done to address climate change and variability, it will likely result in food insecurity, with poor countries being particularly at risk given how it affects agriculture productivity (Serdeczny et al., 2016; Simane et al., 2016).

Climate change has impact on agriculture due to sea level rises, increase in temperature, flooding which affects agricultural crops, animals, and other components of the environment leading to famine, and poverty as shown in the (**Table 1below**).

Table 2: The impact of climate change in Africa

Climate Impact	Human Impact	Overall impact
Sea Level Rise • Flooding • Sea surges • Erosion • Salination of land and water	• Loss of land • Drowning, injury • Lack of clean water, disease • Damage to coastal infrastructure, homes, and property • Loss of agricultural lands & Livestock • Threat to tourism, lost beaches • Salinity ingress root – level of crops and trees	• Increase in poverty
Temperature Increase • Change in disease vectors • Coral bleaching • Impact on fisheries	• Spread of disease • Changes in traditional fishing • livelihood and commercial fishing • Threat to tourism, lost coral and fish diversity	• Decline productivity – overall production - Agriculture - Livestock - Fishes
Extreme Weather Events • Higher intensity storms • Sea surges • Delayed monsoon • Long interval between rain – spells • Early withdrawal of monsoon	• Dislocation of populations • Contamination of water supply • Damage to infrastructure: delays in medical treatment, food crisis • Psychological distress • Increased transmission of disease • Damage to agricultural lands • Disruption of educational services • Damage to tourism sector • Massive property damage	• Threat to food and health security of hungry million

International Journal of Academic and Applied Research (IJAAR)
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Changes in Precipitation • Change in disease vectors	• Outbreak of disease – both in crops and trees & Human beings • Depletion of agricultural soils	• New health problems

Due to their low capability for adaptation and susceptibility to climatic shocks, Sub-Saharan African nations will be the ones most impacted by climate change (UNDP, 2006). There is not a developing nation that is immune to the effects of climate change; rather, they are all thought to be more susceptible to climate fluctuation and change (Chakravarty et al., 2020). One of the reasons that negatively impacts developing nations is the low agricultural productivity. More droughts, which can cause significant setbacks in human progress, are anticipated to occur as a result of these changes in both large and minor incremental ways

Future rainfall, floods, and drought projections due to climate change are uncertain. Different historical research has identified a relationship between rainfall extremes and reduced GDP as a result of reduced agricultural productivity. The principal factors contributing to climate change, such as temperature increases and geographical and temporal variations in precipitation, have an impact on agricultural production. Inadequate soil moisture, a rise in pests and diseases that harm crops, unpredictable and strong rainfall, and more extreme weather events will all be brought on by an increase in temperature.

Similar to this, the effects of carbon-dioxide fertilization caused by climate change can have a substantial impact on changing plant growth and harvestable output. Most climate model scenarios indicate that sub-Saharan African nations will likely lose their ability to produce by the 1980s.

2.3. Mitigation strategies towards Climate Change in Africa

(I) Technological

Energy distribution and supply have improved as a result of the switch from fossil fuels to renewable energy sources like solar and wind (Kalair et al., 2021). While hydropower in Africa generates a significant portion of the continent's electricity and emits little greenhouse gas (Chapman et al., 2018), the continent's rainfall is erratic and is only expected to become more so as a result of climate change (Nyiwul, 2021).

Transportation: More fuel-efficient cars; more rail travel as opposed to road travel; more usage of public transportation and motorized modes of transportation including biking and walking. Housing layouts should be planned and designed to promote physical activity such as cycling, walking, and running.

Buildings: By consuming less energy and increasing building energy efficiency, significant progress can be made in the fight against global warming (Economidou et al., 2020). Costly high-tech solutions are not the best way to enhance the energy efficiency of buildings in Africa (Kebir et al., 2022); instead, we should look to basic solutions like those found in our vernacular architecture, which links building design to climate (Dinh et al., 2021). These remedies include optimal building orientation, solar shading, natural ventilation, building shape, and enhanced building envelope insulation. Additionally, an environmentally friendly structure would gather and reuse rainwater and waste water (Amaral et al., 2020), generate the majority of its energy at an on-site cogeneration plant, and construct itself using recycled materials (Park & Kim, 2021).

Agriculture and Forestry: Improved crop and grazing land management to increase soil carbon storage; restoration of degraded lands; improved rice cultivation techniques; improved livestock and manure management to reduce emissions; improved nitrogen fertilizer application techniques to reduce N20 Emissions; dedicated energy crops to substitute for fossil fuels; and improved energy efficiency, good forest management, decreased deforestation, greater afforestation.

(II) Non-Technological

Non-technological actions like alterations to consumption and lifestyle habits can lower GHG emissions in all sectors and aid in the fight against climate change. Management procedures might also be advantageous. Public education, training, and awareness campaigns would aid in increasing public acceptance of energy efficiency measures.

3. Adaptation measures to climate change

Living with climate change is a concern of adaptation strategies. In the next two to three decades, it won't be feasible to stop climate change, but by using adaptation tactics, our communities and economies can still be partially shielded from its effects. Included in adaptation efforts are the following: -

Energy

“Compact Fluorescent Light Bulbs (CFLs) and Light Emitting Diodes (LEDs)”, two recent developments in energy-efficient lighting technology, promise to provide clean, portable, long-lasting, less expensive, and higher-quality lighting. Making these things available to Africa's millions of underprivileged people is a difficult task. A mostly untapped solution to the global warming and energy crisis problems is the idea of fulfilling energy needs by improving energy efficiency and intelligent use of energy rather than by increasing energy production.

