

Effects and Adaptability Due to Climate Change in Developing Countries

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Abstract- In this paper, the authors discuss the effect of climate changes and adaptability to prevailing situations in developing countries of Africa in comparison to that of Asia. Statistical distribution of global weather patterns lasts for an extended period of time leading to considerable climate change of concern. The time variation of weather within the context of long-term average conditions may be considered as a primary cause next to global warming. Factors such as biotic processes, variations in solar radiation, plate tectonics and volcanic eruptions added to human activities have been identified as major contributors to the ongoing global climate changes. The rise in average globe temperature is only one indicator of broader changes leading to hot spots, drought, flooding, storms, rising sea levels, depleted food production and infectious diseases. There is no general agreement in scientific, media or policy documents as to the precise term to be used to refer to anthropogenic forced changes. Although the scientific community has been aware of the link between greenhouse gases and climate change since years, world leaders have been slow to react and implement measures to mitigate the risks. Unless new policies are implemented by the parties of UN Framework Convention on Climate Change, global warming may further exceed the threshold of 2°C of prevailing weather patterns.

Keywords— Adaptability; Anthropogenic changes; Broader changes; Global weather patterns; Mitigate risk; Policy documents; Threshold; **Highlights:** Variation of climate worldwide, Adaptation priorities due to climate change, Impacts of climate change worldwide, Adaptation strategies administered by developing countries against climate change.

I. INTRODUCTION

The world today is using all forms of media to conduct extensive discussions on the subjects of global warming and climate change with major focus on the global dangers caused due to earth's warming. Based on the way humans are utilizing resources, congregations have been held on the depletion of resources. Due to the depletion of these natural resources sustainability has become an adverse task and many researchers have concluded that this adversity is due to Climate Change. During the year 2013, the Intergovernmental Panel on Climate Change (IPCC) concluded [1] that the emission of greenhouse gases such as carbon dioxide, methane, and nitrous oxide has caused a major impact and humans play a major role for such emissions. Considering the superior role of human activity, this phenomenon is called "anthropogenic global warming" or "anthropogenic climate change". Global estimates of the economic impacts of carbon dioxide emissions may obscure regional heterogeneities.

A modular framework [2] for estimating the country-level social cost of carbon, climate change and associated impacts may differ from region to region. Rise in sea levels, precipitation patterns changing and amplification of deserts in the subtropics may be taken into consideration for climate change in a particular region. Warming is generally greater over land than over the oceans and have the greatest impact in the Arctic, with the continuing retreat of glaciers, permafrost and sea ice. Other likely changes due to shifting temperature regimes may include more frequent extreme weather events such as heat waves, droughts, heavy rainfall with floods, heavy snowfall, acidified oceans and species extinctions. Decreasing crop yields due to climate change results in the threat to food security and the abandonment of populated areas due to rising sea levels are a few adversities caused to humans.

II. CLIMATE CHANGE

Adaptation to climate change did not receive much attention for many years during the reign of international climate change studies as the focus was fixed towards mitigation and impacts. During 2008, in Vienna, a workshop was organised [3] to discuss the climate change impacts, vulnerability and adaptation where an immediate need for understanding the emerging process was discussed. As shown in fig. 1, the climate change was discussed as a mainstreaming issue which is linked to the development of poverty reduction strategies. This process has so far primarily been donor driven because many developing countries for good reasons do not consider climatic change as one of their greatest concerns. More immediate needs for economic growth and poverty reduction take priority and it is symptomatic that most of the first generation

Poverty Reduction Strategy Papers (PRSPs) [4] had little reference to environmental concerns, let alone climate change. Over the next decades, it is predicted that billions of people, particularly those in developing countries may have to face shortages of water and food and greater risks to health and life if the cause of climate change is not

fixed. Concerted global action is needed to enable developing countries to adapt to the effects of climate change that are happening now and that may worsen in future. As the climate system has a large inertia, the greenhouse gases will remain in the atmosphere for a long time and the effects shall persist for centuries.

