International Journal of Innovative Human Ecology & Nature Studies 13(3):1-14, July-Sept, 2025

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doi:10.5281/zenodo.15974707

Climate Change Response: Evaluating Adaptation and Mitigation Methodologies

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ABSTRACT
The consequences of Climate change have in recent times gained global attention; the causes of these changes could be caused by natural or artificial phenomena. In this study, archival research was adopted which aided us to discuss the causes of climate change across the globe, its effect as well as the impact it makes on humans and other living things. We further discussed the indicators of the consequences of climate change and its management. We further discuss the methods of climate change mitigation and the methods of climate change adaptation. We finally recommended the whole climate change to be included in all government plans and programs so that the adverse effect of climate change will be addressed by all members of the global community. It is also recommended that for effective climate change management, it is paramount to use a combination of both the mitigating strategies as well as the adaptive strategies, these will aid in the management and preventive strategies of handling the climate change across the globe. Government should create awareness on the need to regulate activities that has direct bearing on climate change such as lumbering, burning of fossil fuel; oil bunkering etc. Finally, there is need for government to promulgate policies to regulate human activities that has negative impacts on the environment.
Keywords*:* Climate, change, global, natural, artificial phenomena, mitigation, adaptation.

INTRODUCTION
Climate change has in recent times gained global, the climate change which is a long-term shift or changes in the pattern and nature of weather and temperature. In the word of Ayoade, (2004), climate change is a long-term shift, alternation or change in the type of climate prevailing over specific location, a region or the entire planet. Climate change could also be seen as a change in the variability of climate even if average weather conditions remain unchanged (Hengeveld et al., 2002). These changes could be caused by natural or artificial phenomena. According to Hengeveld et al., (2002), changes in the intensity of sunlight reaching the earth can cause cycles of warming and cooling, like the four large glacial-interglacial swings during the past 400,000 years. Which so ever is the leading cause; climate change poses some hazards to mankind and threatens the general ecosystem and its suitability for survival.
The impacts of climate change are visible, Dhanas et al (2014), claimed that the impact of climate change is largely interrelated and have the potency to exacerbate the existing social and economic problems like; drought, flood, landslides, rising sea level, high temperature and damage to infrastructure. For instance increased GHG concentration in space is a problem for both scientific and social relevance (Kishore et al., 2016). Similarly, air temperature is directly proportional to the evaporation rate and atmospheric moisture content (Boulet et al., 2020). Theoretically, high levels of atmospheric water vapor content due to global warming gives rise to acceleration/intensification of hydrological cycle.
On the need to control or eradicate the consequences of climate change, global efforts are being made to mitigate its effects or to adapt to its effects since its eradication has been considered to be impossible. For instance Smith, Powlson, Smith, Falloon & Coleman (2000) have demonstrated that fuzzy-leaved varieties of plants could help ameliorate climate change. They explained that hair-like structures on leaves tend to scatter light and reduce leaf temperature on individual plants and thus bring about the cooling effects of the structures and the environment. Conversely, Doughty et al. (2010) used a model to simulate the impact of global climate of several scenarios in which reflectance of light from leaves of all plants across the globe was enhanced by varying amounts within certain ranges of wavelengths. They found that the cooling effect was most pronounced at latitudes above 300, where each 0.01 rise in albedo – a measure of surface reflectivity, decreased daily high temperatures in agricultural regions by an average of 0.250C.
Furthermore, Perkins (2010) demonstrated that, irrigation can enhance evaporation, irrigation cools the earth's surface and provides a counter balance to global warming, particularly in the higher latitudes but additional warming from the tropics if not checkmated is capable of throwing that balance off-kilter.
Despite increasing awareness of climate change, our emissions of greenhouse gases continue on a relentless rise. In 2013, the daily level of carbon dioxide in the atmosphere surpassed 400 parts per

million for the first time in human history. The last time levels were that high was about three to five million years ago, during the Pliocene Epoch.

Statement of the problem

Climate change poses significant challenges to global sustainability, requiring effective response strategies. Despite the development of various adaptation and mitigation methodologies, their effectiveness, feasibility, and scalability remain uncertain. This uncertainty hinders the ability of governments, organizations, and communities to respond to climate change impacts efficiently, underscoring the need for a comprehensive evaluation of existing methodologies to inform climate change response efforts.

