Africa and global climate change: Impacts, vulnerabilities and adaptation challenges

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Introduction

According to the Inter-Governmental Panel on Climate Change's (IPCC) Fourth Assessment Report (AR4), Africa is the continent most vulnerable to climate change and climate variability.[1] Climate change and variability affect ecosystems and their productivity through the changing patterns in temperature and precipitation, droughts, floods, heavy winds and other extreme events, representing both new threats for some regions and opportunities for others. In addition, the internationalization of the global economy might also exacerbate stresses associated with climate change depending on the existing local social and economic conditions.[2] Today, climate change represents a new major security threat for the world, and particularly for Africa.[3]

This chapter explores potential impacts of climate change, human vulnerability and potential adaptations and adaptation challenges in African countries. Human vulnerability is typically described as a function of three factors: exposure, sensitivity and adaptive capacity.[4] Exposure components characterize the stressors and entities under stress; sensitivity components characterize the areas affected by stresses; and adaptive capacity components characterize potential social responses to the effects of stresses.[5] Social, political and economic factors and processes, such as economic development, institutional structures, and land-use and land tenure systems, are likely to be determinant factors of human vulnerability and adaptations to the impacts of climate change. The projections of exposure to climate change impacts on human development are largely based on climate modelling scenarios.[6] On the other hand, sensitivity and adaptive capacity of the population to climate change impacts are primarily determined by human factors, such as: the level of economic development; wealth; access to technology and information; institutional changes (agricultural reforms, management practices, policies, legislation); and more recently, responses to globalization.[7] The same human dimensions also determine the causes and impacts of the local environmental processes and changes, such as rangeland degradation, salinization of arable lands, deforestation, depletion of water resources, and many others.

Climate change and variability in Africa

The climate of Africa is predominantly tropical in nature, ranging from extra arid to humid. Based on the Köppen-Geiger climate classification system, it can be classified into several climatic zones: equatorial (Af), monsoonal (Am), tropical savannah (Aw), warm desert climate (BWh), warm Mediterranean (Csa), and cool climate (Cwb) in the highlands.[8] Within these zones, altitude and other localized variables also produce distinctive regional climates. Atmospheric circulation over the continent is controlled by complex maritime and terrestrial interactions that produce a diverse spectrum of climate and vegetation zones, from the humid tropics of the Congo basin to the hyper-arid Sahara desert.

The climate also varies cyclically over periods of decades, centuries and millennia, as well as from year to year. Palaeoclimatic and archaeological data indicate that the African continent has experienced many natural climatic fluctuations and abrupt changes in the past which might be comparable with future climate change scenarios.[9] The climatic, hydrological and environmental fluctuations of the low-latitude regions during the Holocene epoch (the last ~10,000 years) are linked to changes in earth surface temperatures, sea surface temperatures, ocean and atmospheric circulation patterns, regional topography, and land surface albedo.[10] Although the relative importance of these forcing factors and their interconnections are still not fully understood, there is growing evidence that since the beginning of the past century the climate of Africa has been increasingly affected by global and regional anthropogenic trends, such as increasing concentrations of greenhouse gases (GHGs) in the atmosphere and also land-use changes.[11]

According to the IPCC AR4 report, there was an increase in the number of warm spells over most of the continent, and a decrease in the number of cold days between 1961 and 2000. Geographic patterns of precipitation changes are much more complicated. Rainfall exhibits notable spatial and temporal variability.[12] Inter-annual rainfall variability is large over most of Africa and for some regions multi-decadal variability is also substantial, including evidence for changes in seasonality and weather extremes.

Although temperature and precipitation changes affect the entire continent, their geographic patterns are uneven. Climate change in the arid and semi-arid regions of Africa is generally expected to enhance human-induced desertification and bring further decline in vegetation cover. In the Sahara and Sahel, rainfall is predicted to drop, resulting in soil degradation and an increasing number of dust storms.[13] In north-east Africa, more intense dry periods and shorter wet seasons are expected to affect even huge river systems such as the Blue Nile, leading to serious water shortages and adverse consequences for the agriculture and forestry sectors throughout the region. At the same time, Central Africa is expected to experience precipitation increase and more flooding.[14] Coastal areas may also be affected by rising sea levels and the intrusion of salt water into inland freshwater resources.