On Earth, an atmosphere containing naturally occurring amounts of greenhouse gases causes air temperature near the surface to be warmer by about 33 °C [5] than it would be in their absence. But without this, the average temperature would be well below the freezing temperature of water. The contribution of major greenhouse gases [6] has been studied. Even with a temperature rise of about 1.0-2.5°C, the IPCC predict serious effects including reduced crop yields in tropical areas leading to increased risk of hunger, spread of climate sensitive diseases such as malaria, and an increased risk of extinction of plant and animal species. The year 2020 may leave around 250 million people in Africa at a greater risk of water stress. Sea level rise may lead to inundation of coasts worldwide with some small island states possibly facing complete inundation. People living with the constant threat of tropical cyclones are now facing an increased severity and possibly increased frequency of these events with all associated risks to life and livelihoods.

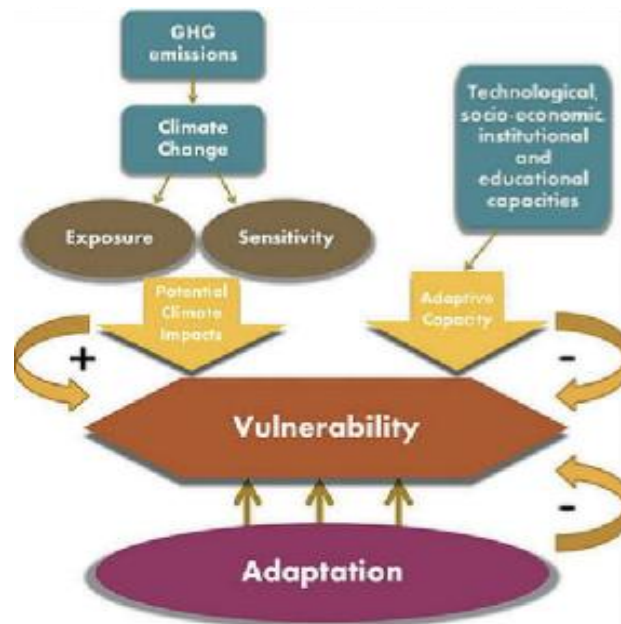


Fig. 1. Climate change impacts, vulnerability & adaptation

The UNFCCC secretariat has estimated that by the year 2030, most of the developing countries may require a huge fund of about 28 to 67 billion US dollars in order to enable the countries to adaptation to climate changes. These statistics were based on the available information related to projected investment flows and financing relevance. Developing countries are the most vulnerable to climate change impacts because they have fewer resources to adapt [7] socially, technologically and financially. Climate change is anticipated to have far reaching effects on the sustainable development of developing countries including their ability to attain the United Nations Millennium Development Goals. They may also need international assistance to support adaptation in the context of national planning.

III. EFFECTS OF CLIMATE CHANGE WORLDWIDE

Global climate change has already resulted in observable effects on the environment. Depletion of glaciers, ice on rivers and lakes have been breaking up earlier, plant and animal ranges have shifted and trees are flowering earlier. According to the IPCC, the extent of climate change effects on individual regions will vary overtime but most of the individuals should have the ability to adapt and mitigate to the present environment. Global climate is predicted to continue to change even if the emissions are reduced drastically because of their heat absorbing capacity. This effect of climate change can be measured based on the amount of reduction of heat absorbing gases over the years and also based on the sensitivity of Earth's climate to climate change.

3.1 Rise In Sea Level

Sea level rise is caused primarily by two factors related to climate change: the added water from melting land ice and the expansion of sea water as it warms. The recent observations as shown in figure 2 reflect a global average sea

level rising currently at 3.4 mm per year. It has risen 8 inches since 1880, and is projected to rise another 1 to 4 feet by 2100. Ice losses from Antarctica have tripled since 2012 as shown in figure 3 which depicts increasing global sea levels by 3mm in that timeframe alone, according to NASA. In the next several decades, storm surges and high tides combined with sea level rise could further increase the flooding in many coastal regions which in turn results in the fleeing of people living in the coastal regions worldwide. Due to the actions caused by climate change The Arctic Ocean is expected to become essentially ice free before the mid-century.