Aim and Objectives of the Study

The main aim of this study is to assess climate change response by evaluating adaptation and mitigation methodologies**.** Specifically, the study sought to:

1. Examine the impacts of climate change.
2. Investigate the efforts towards the management of climate change across the globe.
3. Assess the methods and strategies for adapting and mitigating climate change.
4. Examine the strategies that achieve climate mitigation and adaptation simultaneously.
5. Investigate the challenges of managing climate change.

Research Question

To achieve the objectives of this study, the following research questions were answered.

1. What are the impacts of climate change?
2. What are the efforts towards the management of climate change across the globe?
3. What are the methods and strategies for adapting and mitigating climate change?
4. What are the strategies that achieve climate mitigation and adaptation simultaneously?
5. What are the challenges for managing climate change?

Significance of the Study

This study is significant in that:

1. It provides information about climate change.
2. It gives insight into various strategies for curbing climate change.
3. It equally provides efforts towards the management of climate change across the globe.
4. Government, stakeholders and the general public will greatly benefit from this study as the study provides practical solutions in fighting climate change.

Scope and Limitations of the Study

This study covers the following areas:

1. Impacts of climate change.
2. Efforts towards the management of climate change across the globe.
3. Methods and strategies for adapting and mitigating climate change.
4. Strategies that achieve climate mitigation and adaptation simultaneously.
5. Challenges for managing climate change

Limitations

The study does not involve data analysis, field work and also the findings of the study may not be generalized to other regions as every region has its own climate change dynamics.

Literature Review

Impacts of climate change

The impact of climate change is multifaceted and it largely cuts across all spheres of human life. In fact, Dhanas et al (2014), claimed that the impact of climate change is largely interrelated and have the potency to exacerbate the existing social and economic problems like; drought, flood, landslides, rising sea level, high temperature and damage to infrastructure.

Climate change poses a significant challenge for the agricultural sector in India and globally. With rising temperatures, shifting rainfall patterns, and escalating extreme weather events, Indian farmers are directly

experiencing the impacts of climate change on their crop yields and livelihoods. Combating these challenges requires the Indian government and stakeholders to prioritize developing and implementing effective adaptation and mitigation strategies. These strategies should focus on enhancing water use efficiency, promoting sustainable agricultural practices, and supporting farmers in adapting to the changing climate conditions.

a. Temperature rise: Global temperatures are escalating, resulting in heat waves, extreme heat events, and rising average temperatures worldwide. This has consequences for human health, agriculture, ecosystems, and infrastructure.
b. Precipitation pattern shifts: Climate change is altering precipitation patterns, leading to changes in rainfall intensity, frequency, and distribution. This can cause more frequent droughts, floods, and fluctuations in water availability, impacting water resources, agriculture, and freshwater ecosystems.
c. Sea-level rise: Melting of ice caps, glaciers, and thermal expansion of seawater are causing sea levels to rise. This poses risks to coastal communities, infrastructure, and ecosystems, leading to coastal erosion, saltwater intrusion, and increased flooding during storms.
d. Extreme weather events: Climate change is associated with an increase in the frequency and intensity of extreme weather events like hurricanes, cyclones, heatwaves, heavy rainfall, and wildfires. These events can cause widespread devastation, loss of life, population displacement, and damage to infrastructure and ecosystems.
e. Agricultural impacts: Changes in temperature and precipitation patterns affect agricultural productivity, crop yields, and livestock health. Heat stress, water scarcity, pests, and diseases can reduce crop yields, disrupt food supply chains, and threaten food security, particularly in vulnerable regions.
f. Biodiversity loss: Climate change is driving shifts in ecosystems, species distributions, and habitats, leading to biodiversity loss and disruption of ecological processes. Many species face extinction due to habitat loss, temperature regime changes, and disruptions to food webs and migration patterns. Health impacts: Climate change affects human health through various pathways, including heat-related illnesses, vector-borne diseases, air pollution, food insecurity, and mental health impacts. Vulnerable populations like children, the elderly, and marginalized communities are particularly at risk.
g. Social and economic disruptions: Climate change can exacerbate social inequalities, increase poverty, and disrupt livelihoods, particularly in developing countries and vulnerable communities. Extreme weather events, loss of agricultural productivity, and population displacement can lead to economic losses, social unrest, and migration.
h. Water scarcity and quality: Changes in precipitation patterns and increased evaporation rates can lead to water scarcity, affecting water availability for drinking, agriculture, industry, and ecosystems. Water quality may also be compromised due to pollution, salinization, and contamination from agricultural runoff and industrial activities.
i. Ocean acidification: Increased atmospheric CO2 levels are absorbed by the oceans, leading to ocean acidification. This poses risks to marine ecosystems, including coral reefs, shellfish, and plankton, with implications for fisheries, coastal communities, and marine biodiversity. These impacts highlight the urgent need for mitigation efforts to reduce greenhouse gas emissions and adaptation measures to build resilience and prepare for unavoidable climate change consequences. Addressing climate change requires coordinated action at local, national, and global levels to protect ecosystems, safeguard human health and well-being, and ensure a sustainable future. Challenges for sustainable agriculture include climate change, growing population, urbanization, low crop yields, water scarcity, land degradation, and poverty. Given the urgency and complexity of climate change, it is crucial for economists and researchers to examine vulnerability, adaptation, and mitigation in the context of agricultural economies such as