Reliable and well-distributed climate observations are essential for monitoring and modelling climate change and developing informed adaptation policies. Unfortunately, the climate observing system in Africa is currently the worst in the world and continues to deteriorate.[15] The network of 1,152 World Meteorological Organization (WMO) World Weather Watch (WWW) stations (www.wmo.int/pages/index_en.html), which provides real-time meteorological data and forms the basis of international climate archives, has an average station density of only one per 26,000 sq. km, which is only one-eighth of the WMO minimum recommended level.[16] African countries have the lowest weather reporting rate of any continent and the shortage of data-monitoring sites and long-term observation series is exacerbated by a very uneven geographic distribution of meteorological stations. Substantial areas of Africa, particularly those in Central Africa, remain largely unmonitored.

Several studies also have highlighted the importance of land-use and land-cover changes and the associated dynamic feedbacks on the physical climate.[17] An increase in vegetation density, for example, has been suggested to result in a year-round cooling of 0.8°C in the tropics, including tropical areas of Africa.[18] Complex feedback mechanisms, mainly due to deforestation and related land-cover change, and changes in atmospheric dust loadings, also play an important role in climate variability, particularly for drought persistence in the Sahel and its surrounding areas.[19]

Changes in extreme events, such as droughts and floods, have major implications for numerous Africans and require further attention. One-third of the people in Africa live in drought-prone areas and are vulnerable to the impacts of droughts and floods. These impacts are often further exacerbated by health problems, particularly diarrhoea, cholera and malaria.[20] During the mid-1980s the economic losses from droughts totalled several hundred million US dollars.[21] Droughts have mainly affected the Sahel, the Horn of Africa and Southern Africa, particularly since the end of the 1960s.[22]

Climate change scenarios

Given that Africa is such an enormous landmass, stretching from about 35°N to 35°S, the predicted climatic changes are very different in different parts of the continent. Some areas of the continent are likely to become drier, others wetter; some regions may derive some economic benefit, while most regions will likely be adversely affected. Because mainland Africa is divided into 50 countries, geographic variations of climate-related changes are likely to be very complex and uneven.

The major source of current information available about future global and regional climatic changes are scenarios generated by Atmosphere Ocean General Circulation Models (AOGCMs), which simulate physical processes in the atmosphere, ocean, cryosphere and land surface, and also responses of the global climate system to increasing greenhouse gas concentrations. The most important elements of climate change scenarios predicted by climate models include CO_2-fertilization effect on natural agricultural ecosystems, temperature increases, changes in precipitation patterns and changes in extreme events.[23]

Annual temperature is predicted by AOGCMs to increase by as much as 2.4°C in the Sahara and Kalahari deserts by around 2050, and by about 1.4°C in the inter-tropical regions (see Table 22.1). Precipitation is generally simulated to increase over much of the continent by the middle of the century, with the Sahel and other semi-arid parts of Africa being predicted to receive as much as 15% of precipitation increase over 1961–90 by the middle of the century.[24] However, as Hulme *et al.* have demonstrated,[25] AOGCMs are not capable of simulating the same magnitude of inter-decadal and inter-annual climatic variability, particularly precipitation variability, that has been observed over the past century, which raises questions about the ability

Table 22.1 Regional mean annual temperature and mean annual precipitation change scenarios for the period centred around 2050, simulated by 20 Atmosphere Ocean Circulation Models

Region	*North Africa*	*Central Africa*	*Southern Africa*	*Eastern Africa*
Temperature change, °C	from +1.7 to +2.4	from +1.7 to +1.9	from +1.4 to +2.5	from +1.6 to +2.1
Precipitation change, mm	from -2.0 to +6.0	from +0.4 to +2.6	from -14.0 to -2.7	from +8.0 to +13.0

Source: (Scenarios were computed by the author with MAGICC/SCENGEN 5.3.2 model) of models adequately to simulate the key climatic mechanisms for tropical regions. Regional temperature and rainfall projections for the period around 2050 are summarized in Table 22.1.

One of the major problems associated with the scarcity of climate observations in Africa is that climate scientists still have very limited systematic understanding of the basic state of atmospheric circulation over many parts of the continent, particularly the central African convective region, which is the largest on the planet during significant parts of the year.