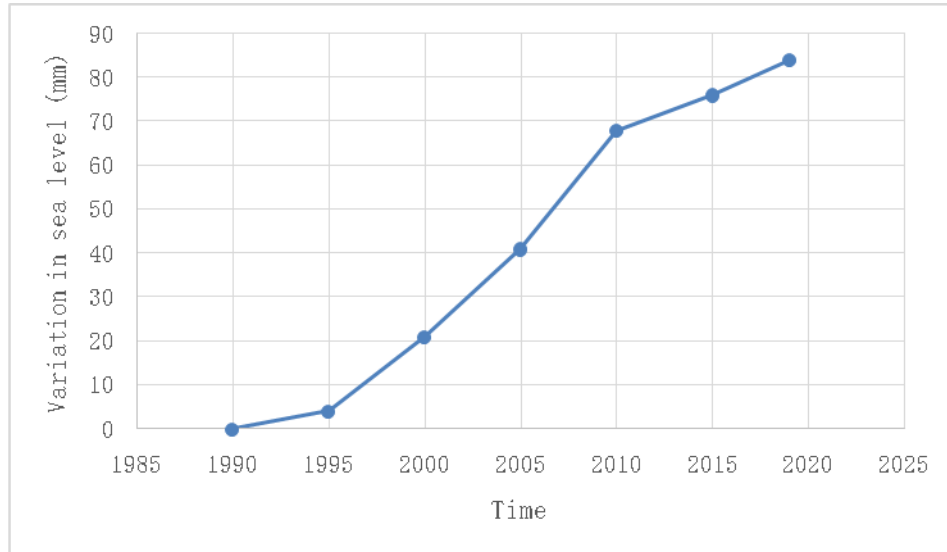


Fig. 2. Satellite data depicting rise in sea level

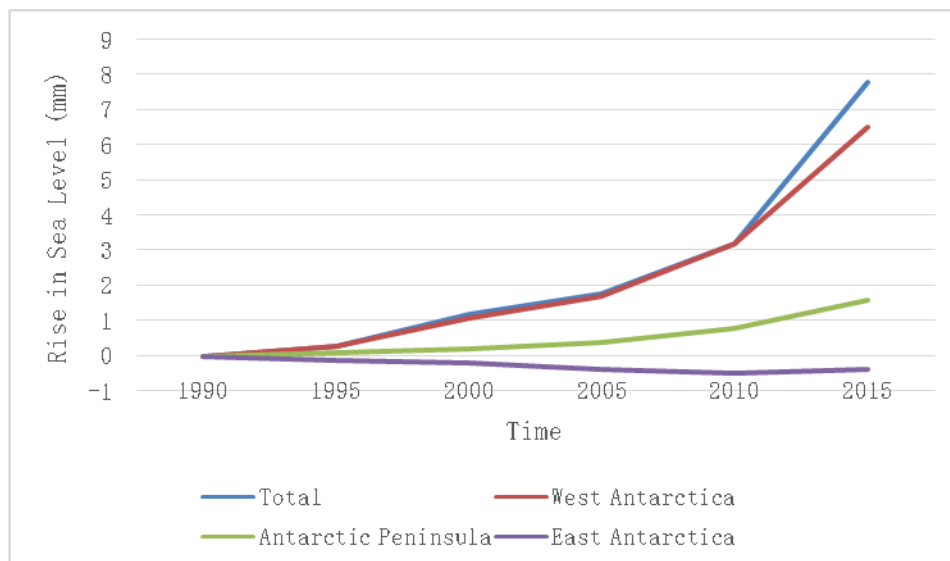


Fig. 3. Antarctic Ice sheet contribution to rise in sea level

3.2 Rise in global temperature

The present century has seen the warmest seasons ever recorded since 1880. Since 1906, the global average surface temperatures has increased by more than 0.90C-even more in sensitive polar regions. The heat is melting glaciers and sea ice and shifting precipitation patterns. Due to increasing temperatures Ice is melting worldwide and the number of glaciers in USA alone have declined to fewer than 30 from more than 150 in 1910. Rising temperatures are effecting wildlife and their habitats. Vanishing ice has challenged species such as penguins in Antarctica where some populations on the western peninsula have collapsed by 90% or more. Global warming is caused due to Sun's heat getting trapped in the Earth's atmosphere. But over the decades the Solar Irradiance have been nearly constant but the amount of heat getting trapped has been increasing exponentially.