India's. Addressing climate change in Indian agriculture requires a comprehensive approach that includes policies and investments in research, technology, and infrastructure.

j. Impact on food production and availability: Climate change affects food production and availability through various channels. Changes in temperature and precipitation patterns can lead to reduced crop yields, shifts in growing seasons, and alterations in crop suitability. This can result in food shortages, price volatility, and reduced access to nutritious food, undermining progress towards Zero Hunger.
k. Nutritional impacts: Climate change can affect food's nutritional quality by altering crop composition, reducing nutrient content, and increasing foodborne disease risks. Poor nutrition undermines human health, contributes to malnutrition, stunting, and micronutrient deficiencies, hindering progress towards Good Health and Wellbeing. Gender dimensions: Women, central to food production, processing, and household food security, are disproportionately affected by climate change impacts. Climate-related shocks can increase women's workload, limit their access to resources and decision-making power, exacerbating gender disparities in food security and nutrition, undermining Gender Equality.
l. Rural livelihoods and poverty: Climate change can disrupt rural livelihoods, reduce agricultural incomes, and force rural communities to migrate for alternative income and livelihoods. This can perpetuate poverty, exacerbate social inequalities, and undermine progress towards Decent Work and Economic Growth.
m. Environmental sustainability: Climate change affects environmental sustainability by degrading land, water, and ecosystems, reducing agricultural productivity, and threatening biodiversity and ecosystem services. Unsustainable land use practices, deforestation, and soil degradation exacerbate climate change impacts, undermining progress towards Life on Land.

Management of climate change

There has been a concerted effort towards the management of climate change across the globe; these efforts constitute governmental policies and programs aimed at reducing the extreme consequence of climate change. The management of climate change has been classified into two basic groups, the mitigation group and the adaptation group.

i. Mitigation group

As seen from the word, mitigation simply means to reduce the effect of something or to reduce the adverse effect of something. Mitigation is the strategy employed to make the effect of climate change to be less severe or harsh. These activities are undertaken to reduce the consequences of the effect of climate change.

In mitigating the effect of climate change, a number of activities have been designed and encouraged, these activities are; minimizing the level of greenhouse emissions, adoption of renewable energy sources, efficient and effective energy use, the implementation of effective and efficient technology especially in industries, recycling and re using resources, reduction of waste, recycling of water, afforestation and intelligent mobility.

ii. Adaptation;

This refers to the act of adjusting to the activities of the environment. Legonro et al (2024) considers it to be a responsive adjustment to the changing environmental conditions. Here a change is made so as to fit into the new environmental realities. Legonro et al (2024) argues that adaptation in relation to climate change is considered to be the adjustments or changing behaviors to a way that lessens the vulnerability of the ecosystem to the real and potential effects of climate change. On this note, efforts are being made towards building the resilience of target groups, habitats, communities and the entire ecosystem to help achieve adaptation by helping them to adjust to changes in the entire environment.

Adaptation will give humans an edge towards withstanding more frequent and severe heat waves, rising sea level, rising temperature fluctuations and increase, unpredictable and irregular rainfall, land slide, glaciers, flooding etc.