Key areas of human vulnerability to climate change in Africa

Human vulnerability to climate and environmental changes constitutes a critical set of interactions between society and the natural environment. Although many definitions of human vulnerability have been proposed by different authors, it is usually understood as a function of the character, magnitude and rate of climate change, and the exposure, sensitivity and adaptive capacity of the human-environmental system.[26] One of the key dimensions of human vulnerability is exposure—a degree to which a system is exposed to a hazard, perturbation or stress caused by the changing climatic conditions. Sensitivity can be defined as a degree to which a system is affected by, or responsive to, climate change stimuli.[27] Adaptive capacity or adaptability is understood as the potential or capability of a system to adapt to climatic stimuli. The capacity of a sector or region to adapt to climatic changes depends on many non-climatic factors, such as the level of economic development and investments, access to markets and insurance, social and economic policies, access to education and technology, cultural and political considerations, the rule of law regarding private and public properties, including natural resources, etc.

The projected impacts of climate change on African countries include changes in the regional hydrometeorology, increases in the inter-annual variability and more frequent catastrophic climate events, such as droughts and floods, intensification of the human-induced desertification by the increasing incidence of more frequent, severe and persistent droughts, reduction of biodiversity and the CO_2-fertilization effect.[28] These changes, in turn, are likely further to exacerbate many already existing problems, such as unstable economic development, food and water insecurity, poverty and low standards of life, and human health issues. Exposure and sensitivity to climate change and related environmental hazards are highly varied between the regions and sectors within Africa. Three areas of climate impact and human vulnerability are especially critical for African countries: agriculture and food security; water availability and stress; and human health.

Agriculture and food security

Agriculture constitutes approximately 30% of Africa's gross domestic product (GDP) and contributes about 50% of the total export value, with more than 70% of the continent's population depending on this sector for their livelihood.[29] Seasonal out-migration is already a consistent feature of many rural communities of sub-Saharan Africa where food security is no longer dependent upon locally grown produce.[30] Even without climate change, agriculture in many parts of Africa is already severely stressed by the population growth, political instabilities, and shortage of investments and technology.

Field experiments and agro-ecological modelling studies indicate that crop yields in many parts of Africa are likely to decline due to temperature increases, proliferation of pests, increasing frequency of dry spells and floods, and reductions in soil fertility.[31] A study on South African agricultural impacts, based on three AOGCM scenarios, indicates that crop net revenues will likely fall by as much as 90% by 2100, with small-scale farmers being the most severely affected.[32] An assessment by Fischer *et al.*, based on the Agro-Ecological Zones model (AEZ) developed by the Food and Agriculture Organization (FAO), in conjunction with the Basic Linked System developed by the International Institute for Applied Systems Analysis (IIASA), suggests that by the 2080s, there will be a significant decrease in suitable rain-fed land extent and reduced production potential for cereals is estimated under climate change.[33] Furthermore, for the same projections, during the same time interval, the area of arid and semi-arid land in Africa could increase by 5%–8% (60 million–90 million hectares). This study shows that wheat production is likely to completely disappear from Africa by the 2080s. Regional modelling assessments have also shown that Southern Africa would be likely to experience notable reductions in maize production under possible increased El Niño–Southern Oscillation (ENSO) conditions.[34]

However, not all changes in climate and climate variability will be negative, as agriculture and the growing seasons in certain areas (for example, parts of the Ethiopian highlands and parts of Southern Africa, such as Mozambique), may lengthen under climate change, due to a combination of increased temperature and rainfall changes. The utmost concern should be a better understanding of the potential impact of the current and projected climate changes on African agriculture and identifying ways and means to adapt to and mitigate its detrimental impacts.

Water supply and water stress

Even in the absence of climate change, present population trends and current patterns of water use indicate that the majority of African countries will exceed the limits of their economically usable, land-based water resources before 2025.[35] The population at risk of increased water stress in Africa is projected to be 75 million–250 million and 350 million–600 million people by the 2020s and 2050s, respectively.[36] The impact of climate change on water resources across the continent is not uniform. An analysis of AOGCMs scenarios by Arnell shows a likely increase in the number of people who could experience water stress by 2055 in northern and southern Africa.[37] The same study suggests that in contrast, more people in eastern and western Africa will likely experience a reduction rather than an increase in water stress. Strzepek and McCluskey examined water availability scenarios using 10 AOGCMs and reported that the possible range of Africa-wide climate change impacts on stream flow would significantly increase between 2050 and 2100.[38] The range is from a decrease of 19% to an increase of 14% by the end of the century. Parts of southern Africa are projected to experience significant losses of runoff, with South Africa being particularly impacted.[39] Other regional assessments report emerging changes in the hydrology of some of the major water systems, like the Okavango River basin, which could be negatively impacted by changes in climate. These impacts could possibly be greater than those associated with land-use changes.[40]

The African continent hosts over 80 shared river basins, covering about 60% of its area. Some 13 of them have a great significance, such as the Nile, Niger and Zambezi, each of which touches the geographic area of 10 or more countries. Many river channels and basin watersheds demarcate about 405 of the international boundaries in Africa.[41] The impacts of climate change will differ from one catchment to the other and will require a management system to match. International rivers pose particular challenges because of competing national interests and few, if any, well-established mechanisms for collaborative management between nations that share the river basins. Water stress can also potentially become a source of international conflicts.