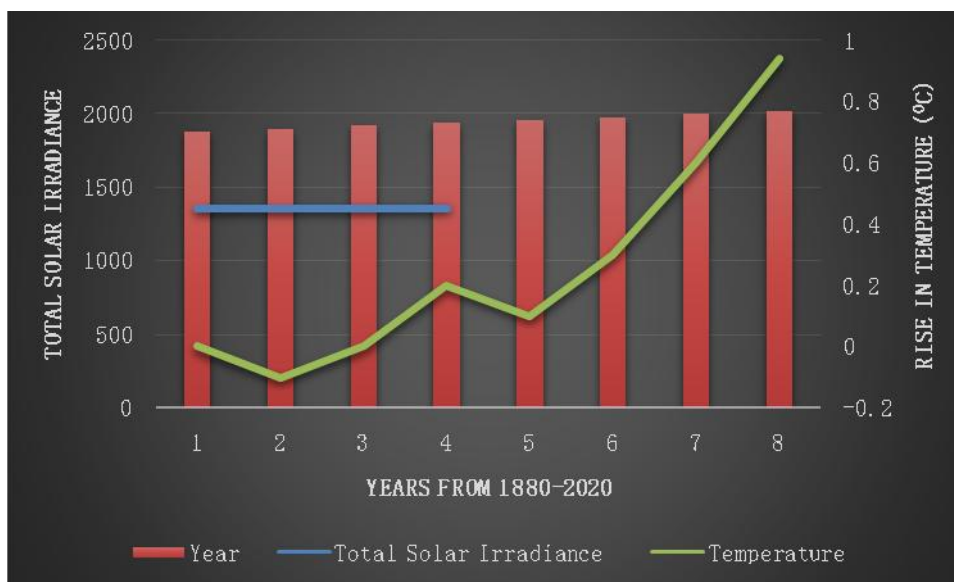


Fig. 4. Temperature rise vs Solar activity over the decades

3.3 Rise In Carbon Di Oxide Level

The global average atmospheric carbon dioxide in 2019 was 415.00 parts per million which was the highest ever recorded. In fact, the last time the atmospheric CO₂ amounts were this high was more than 3 million years ago, when temperature was 20-30C higher than during the pre-industrial era and sea level was 15-25 meters higher than today. In the present century burning fossil fuels have become a necessity and resulted in the emission of greenhouse gases which, at present is effecting the sustainability of living beings. As the carbon dioxide is a green house gas, it absorbs heat coming from sunlight. So natural increase in carbon dioxide concentrations have periodically warmed Earth's temperature during ice age over the past million years or more. That extra bit of carbon dioxide accumulated in the atmosphere over millions of years and caused the increase in carbon dioxide concentration.

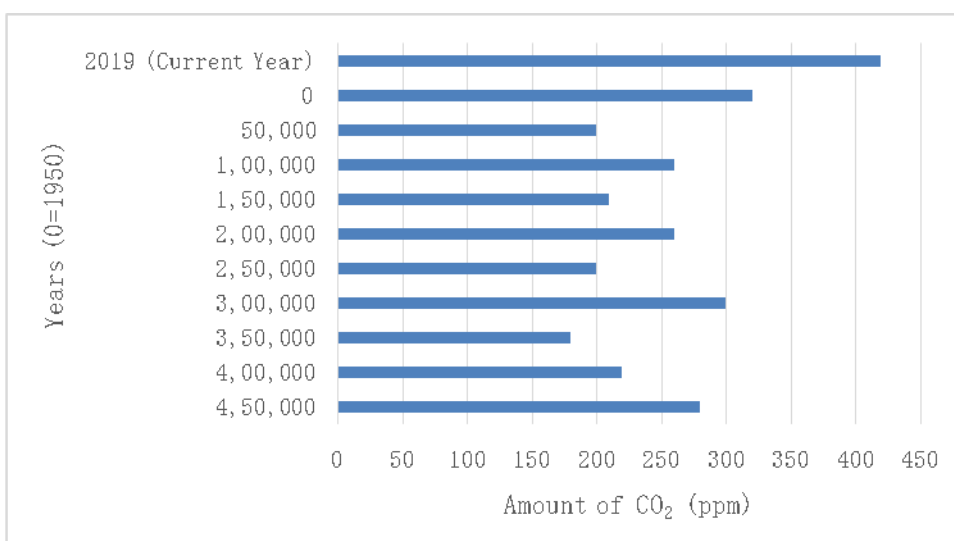


Fig. 5. Carbon dioxide levels in the atmosphere over the decades

3.4 Decrease In Ice Sheet Area

Due to the increasing temperatures worldwide the most effected regions are the polar regions. Due to climate change ice patterns are changing everywhere. The famed Kilimanjaro snow[30] have melted to more than 80% since 1912. The Glacier park located in USA once consisted of glacier which was about 800 acres in 1901. But due to climate