According to Puritanti et al (2021), the adaptation strategies are actual actions which are aimed at adjusting the natural and social systems of man to be able to confront and face the negative impact of climate change.

Meanwhile the climate change mitigation strategies are aggregation of policies and action which have the target of reducing the effect of greenhouse emissions, ultra violet rays etc. to prevent them from entering into the atmosphere. It is worthy of note that these plans and policies or programs are implemented at all levels of the international communities, national or local levels to aid combating climate change and its resultant effect.

Considering the importance of the mitigation and adaptation of climate change, it is therefore necessary to make judicious use of the two approaches concurrently so that while we are adjusting to the realities of climate change, we are also mitigating/reducing its effect on us.

Mitigation and Adaptation

Mitigation – reducing climate change – involves reducing the flow of heat-trapping greenhouse gases into the atmosphere, either by reducing sources of these gases (for example, the burning of fossil fuels for electricity, heat, or transport) or enhancing the "sinks" that accumulate and store these gases (such as the oceans, forests, and soil). The goal of mitigation is to avoid significant human interference with Earth's climate, "stabilize greenhouse gas levels in a timeframe sufficient to allow ecosystems to adapt naturally to climate change, ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner" (from the 2014 report on Mitigation of Climate Change from the United Nations Intergovernmental Panel on Climate Change, page 4).

In a climate context, as the IPCC describes, mitigation is "human intervention to reduce the sources or enhance the sinks of greenhouse gases".

In practice, mitigation can take a variety of forms, including:

✓ Replacing greenhouse gas-emitting fossil fuels like coal, oil, and natural gas with clean, renewable energies like solar, wind, and geothermal. With renewables becoming "the cheapest form of new electricity generation across two thirds of the world" in 2019 (compared to in just 1 percent of the world five years ago), this measure has quickly gone from a dream to an everyday reality.

✓ Replacing traditional internal-combustion vehicles with electric options (ideally charged with renewable energy). Just like renewables, electric vehicles are looking better than ever. As Bloomberg NEF describes: "Over 2 million electric vehicles were sold in 2018, up from just a few thousand in 2010."

✓ Retrofitting old buildings to make them more energy efficient — a fast-growing industry worth $300 billion globally.

✓ Planting trees and preserving forests so they can absorb and store more carbon dioxide from the atmosphere. Just like the other strategies, in recent years tree planting has seen unprecedented action by governments and private groups alike. In 2017, for example, the Indian state of Madhya Pradesh planted 66 million trees in just one day.

These are just four examples, but we have dozens of tried-and-tested ways to reduce our greenhouse gas emissions. So, given those two choices, how do we decide which way to go?

Climate Change Mitigation

Climate Mitigation involves efforts to diminish or prevent the release of greenhouse gas emissions. This can be achieved through various means, such as adopting new technologies and renewable energy sources, enhancing the energy efficiency of existing equipment, or modifying management practices and consumer behavior. It can range from intricate endeavours like redesigning city plans to straightforward changes in, for instance, the design of cook stoves.

While the concept of mitigation is relatively straightforward, its execution can be challenging. It requires a shift from reliance on fossil fuels to the utilization of clean, sustainable energy sources. Additionally, we must put a stop to deforestation and work towards restoring natural habitats until we attain a state of net-zero carbon emissions. This means that the amount of greenhouse gases released into the atmosphere is balanced by their capture and storage, such as in tree roots.