Human health and vector-borne diseases

Climate change is expected to have significant impacts on human health and the geography of vector-borne diseases.[42] One prime example is that 90% of all malaria cases in the world occur in Africa.[43] Results from the 'Mapping Malaria Risk in Africa' project show an expansion of areas, climatically suitable areas for malaria by 2020, 2050 and 2080, although some regions might experience the contraction of transmission areas due to temperature increases exceeding the mosquito tolerance threshold.[44] An assessment by Hartmann *et al.*, using 16 climate change scenarios, suggests that by 2100, changes in temperature and precipitation could alter the geographical distribution of malaria in Zimbabwe, with previously unsuitable areas of dense human population becoming suitable for transmission of plasmodium. Strong southward expansion of the transmission zone is likely to expand into South Africa. Tanser *et al.* used parasite survey data in conjunction with AOGCM scenarios and estimated a 5%–7% altitudinal increase in malaria distribution, with little increase in the latitudinal extent of the disease by 2100.[45]

Previously malaria-free highland areas in Ethiopia, Kenya, Rwanda and Burundi could also experience modest incursions of malaria by the 2050s, with conditions for transmission becoming highly suitable by the 2080s. By this period, areas currently with low rates of malaria transmission in central Somalia and the Angolan highlands could also become highly susceptible. Among all scenarios, the highlands of eastern Africa and areas of southern Africa are likely to become more suitable for malaria transmission.

Climate variability may also interact with other background stresses and additional vulnerabilities such as conflict and war, population displacement, land degradation and high rates of HIV/AIDS in the future, resulting in increased susceptibility and risk of other infectious diseases (e.g. cholera, typhoid and yellow fever), and malnutrition. The potential for climate change to intensify or alter flood patterns may become a major additional driver of future health risks from flooding.[46]

The politics of climate change negotiations and Africa

African leaders have been voicing concerns about climate change for their countries. At an African Union summit in 2007, Museveni, the President of Uganda, called climate change an 'act of aggression' against the developing countries by the developed world and suggested that the damage that global warming would cause African nations must be compensated.[47]

Based on the tradition of the United Nations (UN), parties to the UN Framework Convention on Climate Change (UNFCCC) are organized into five regional groups, namely: African states, Asian states, Eastern European states, Latin American and the Caribbean states, and the Western European and other states (Australia, Canada, Iceland, New Zealand, Norway, Switzerland and the USA, but not Japan, which is in the Asian group). The 50 countries defined as least developed countries (LDCs) by the UN regularly work together. They have become increasingly active in the climate change process, often working together to defend their particular interests, for example with regard to vulnerability and adaptation to climate change. All countries have been required to provide national communications on climate change impacts and vulnerabilities, and to produce National Adaptation Programs of Action (NAPAs). These plans may soon provide the basis and condition on which LDCs can apply for funds in the area of adaptation. While most African countries have undertaken steps to fulfil such commitments, in many cases their capacity to do so appears to be limited. Moreover, in many African countries, adaptation planning remains a stand-alone activity that is not integrated into development planning processes. This weakens the ability of African states to implement efficiently adaptation plans and programmes.[48]

The African Group's position is that developed countries must recognize ambitious mitigation commitments for a second and subsequent commitment periods of the Kyoto Protocol. Developed countries must reduce their emissions of greenhouse gases by at least 40% by 2017, and by at least 95% cent by 2050, compared to 1990 levels. To ensure the environmental integrity of these targets, offsets should be limited to 10% and existing loopholes should be closed.[49] The Green Climate Fund (GCF) was launched at the 2011 UN Climate Change Conference held in Durban, South Africa. Despite its establishment, it continued to be empty. It was due to begin dispensing money in 2013 to help developing countries cope with climate change; however, rich industrialized countries have failed to deliver on their financial pledges and the issue has not been fully resolved.[50]