change this glacier has melted and is now having an area of about 250 acres. Glaciers in the Himalayas are retreating so fast that researchers believe that most of the Central and Eastern Himalayas could disappear by 2035. Arctic sea ice has thinned significantly over the century and its extent declined about 10% in the past 30 years. According to observation Arctic sea ice reaches its minimum extent each September. But according to the National Snow and Ice Data Centre the average Arctic sea ice is declining at a rate of 13.3% per decade with 2012 being the lowest in satellite records.

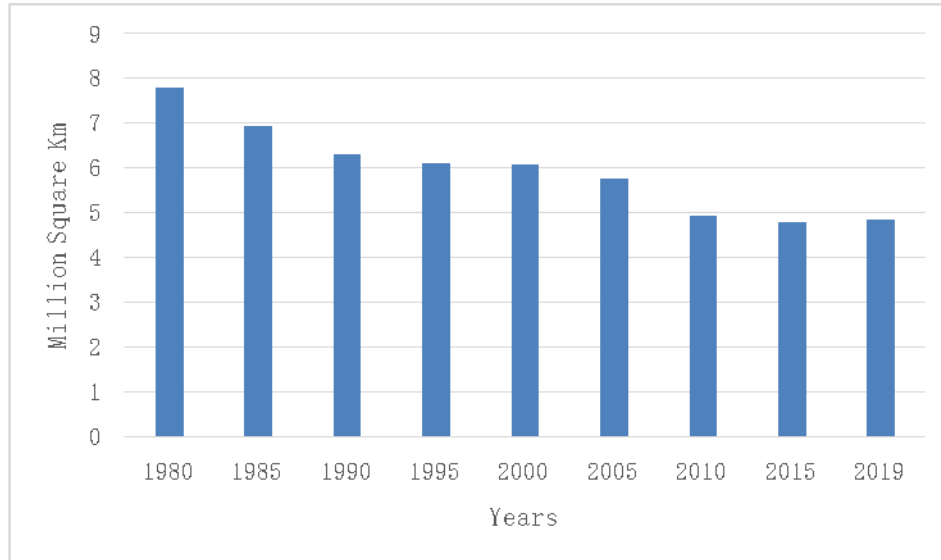


Fig. 6 Average September extent of the Arctic ice sheet over the years

IV. ADAPTATION STRATEGIES

Warming of the climate system is now unequivocal as global warming is mostly due to man-made emissions of greenhouse gases. Over the last century, atmospheric concentrations of carbon dioxide increased [8] many fold resulting into an average global temperature rise of 0.74°C . Changes in the distribution of disease vectors put more people at health risks. Increasing sea levels countries results in posing dangers on mitigation, inundation and due to wave magnitude the population residing in the coastal regions will be majorly impacted. It is thus understood that a rise in extreme events may have its adverse effects on health and lives associated to environmental and economic impacts.

V. ADAPTATION TO CLIMATE CHANGE

Adaptation to climate change is a difficult task for all the developing countries because of the increased population and industries that lead to adverse environment affects. The capacity and potential for humans to adapt (called adaptive capacity) is unevenly distributed across different regions and populations with a lower capacity in under-developed and developing countries. Furthermore, the degree of adaptation correlates to the situational focus on environmental issues and the country's economic strategy. Therefore, adaptation requires the situational assessment of sensitivity and vulnerability [9] to environmental impacts. Adaptive capacity is closely linked to social and economic development according to IPCC. Donor countries may contribute through their Green Climate Fund thus facilitating developing countries to adapt quickly. However, while the fund was set up during COP16 [10] in Cancún, concrete pledges by developed countries have not been forthcoming as the adaptation challenge grows with magnitude and rate of climate change, per region. Another response to climate change is known as climate change mitigation that advocates reducing greenhouse gas emissions or enhancing the removal of these gases from the atmosphere (through carbon sinks). Such a study has concluded that in the absence of mitigation efforts, the effects of climate change would reach such a magnitude as to make adaptation impossible for some natural ecosystems. Such programs are considered as an interference with the existing development programs.