Methods and Strategies for Mitigating Climate Change

a. Carbon Sequestration: Carbon capture and storage (CCS), also known as carbon sequestration, encompasses technologies aimed at addressing global warming. These technologies involve capturing CO2 emissions from power plants, industrial facilities, or even directly from the atmosphere, and securely storing it underground for an indefinite period.
   Carbon sequestration specifically pertains to the prolonged storage of carbon dioxide or other carbon forms to mitigate and delay global warming effects. This approach has been suggested as a means to decelerate the buildup of greenhouse gases in the atmosphere and oceans resulting from the burning of fossil fuels.
b. Carbon Sink: A carbon sink is a natural or human-made reservoir that gathers and retains carbon-containing compounds for an extended period, thereby reducing CO2 levels in the atmosphere. The two primary global carbon sinks are vegetation and the ocean. Since the implementation of the Kyoto Protocol, which promotes the utilization of CO2 sinks as a form of carbon offset, there has been a heightened public awareness of their significance.
   The term "blue carbon" pertains to carbon captured by marine ecosystems. The majority of marine plant life comprises mangroves, salt marshes, and seagrasses, which store substantial amounts of carbon. Various endeavors are underway to enhance natural carbon sequestration in soils and oceans. Additionally, diverse artificial sequestration projects, including the development of new building materials, carbon capture and storage, and geological sequestration, are in progress.
c. Carbon Credit: A carbon credit is a permit that authorizes the holder to release a specific quantity of CO2 or other greenhouse gases. Each credit permits the emission of one metric ton of CO2 or its equivalent in other greenhouse gases. This credit is a fundamental element of a "cap-and-trade" program. Entities with emissions allowances are permitted to emit up to a defined limit, which is progressively reduced over time. Simultaneously, companies have the option to sell any unused credits to other companies in need.
   This system offers private companies a dual incentive for curbing greenhouse gas emissions. Firstly, if their emissions surpass the established limit, they must invest in additional credits. Secondly, they have the opportunity to generate profits by reducing their emissions and selling any surplus allowances.
d. Carbon Offsetting: Carbon offsetting is often the fastest way for businesses to achieve substantial reductions in emissions. Additionally, it frequently brings about supplementary benefits at the project location, including job creation, community development initiatives, and opportunities for training and education.
e. Carbon Tax: A Carbon Tax is a type of pollution levy that charges a fee on the production, distribution, and utilization of fossil fuels, determined by the quantity of carbon emissions generated during combustion. It stands as a potential alternative to the current 'cap and trade' method employed by the protocol. This tax is levied based on the carbon content within fuels, such as coal, for instance. Its objective is to diminish the reliance on fossil fuels while creating an incentive to shift towards alternative energy sources. If implemented, the carbon tax would be introduced gradually, commencing with a modest levy and incrementally rising. This phased approach allows for the advancement of superior industries and technologies.
f. Geo-Engineering: Geoengineering, a form of climate engineering or deliberate human intervention in the climate, aims to bring about long-term changes in Earth's climate patterns. Its primary goal is to modify and cool the Earth's environment, with the aim of mitigating environmental damage, countering resulting climate shifts, and ultimately creating a more hospitable planet.
   Various approaches fall under the umbrella of geoengineering, including deploying parasols in space, positioning mirrors in orbit, using sulfate aerosols to brighten the stratosphere, applying

reflective coatings to building roofs, and introducing iron filings into the ocean to stimulate carbon-absorbing algae.

Measures to Mitigate Climate Change

i. Improving energy efficiency and conservation, as well as establishing a Bureau of Energy Efficiency
ii. Reforms to the power sector
iii. Promoting hydro and renewable energy
iv. Promotion of clean coal technologies
v. Coal washing and efficient utilization of coal
vi. Forest reforestation and conservation
vii. Reduced gas flaring
viii. Cleaner, less carbon-intensive transportation fuel
ix. Encourage the use of Mass Rapid Transit systems
x. Management of environmental quality and increased energy efficiency

Global Initiatives to Reduce Greenhouse Gas Emissions

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). Its purpose is to provide policymakers with periodic assessments of the scientific foundation of climate change, including its impacts, future risks, and potential strategies for adaptation and mitigation.

The United Nations Framework Convention on Climate Change, signed in 1992 and enacted in 1994, aims to achieve the "stabilization of atmospheric greenhouse gas concentrations at a level that would prevent dangerous anthropogenic intervention with the climate system."

Adaptation

Adaptation – adapting to life in a changing climate – involves adjusting to actual or expected future climate. The goal is to reduce our risks from the harmful effects of climate change (like sea-level rise, more intense extreme weather events, or food insecurity). It also includes making the most of any potential beneficial opportunities associated with climate change (for example, longer growing seasons or increased yields in some regions).

Throughout history, people and societies have adjusted to and coped with changes in climate and extremes with varying degrees of success. Climate change (drought in particular) has been at least partly responsible for the rise and fall of civilizations. Earth's climate has been relatively stable for the past 10,000 years, and this stability has allowed for the development of our modern civilization and agriculture. Our modern life is tailored to that stable climate and not the much warmer climate of the next thousand-plus years. As our climate changes, we will need to adapt. The faster the climate changes, the more difficult it will be.