Decisions of the 18th session of the Conference of the Parties to the UNFCCC and the eighth session of the Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol held at the end of 2012 provided very limited help to African countries.[51] Progress on a long-standing commitment for rich countries to contribute US$100 billion a year by 2020 to help poor nations cut emissions and adapt to a warmer world was also put off for another year. Concerning the second commitment period of the Kyoto Protocol, African countries have succeeded at the UNFCCC conference in Doha to secure it with an eight-year extension period. While Africa, along with others, keeps the breath of the Protocol, its existence is very weak with a refusal for the extension of previous industrialized signatories such as Japan, Russia and Canada along with the USA, which previously did not ratify the protocol. Perhaps the biggest recent gain for African countries is an agreement for a new treaty to be forged in 2015, and enter into force by 2020. This would create a chance for all major emitters to get a comprehensive binding deal in 2015.

To cope with the complexities of the international negotiations ahead, African countries should prepare themselves very well starting from creating awareness among its people to building the capacities of its expertise in understanding the detailed issues of negotiation. However, the recent conference in Doha has also opened a new direction for Africa as it has agreed for the first time to establish a process to look at compensating poorer countries for loss and damage suffered because of climate change—something wealthy countries have long resisted. This can be considered Doha's most important achievement. The 'principle of loss and damage' has been explained as a mechanism where developed countries are required to assist developing countries with cleaning up and reconstruction after extreme weather events. The principle is an important step forward because until now developed nations stopped short of accepting responsibility for the damage caused by climate change elsewhere.[52] The exact details of the loss and damage scheme, including how much developed countries will have to pay, are expected to be worked out at future meetings of the UNFCCC.

In addition to a legally binding adaptation framework, the African negotiating bloc has outlined several other demands, including adequate, sustainable, new and additional, and predictable financial resources, investment to support action on mitigation and adaptation as well as technology co-operation.[53] Details on how much funding will be made available for adaptation finance, as well as the arrangements by which these funds will be administered, are still emerging. None the less, it is clear that in order to make a strong case in negotiating for adaptation finance, African countries will have to prove that they are able to utilize adaptation funding efficiently, transparently and for the purpose it was intended. Unfortunately, the Doha conference, while registering modest results, has not brought any firm commitments on reducing carbon emissions, which Africa advocates most, or on climate change aid.

Possible adaptations and challenges

Projections of climate changes and their impacts suggest that African countries are extremely vulnerable to current climate change and variability, and this vulnerability is exacerbated by existing developmental challenges such as endemic poverty, population growth, ineffective governance, corruption and other institutional dimensions, limited access to capital, information, infrastructure and technology, ecosystem degradation, conflicts and forced migrations. These factors in turn are contributing to Africa's high sensitivity and low adaptive capacity, increasing the continent's vulnerability to projected climate change. Development of adaptations strategies to climate change is only possible if the impacts of climate change are considered in the context of many other processes, such as political and institutional changes, economic development and globalization, changes in the land-use practices and livelihoods, etc. Capacity of countries, regions and communities to implement potentially useful adaptation strategies depend on a variety of geographic, historical, political and economic factors. There is compelling evidence from many other parts of the world that there is a strong relationship between vulnerability to climate change and sustainable development. Factors such as social inequality, poverty, uneven access to health care, education and technology, ineffective institutions, population migrations and ethnic conflicts must first be taken into account by the national and local decision makers as the most crucial factors of human vulnerability to climate change.

Another serious problem is the lack of integration of possible adaptation strategies at the continental scale. Development of effective and realistic adaptations could benefit from an integrated continent-wide approach reaching beyond the national borders, especially because adaptation measures are rarely undertaken in consideration of the impacts of climate change alone, and are typically imbedded within other initiatives such as land-use planning, water resource management, drought warning, desertification control, health care programmes and diversification of agriculture.

Non-climatic stresses are likely to increase human vulnerability in Africa to climate change and reduce its adaptive capacity because of resource deployment to competing needs. For example, increases in surface temperature and frequency of droughts, soil salinization and degradation, degradation of vegetation cover, water loss due to inadequate irrigation practices, combined with poverty, malnutrition and limited access to drinking water and sanitation, health care collapse and outbreaks of many chronic and infectious diseases, and many other regional stresses would require unprecedented amount of resources to alleviate just some of them. Short-term, unplanned reactive coping strategies aiming to address separately some of these stresses (e.g. droughts), usually provide only an immediate solution for a limited area or group of the population, but in the long term they only exacerbate the problem. Focusing on effects but not on the causes of the problems can only further aggravate the ongoing adverse environmental changes in the long term.