VI. ADAPTATION PRIORITIES

The reviews of each country on its adaption priorities may differ significantly in terms of its population size, geography, economic profiles and exposure to climate risks in order to share a suitable adaptation priority. Many such survey reports related under-developed and developing countries [11] have been discussed with a view to understand

the priorities set for adaption to climate changes. However, the major emphasis always remains as the impact on food, water, health, weather and energy sectors.

6.1 Agriculture Under Pressure

Every single country that was surveyed for adaption to climate change had indicated its agricultural sector as a priority. The response varied depending on national circumstances and significance to provide drought-tolerant seeds, expanded irrigation systems and improved access to seasonal weather forecasts. Due to climate change the percentage of crop production would gradually decrease which in turn causes scarcity in food throughout the world.

6.2 Protecting Of Fresh Water Supplies

One of the main priority in the present century is the protection of fresh water supplies and their exchange with other regions. In the present era water has become the most important necessity and many wars have been waged between regions. This depletion of water sources is due to global warming and also due to extensive use of natural resources which are required to cope up with the increasing population. Countries with large arid and semi-arid regions want to capture and store available surface and groundwater resources while in coastal areas, countries are protecting freshwater from saline intrusion and damage from strong storm surges. Climate change results in the reduction of water level that may lead to drought conditions.

6.3 Climate Impacts On Health

Nearly all of the countries that were surveyed intended to raise awareness in their healthcare systems resulting from predicted risk of climate changes. There is a demand for health care workers in order to better manage the resulting impacts, strengthen the ability of life expectancy and reduce the incidence of water-borne diseases that could prevail abruptly.

6.4 Fisheries And Local Livelihood

Fisheries (marine, freshwater or aquaculture) were also prioritized by several countries, reflecting the importance of this industry for local livelihoods and diets. Countries with marine fisheries are interested in improving fish management and promoting sustainable fish farming. Similarly, countries with inland fresh water fisheries are focused on promoting integrated fish management and increasing agriculture production to the extent possible.

6.5 Reducing Risks From Extreme Weather

Disaster risk reduction and capacity of countries to cope with extreme weather events such as floods, droughts and cyclones were also highlighted. Many of the surveyed countries were interested in strengthening their hydro-meteorological institutions and thus plan to prepare climate forecasts and projections while improving early warning and disaster risk management systems.

6.6 Risks Posed To The Energy Sector

A number of countries highlighted the risks that their energy sector may have to face particularly for those dependent on hydropower. They see the need to diversify their energy systems by expanding their other available resources like geothermal, solar, wind or even adapt biogas production. They also plan to implement energy efficient technologies.

VII. IMPACTS AND VULNERABILITY TO CLIMATE CHANGE

The impacts of climate change and the vulnerability to adapt accordingly can be planned and implemented only based on related quality information. Every country has to gather [12] climatic and non-climatic data. Climate data includes significant seasonal temperature changes, rainfall and frequency of extreme events. The non-climatic data are the current situation of water resources, agricultural land, food security, human health, terrestrial ecosystems, biodiversity and coastal zones. For countries to understand their local climate better and be able to predict changes, they must have adequate operational national systematic observing networks and have access to the data available from other global and regional networks. Systematic observations of the climate system are usually carried out by national meteorological centers and other specialized centers. They take observations at standard preset times and places and monitor atmosphere, ocean and terrestrial systems. Systematic observation and forecasting services is essential to monitor climate, detect and attribute climatic change, improve the understanding of the dynamics of the climate system and its natural variability, which in turn provides information on the process of adaptation and mitigation to climate change.

Article-5 of the UNFCCC [13] refers to a need for an international community that can support and further develop climate research and systematic observation systems, taking into account the concerns and needs of developing countries. Action Plans were subsequently developed and are now being implemented for developing regions of Eastern and Southern Africa, Western and Central Africa, East and Southeast Asia, Central Asia, South and South-west Asia along with similar regions of other continents. The plans highlight the effective adaptation planning, regional, national and global data. With the assistance of the present technology, building a support system on the adaptation to climate change between communities is very essential in the present era.