While climate change is a global issue, it is felt on a local scale. Local governments are therefore at the frontline of adaptation. Cities and local communities around the world have been focusing on solving their own climate problems. They are working to build flood defenses, plan for heat waves and higher temperatures, install better-draining pavements to deal with floods and stormwater, and improve water storage and use.

According to the 2014 report on Climate Change Impacts, Adaptation and Vulnerability (page 8) from the United Nations Intergovernmental Panel on Climate Change, governments at various levels are also getting better at adaptation. Climate change is being included into development plans: how to manage the increasingly extreme disasters we are seeing, how to protect coastlines and deal with sea-level rise, how to best manage land and forests, how to deal with and plan for drought, how to develop new crop varieties, and how to protect energy and public infrastructure.

In the climate world, the IPCC defines adaptation as "the process of adjustment to actual or expected climate and its effects." It's doing what we can to live with and minimize the destruction and suffering that comes from climate change.

Because – to be clear – we have to adapt. To choose just one example, seas *are* already rising. Now, scientists project that the cities and land currently home to as many as 110 *million* people could be underwater at high tide by 2050 if current emissions continue.

Failing to adapt to the reality we know is coming (and in many cases, is already here) to prevent widespread misery and death isn't just irresponsible – it's criminal. Especially when we know that the worst climate impacts hit poor families and people of color the hardest.

The bottom line is this: We've got to build homes and infrastructure that can handle the stronger storms and floods on the horizon. We've got to figure out how to feed billions even as global warming slashes farm yields, turns staple crops into junk food, and transforms where we can grow what. And on and on.

Potential climate adaptations span a variety of sectors, from agricultural, to coastal, to urban, and many more. Some strategies include:

- Building sea walls, elevating infrastructure, or retreating from low-lying coastal areas altogether. In the U.S., for example, cities like Charleston, Houston, Miami, and San Francisco (to name a few) already have billion-dollar investments planned to protect their sea-bound populations.
- Reducing and recycling water use due to drought. For instance, Spain — which has lost 20 percent of its fresh water in just the past 20 years — has made significant changes to its national water policy.
- Using prescribed fires to prevent uncontrollable wildfires. Take the Southeastern United States — the region of the country with the highest use of prescribed fires. It's no surprise this practice is increasing in the region given that by mid-century "NOAA suggests that the risk of very large fire weeks will increase by 300%".
- Favoring drought-tolerant crops like rice, cowpea, and maize, just as many African countries have done in response to decreasing rain.

As these examples (and most of human history) show, we're pretty good at responding to environmental changes when we put our heads to it. However, we can't stop there. We can't adapt our way out of this crisis — especially not with the absolutely unprecedented rate of change we're seeing now. Truly solving the climate crisis calls for mitigation.

Measure Types of Adaptations

i. Structural Adaptations

These are unique features involving certain parts of an organism's body, such as skin, colour, and shape. These adaptations are crucial for an organism's survival in its natural habitat. Examples include the blubber of a whale, the beak of a woodpecker, and the baleen of a humpback whale.

ii. Physiological Adaptations

These are mechanisms within an organism that enable it to carry out specific biochemical reactions for survival in its natural habitat. Examples include a snake's ability to produce venom, a mammal's capacity to regulate constant body temperature, and our body's capability to produce acid for food digestion.

iii. Behavioural Adaptations

These are specific ways an organism behaves to ensure its survival in its natural environment. Behavioural adaptations encompass actions like animal migration, hibernation, and aestivation

Strategies that Achieve Climate Mitigation and Adaptation Simultaneously

Climate actions have often fallen into one of two strategies: mitigation efforts to lower or remove greenhouse gas emissions from the atmosphere, and adaptation efforts to adjust systems and societies to withstand the impacts of climate change. The separation has led to the misinformed view that addressing climate change means pursuing *either* mitigation *or* adaptation.

This divide is counterproductive and dangerous, especially for coastal villages, farmers, small island nations and other communities at the frontlines of climate impacts. The reality is that adaptation and

mitigation are two sides of the same coin. In fact, methods and technologies that *both* curb climate change *and* cope with its impacts already exist.