Agriculture & Forestry

Water harvesting, controlling water discharge from dams, and more efficient water use are all possible adaptation strategies. Hence, "small localized efforts like small scale water management strategies for irrigation, such as rainwater gathering, should be incorporated into large-scale projects like the construction of new dams and reservoirs. It is crucial to plant trees to increase revenues, improve the soil's capacity to retain water, and guard against erosion."

Coastal Areas

Africa's coastal regions can adapt by building sea walls and moving vulnerable human settlements and other socioeconomic facilities. Relocating residents, businesses, and infrastructure would be expensive and difficult. In Nigeria, for instance, more than 20 million people reside in the coastal region, thus enormous economic losses, particularly from the local oil reserves, would result.

The following table outlines some of the implications of climate change in Africa on important industries and provides a sense of how well this continent is able to adapt to these changes. The climate in Africa is likely to change due to global warming, and extreme weather events are predicted to become more frequent and severe, increasing the risk to human health and life. This includes a rise in the likelihood of drought and flooding in new places (Few et al. 2004, Christensen et al. 2007), as well as inundation brought on by sea level rise in the continent's coastal regions (Nicholls 2004; McMichael et al. 2006).

Table 3: The implications of climate change in Africa

Impacts	Sectorial vulnerabilities	Adaptive Capacity
Temperature **– Higher warming (x1.5) throughout the continent and in all seasons compared with global average.** **– Drier subtropical regions may become warmer than the moister tropics.** **Precipitation** **– Decrease in annual rainfall in much of Mediterranean Africa and the northern Sahara, with a greater likelihood of decreasing rainfall as the Mediterranean coast is approached.** **– Decrease in rainfall in southern Africa in much of the winter rainfall region and western margins.** **– Increase in annual mean rainfall in East Africa.** **– Increase in rainfall in the dry Sahel**	Water – Increasing water stress for many countries. – 75–220 million people face more severe water shortages by 2020. Agriculture and food security – Agricultural production severely compromised due to loss of land, shorter growing seasons, more un-certainty about what and when to plant. – Worsening of food insecurity and increase in the number of people at risk from hunger. – Yields from rain-fed crops could be halved by 2020 in some countries. Net revenues from crops could fall by 90% by 2100. – Already compromised fish stocks depleted further by rising water temperatures. Health – Alteration of spatial and temporal transmission of disease vectors, including malaria, dengue fever, meningitis, cholera, etc. Terrestrial Ecosystems – Drying and desertification in many areas particularly the Sahel and Southern Africa. – Deforestation and forest fires. – Degradation of grasslands.	Africa has a low adaptive capacity to both climate variability and climate change exacerbated by existing developmental challenges including: – low GDP per capita – widespread, endemic poverty – weak institutions – low levels of education – low levels of primary health care – little consideration of women and gender balance in policy planning – limited access to capital, including markets, infrastructure and technology – ecosystems degradation – complex disasters – conflicts

may be counteracted through evaporation. **Extreme Events** **– Increase in frequency and intensity of extreme events, including droughts and floods, as well as events occurring in new areas.**	– 25–40% of animal species in national parks in sub-Saharan Africa expected to become endangered. Coastal Zones – Threat of inundation along coasts in eastern Africa and coastal deltas, such as the Nile delta and in many major cities due to sea level rise, coastal erosion and extreme events. – Degradation of marine ecosystems including coral reefs off the East African coast. – Cost of adaptation to sea level rise could amount to at least 5–10% GDP.	

Source: (Turyasingura & Chavula, 2022).

In addition, farmers must adapt if they want to increase their resilience to various environmental changes. In order to adjust to the changing climate, farmers must abandon their traditional farming methods (Antwi-Agyei & Stringer, 2021). One strategy for transforming and reorienting agricultural operations in the context of climate change is climate smart agriculture (Turyasingura & Chavula, 2022). It entails farming methods that advance national development objectives while also boosting agricultural productivity, enhancing farmers' capacity for adaptation, and cutting greenhouse gas emissions. The three categories of adaptation measures are autonomous or spontaneous, proactive or anticipatory adaptation, and planned adaptation measures (Holman et al., 2019). Autonomous measures are adaptation actions started and carried out by the decision-maker themselves, independent of governmental intervention (Kovács & Kálmán, 2022). Actions started by adaptation planners, such as development organizations or extension officers, are included in planned adaptation (Grafakos et al., 2019). It is predicated on the knowledge that action is necessary to go back to, keep, or achieve a desirable state because conditions have changed or are about to change. The proactive or anticipatory adaptation occurs before the effects of climate change become evident.

CONCLUSION AND RECOMMENDATIONS

The contributions of Africans to climate change can be described in a variety of disciplines, including agriculture, technology, health, government institutions, environment, and other disciplines, according to this paper's review. In terms of Africa's contribution to climate change, the problematic issues are poverty, a lack of climate savvy agriculture, an excessive reliance on aquatic resources for irrigation, fishing, and pollution, population expansion, and over-exploitation of coastal resources. According to the study, it is therefore preferable to deploy climate-smart agriculture, effective government structures, and as many of the national and international mitigation programs as is practical.

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