VIII. ADAPTION STRATEGIES OF UNDERDEVELOPED COUNTRIES OF AFRICA AND ASIA AGAINST CLIMATE CHANGES

Many countries in their national development strategies have identified climate change as a major issue which needs a solution and tackle it through adaptation strategies. Some are engaged in national adaption plan processes, while others have already produced standalone plans. The underdeveloped African countries surveyed [14] have acknowledged the need to prepare for the impacts of climate change with a varying approach [15]. The status of a few selected countries of the continents of Africa are discussed here and compared with India and its neighboring countries from Asian continent.

8.1 Ghana

Ghana, a sub-saharan African country has updated its guidelines since five years for medium-term development planning [16] both at the district and municipal level that includes its concern for climate change. A medium-term plan that link climate change adaptation and disaster risk reduction and that in turn incorporate community-level adaptation was the goal of Ghana local government. A Local Climate Adaptive Living Facility supports these activities on a pilot basis. While these initiatives create opportunities, their effectiveness is constrained by local governments' significant capacity and resource challenges.

Year	Sudan	Guinea	Transitional	Deciduous rainforest	Rainforest	Coastal Savannah
2020	-1.1	-1.9	-2.2	-2.8	-3.1	-3.1
2050	-6.7	-7.8	-8.8	-10.9	-12.1	-12.3
2080	-12.8	-12.8	-14.6	-18.6	-20.2	-20.5

Table 1 Represents the scenario of mean annual rainfall (%) decrease for ecological zones

Year	Sudan	Guinea	Transitional	Deciduous rainforest	Rainforest	Coastal Savannah
2020	0.8	0.8	0.8	0.8	0.8	0.8
2050	2.6	2.5	2.5	2.5	2.5	2.5
2080	5.8	5.4	5.4	5.4	5.4	5.4

Table 2 Represents the mean annual temperature change for ecological zones

8.2 Burkina Faso

A National Adaptation Programme of Action of this West African country is more than decade old. But in the recent past, during 2015, Burkina Faso [17] has released its National Adaptation Plan and thus established a National Council for the Environment and Sustainable Development under its Ministry of Environment and Sustainable Development. The ministry is set responsible to coordinate and harmonize, among other issues, climate change planning and action. However, Burkina Faso being one of the least developed countries globally, it lacks the capacity and financing required to implement its adaptation plans.

8.3 Kenya

This African country has recently passed a Climate Change Bill and has in place a National Climate Change Strategy [18] and National Climate Change Action Plan. It has prepared a draft national climate change framework policy and a draft climate finance policy. These measures taken by the government depicts the resilience towards climate change. Kenya being one of the major developing country in Africa plans to tackle climate change by reducing its greenhouse emission by 30% by 2030. The government also established institutions to provide awareness to local people on the ill effects of climate change and their impacts for the future generations.

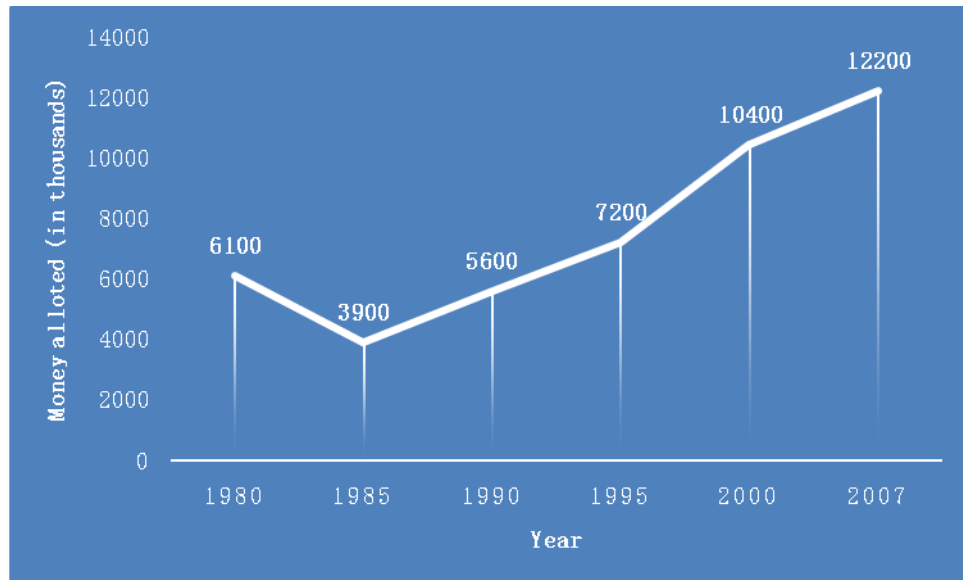


Fig 7 Graphical data on the amount of money allotted for implementing Climate Change during the past years

8.4 Bangladesh and Nepal

This Asian country has prepared a climate change strategy and action plan [19] with funding earmarked for their implementation. The Bangladesh Climate Change Trust Fund was established and funded by the Government of Bangladesh, while a second fund, the Bangladesh Climate Change Resilience Fund, is financed by donors. Both funds provide millions of dollars to invest in actions like river bank protection, afforestation and disaster management.