To cope with the multiple regional stresses in the context of multiple increasing stresses, both related and unrelated to climate change, it is important to consider such adaptive strategies that could place equal importance on environmental, social and economic considerations. The development of such adaptation strategies involves inevitable trade-offs between environmental, economic and socio-cultural and political considerations and priorities. Evidence from around the world suggests that development and implementation of adaptation strategies and policies are successful only when they are driven by the interests of stakeholders—groups of individuals and communities vulnerable to the risks of climate change.[54] At the national and regional scale adaptations are usually undertaken by the governments on behalf of the entire society or particular groups but regardless of the geographic scale, these decisions, policies and projects must be driven by the 'place-based' initiatives and integrate the needs of various communities at multiple scales. Communities rarely face only one effect or risk of climate change at a time and the interaction of multiple vulnerabilities often can lead to the amplification of risks.[55] Climate change impacts are interconnected with land-use changes, socio-economic changes and many other processes that interact in the human-environmental system. Therefore, adaptations can be sustainable only if they target multiple processes and risks in the integrated manner, reaching across various aspects of human life (food security, water resources, health, quality of life, etc.) at multiple geographic and temporal scales. For example, reduction of monoculture, diversification of crops and application of no-tillage techniques in agriculture would not only help to increase food security in African countries, but also would decrease the use of water, improve soils through nitrogen fixation in soil, and sequestrate carbon, a useful climate change mitigation measure. The introduction of more advanced irrigation techniques, such as drip irrigation and more water-efficient crops could reduce the loss of water resources in drylands, but also would improve crop productivity, reduce the soil losses due to salinization, and help reduce the risks of water contamination and transmission of many vector-borne and water-borne diseases.

Conclusion

Africa is the most vulnerable continent to climate change. Although temperature and precipitation changes affect the entire continent, their geographic patterns are uneven. In the Sahara and Sahel, rainfall is predicted to drop, resulting in soil degradation and an increasing number of dust storms. More intense dry periods and shorter wet seasons are expected to affect even huge river systems such as the Blue Nile, leading to serious water shortages and adverse consequences for the agriculture and forestry sectors throughout the region. At the same time, Central Africa is expected to experience precipitation increase and more flooding and many coastal areas may also be affected by rising sea levels and the intrusion of salt water into inland freshwater resources.

Reliable and well-distributed climate observations are essential for monitoring and modelling climate change and developing informed adaptation policies. Unfortunately African countries have the lowest weather reporting rate of any continent and the shortage of data-monitoring sites and long-term observation series is exacerbated by a very uneven geographic distribution of meteorological stations. Based on the climate modelling scenarios annual temperature is predicted to increase by as much as 2.4°C in the Sahara and Kalahari deserts by around 2050, and by about 1.4°C in the inter-tropical regions. Precipitation is generally simulated to increase over much of the continent by the middle of the century, with the Sahel and other semi-arid parts of Africa being predicted to receive as much as 15% of precipitation increase over 1961–90 by the middle of the century.

The projected impacts of climate change on African countries are likely to exacerbate further many existing problems, such as unstable economic development, food and water insecurities, poverty and low standards of life, and human health issues. Three areas of climate impact and human vulnerability are especially critical for African countries:

- agriculture and food security;
- water availability and stress; and
- human health and vulnerability to vector-borne diseases.

Development of effective and realistic adaptation strategies could benefit from an integrated continent-wide approach reaching beyond the national borders, especially because adaptation measures are rarely undertaken in consideration of the impacts of climate change alone, and are typically embedded within other initiatives such as land-use planning, water resource management, drought warning, desertification control, health care programmes and diversification of agriculture. One of the major reasons of the low adaptive capacity of African countries is the lack of planned proactive adaptation strategies. In many African countries, adaptation planning remains a stand-alone activity that is not integrated into general development planning processes. Another major problem is the lack of integration between different adaptive strategies both at the national and especially international scales. Climate change impacts are interconnected with land use, water resources, food systems, health care systems, transportation networks, and many other structures and processes that interact in the human-environmental system. Therefore, adaptations can be sustainable only if they target multiple processes and risks in the integrated manner, reaching across various aspects of human life at multiple geographic and temporal scales.

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