It is not always possible or practical to work solely on actions that are both adaptive and mitigating. Nor are these actions a silver bullet to solving the climate crisis. Simply put, where they make sense, governments and communities should pursue such actions. Below are five solutions that can both curb climate change and help us cope with its impacts at the same time:

1. Protect Coastal Wetlands

Salt marshes, mangroves and sea grasses are unique coastal ecosystems that serve as natural water filtration systems and marine habitats. They defend coasts against sea level rise by buffering storm surges and floodwaters, and store tons of carbon in their roots and soils. Mangrove forests currently hold the equivalent of more than two years of global emissions, which would be released into the atmosphere and worsen the effects of climate change if these forests are destroyed.

Increasing protected coastal wetlands and recovering about 40% of the ecosystem's global coverage by 2050 could mitigate one gigaton of CO_2 per year — over three years of emissions. Efforts to maintain coastal wetlands must include local communities that rely on these ecosystems for their homes and livelihoods. Countries like Fiji and Papua New Guinea have successful experiences around community-based conservation and education to manage these wetlands and support the development of surrounding communities.

2. Promote the Benefits of Sustainable Agroforestry

With land use changes from forestry and agriculture accounting for nearly 25% of anthropogenic greenhouse gas emissions, it's clear that current land management schemes need to change. Agroforestry practices integrate diverse trees or shrubs with crops and livestock. In particular, pastures with trees can sequester five to 10 times more carbon than treeless areas of the same size. Farmers can also be more productive by growing crops and raising livestock simultaneously using significantly less land. Diversifying crops and including livestock on these lands can give farmers additional sources of income and reduce the risks to livelihoods caused by climate change and unpredictable weather. Expanding the use of this method to 554 million acres globally, estimated to require an investment of $41.6 billion, could help farmers realize $699 billion in financial gains from revenue diversification.

3. Decentralize Energy Distribution

Climate variability will negatively impact countries' electricity transmission and distribution infrastructure. At the same time, development and population growth are increasing energy demand and usage. Centralized energy systems — with large power plants and infrastructure connected over long distances — are more vulnerable to climate change since disruptions at one point in the system can affect the entire network.

Decentralized systems — often powered by renewable energy, with shorter transmission lines and smaller distribution areas — are more climate-resilient. In the event of a disaster, a community with its own decentralized energy supply isn't affected by power outages in other areas. Smaller, more manageable power sources can also recover from disasters more rapidly. Low-carbon technologies such as solar panels and batteries can also provide reliable, clean energy to critical services, like hospitals in remote areas that aren't already connected to the grid or experience frequent power outages.

4. Secure Indigenous Peoples' Land Rights

Indigenous and local communities manage almost 50% of land on the planet, which up to 2.5 billion people depend on for their livelihoods. These communities have practiced adaptation principles on their lands over generations, developing a deep body of traditional knowledge that can help others understand how to adapt to a changing environment.

What's more, places where indigenous people have legal rights to their land have at least two times lower deforestation rates than similar areas without secure tenure, as seen in Bolivia, Brazil and Colombia. Indigenous people and local communities have protected forests that hold a quarter of all above-ground carbon in tropical forests. Yet these communities legally own less than one-fifth of this land. Securing

indigenous peoples' rights will ensure they can hold onto their land, protect natural resources and better sustain their livelihoods in the face of climate change.

5. Improve Mass Transit

Road transport accounts for 72% of global transportation-related emissions, a percentage which will continue to grow unless more low-carbon transportation options become available and accessible. Transportation infrastructure is also extremely vulnerable to climate change impacts like storms and extreme heat. Disruptions to the network due to extreme weather will disproportionately affect low-income people and other vulnerable urban populations who have fewer mobility options. Resilient, low-carbon mass transit addresses both challenges.

Expanding urban public transportation by 40% by 2050 could decrease the projected number of cars on the road and avoid 6.6 gigatons of carbon emissions. Retrofitting and designing mass transit to withstand climate risks such as natural disasters, sea level rise or extreme heat ensures these transport options are safe and reliable in the long-term. These improvements can influence usage and better accommodate future growth.

Cities like Rome and Buenos Aires have integrated additional adaptation measures like heat-proofing buses and greening stops and routes to improve the commute experience. Increased public transportation also has the added benefits of relieving traffic congestion, reducing accidents and fatalities, and improving air quality.