8.4 Srilanka

National Climate Change Adaptation Strategy (NCCAS) was started by Srilanka [20] during 2010. Climate change has affected all facets and sectors on a regional and global scale. National development policies and strategies are designed from policy and farm-level approach for conservation of ecosystems and biodiversity and highlighted under five areas: productivity, cropping systems, water management, land use and awareness. However, the country will need more allocated funds and expertise for monitoring the impacts and possible adaptation strategies. An integrated and collaborative approach involving state, private sector, civil society and farmer based organizations is essential.

8.5 India

About a decade ago, during the year 2009, India had started a State Action Plan on Climate Change [21] and developed a common framework document to help its country to identify and plan adaptation and mitigation priorities that align to the country's National Action Plan on Climate Change. Insufficient institutional capacities, budgetary constraints, and inadequate attention to the plans' potential to support climate resilient development, however, has impeded the potential benefits of these plans.

Thus, it is observed that most of the sub-national adaptation action is highly dependent on a country's level of decentralization. The Indian government has also distributed the mitigation work between local governments which would enable a much more efficient sustainable plans on tackling climate change.

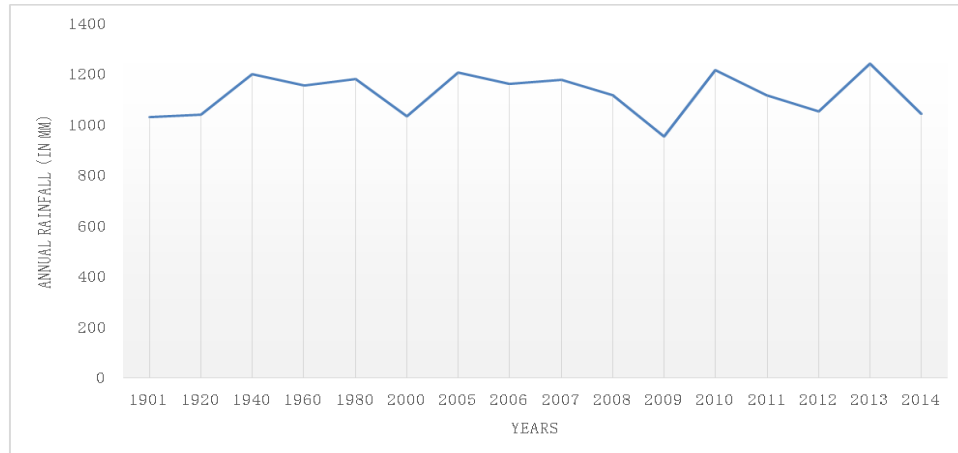


Fig 8 Trends of Annual rainfall over India from 1901-2014

IX. CONCLUSION

A country's progress can be assessed based on innumerable factors like human development, technology, health and ecosystem. Many African countries are less actively engaged in adaptation planning compared to countries Asian countries. Adaptation progress also cannot be attributed solely to differences in exposure to climate risk and its evaluated vulnerabilities to climate change. Rather, progress appears to be driven primarily by government leadership and influenced by the priorities of development assistance agencies in each country. Many countries share a focus on agriculture as its highest priority sector. This is perhaps unsurprising to know that for climate sensitivity of crop and livestock production; governments' primary desire always remains meeting the food security needs of people.

X. FUTURE SCOPE

Adaptation planning to climate changes and impacts is lacking at the sub-national level, particularly in countries where decentralization is underway. More effort is demanded to enhance the ability of such national governments, communities and local institutions to take up their devolved responsibilities. Greater emphasis may be placed on clarifying the roles and responsibilities of different levels of government and establishing effective institutional arrangements.

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XII. CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript and do not have any type of financial relationship with any of the commercial identities mentioned in this paper.

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