Challenges of managing climate change

The adaptive and mitigating strategies have been confronted with several challenges. These challenges are global, however more challenges have been reported in Africa due to several limiting factors. In the developed society, the challenges faced are simply due to poor policy implementation to a reasonable extent, however in developing countries like Africa the below have been identified.

i. Low level of awareness of the global change, its effect and consequences.
ii. Poor political will as most of the political elites do not see it as an urgent and important issue.
iii. Cost of climate change mitigation and adaptation. The cost is usually high and implementation of such policies of mitigation and adaptation will be extremely expensive from a country's budget, it therefore discourages government.
iv. Stringent criteria and conditionality for accessing climate finance.
v. The level of poverty and underdevelopment leaves developing countries to several issues requiring urgent attention of the government; therefore, climate change is the least of the issues bedeviling the society.

METHODOLOGY

For the purpose of this study archival research was conducted. Archival research can be used in various fields for building a reliable knowledge base (Tranfield et al., 2003). In this study, archival research provided insight on existing climate change by congregating available research studies. A literature review of past ten years research (2015 to 2025) was conducted using search engines such as EBSCO, PROQUEST, JSTOR and Google Scholar. And we drew our inferences from aggregating the results of previous researches.

Key Findings of the Study

The following are findings from the study:

1. The study found out that the impacts of climate change are multifaceted. The study established that, climate change affects environmental sustainability by degrading land, water, and ecosystems, reducing agricultural productivity, and threatening biodiversity and ecosystem services. Unsustainable land use practices, deforestation, and soil degradation exacerbate climate change impacts, undermining progress towards Life on Land.
2. The study found out that, the management of climate change is classified into two basic groups, the mitigation group and the adaptation group. The study established that, in mitigating the effect of climate change, a number of activities have been designed and encouraged, these activities are;

minimizing the level of greenhouse emissions, adoption of renewable energy sources, efficient and effective energy use, the implementation of effective and efficient technology especially in industries, recycling and re using resources, reduction of waste, recycling of water, afforestation and intelligent mobility. While in adaptation group, efforts are being made towards building the resilience of target groups, habitats, communities and the entire ecosystem to help achieve adaptation by helping them to adjust to changes in the entire environment.

3. The study further found out the methods and strategies for mitigating climate change. The study established that mitigating climate change can be achieved through various means, such as adopting new technologies and renewable energy sources, enhancing the energy efficiency of existing equipment, or modifying management practices and consumer behavior. While the strategies and methods for mitigating climate change include: carbon sequestration, carbon sink, carbon credit, carbon offsetting, carbon tax, and geo-engineering.
4. Similarly, the study found out the strategies that can achieve climate mitigation and adaptation simultaneously include: protect coastal wetlands, promote the benefits of sustainable agroforestry, decentralize energy distribution, secure indigenous peoples' land rights, and improve mass transit**.** The study established that, these strategies can both curb climate change and help us cope with its impacts at the same time.
5. The study conclusively found out the challenges of managing climate change. They are: Low level of awareness of the global change, its effect and consequences, poor political will, high cost of climate change mitigation and adaptation, stringent criteria and conditionality for accessing climate finance, and high level of poverty and underdevelopment.

CONCLUSION

Climate change has become the new reality of contemporary times and many countries are adopting measures aimed at mitigation and adaptation. The unprecedented floods of 2012 have badly exposed countries of unpreparedness to cope with natural disasters. The overall effects of the floods have affected all facets of development. Climate change mitigation and adaptation methods are now relevant to development across the globe. This is so because the effects of climate change such as the recurrent flooding and desertification often draws back the development of the affected countries and the nation at large. It is recommended that climate change should be integrated into future development plans in in all countries.

RECOMMENDATIONS

Based on the findings of the study it is hereby recommended that:

1. For effective climate change management, it is paramount to use a combination of both the mitigating strategies as well as the adaptive strategies, these will aid in the management and preventive strategies of handling the climate change across the globe.
2. Government should create awareness on the need to regulate activities that has direct bearing on climate change such as lumbering, burning of fossil fuel, oil bunkering etc.
3. Promulgation of policies to regulate human activities that has a negative impacts on the environment.
4. There is need for protecting coastal wetlands, promote the benefits of sustainable agroforestry, decentralize energy distribution, secure indigenous peoples' land rights, and improve mass transit.
5. In order to curb the challenges of climate change; government and stakeholders should provide funds for managing climate change.

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