LUISS

Department of Political Science

Politics: Philosophy and Economics

Chair of African Politics and Society

Climate Change in Africa:

a challenge and an opportunity for sustainable development

Supervisor

Prof. Marco Massoni

Candidate

Francesca Granzotto

101232

Academic Year 2023/2024

"Thus shall we live, because we will have created a society which recognises that all people are born equal, with each entitled in equal measure to life, liberty, prosperity, human rights and good governance."

Nelson Mandela

Table of contents

Introduction 1

1. Climate change as a global issue 2

1.1. History of the Climate Change Regime 5

1.2. Definition and principle of sustainable development 9

1.3. Mitigation and adaptation as strategies to achieve sustainable development 10

2. Vulnerability of Africa and the importance of sustainable development in the African context 13

2.1. Environmental impact of climate change 14

2.2. Economic impact of climate change 16

2.3. Social impacts of Climate Change 19

2.4. Case study of South Africa: impact of climate change on agricultural crops 22

3. Opportunities for sustainable development 26

3.1. Agenda 2063 27

3.2. Renewable energies 29

3.3. Smart Agriculture in Africa 33

Conclusion 39

Bibliography 41

Introduction

This bachelor's thesis aims to explore the dual nature of climate change in the African continent: on the one hand, it will focus on the negative impacts and consequences of climate change, including economic instability and environmental degradation; on the other hand, it will analyze the different opportunities that climate change presents in order to develop in a sustainable way, such as the use of renewable energy and technological innovations.

More specifically, it will focus firstly on the multifaced challenges that vary in nature and form, and it will then highlight how, by having the ability to exploit these challenges and transform them into opportunities, Africa can assume a potential leading role in the development of strategies and policies that focus on the concepts of mitigation and adaptation of climate change, with the final aim of achieving sustainable development.

The work is divided into three main chapters to fulfill this aim better. The first chapter gives an introductory view on the widespread concept of climate change in general, highlighting the relevance of the topic as a pressing global issue, whose repercussions have been witnessed worldwide. The various subsections of the chapter will explain in depth the concepts of climate change mitigation and adaptation, and the several definitions of sustainable development with a focus on the reasons that stay behind the specific vulnerability and susceptibility of climate change for the African continent. The second chapter will discuss in detail the challenges that climate change poses to Africa, with every subsection focusing on a different issue: environmental, economic, social, and institutional challenges. Several case studies of different African states will be taken into consideration and analyzed. Lastly, the third chapter will explore instead all the different opportunities and strategies available for the pursuit of sustainable development, with a specific mention of the role that Agenda 2063 plays within this context. As in the previous chapter, case studies of successful initiatives and policies will be presented.

Finally, the last section will be a conclusion with a summary of the work emphasizing the key points and findings. It will reflect on the importance and urgency of addressing climate change, leaving space for further research in a field that is constantly developing and in need of new solutions.

1. Climate change as a global issue

Over the last decade, climate change has emerged as a concerning global issue that threatens human societies, the environment, and the whole planet. According to the definition proposed by the Framework Convention on Climate Change (FCCC), climate change has been defined as "a *change of climate that is attributed directly or indirectly to human activity, that alters the composition of the global atmosphere, and that is an addiction to natural climate variability over comparable time periods*". On the other hand, the Intergovernmental Panel on Climate Change (IPCC) proposes the following definition: "*any change in climate over time whether due to natural variability or as a result of human activity*". Even though they appear slightly different, it is important to notice the emphasis that both definitions place on the role of human activity in the context of climate change.

In the Earth's history, the Earth's climate has been constantly changing, characterized by the alternance of different geological eras, due to changes in the solar orbit and geological changes. However, since the Industrial Revolution and throughout the 20th century, the climate has been rapidly evolving due to man-made activities which have caused an increase of 0.6°C to the mean temperature of the global surface, as well as the rise of the sea temperature, and periods of droughts and floods. (*IPCC, 2001)* To better understand how this process has been possible, it is fundamental to take a step back and clarify some aspects.

For as long as we have knowledge, the Earth's atmosphere has had the peculiar physical property of acquiring heat from the sun and retaining it, so that, most of the energy received during the day, has the capacity to warm the atmosphere rather than the surface, also at night. This effect, known as the greenhouse effect, is one the most important factors that have allowed the presence of life on our planet, making Greenhouse Gases (GHGs), like CO2, water vapor, and methane, of fundamental importance. There was therefore a natural level of GHGs within the atmosphere, that, since the 1850s, has started to steadily increase. The following figure (fig.2) shows the increase of per capita CO_2 world emissions from the burning of fossil fuels coming from industrial processes. The graphic does not take into consideration fossil emissions that include land use change and processes of deforestation.

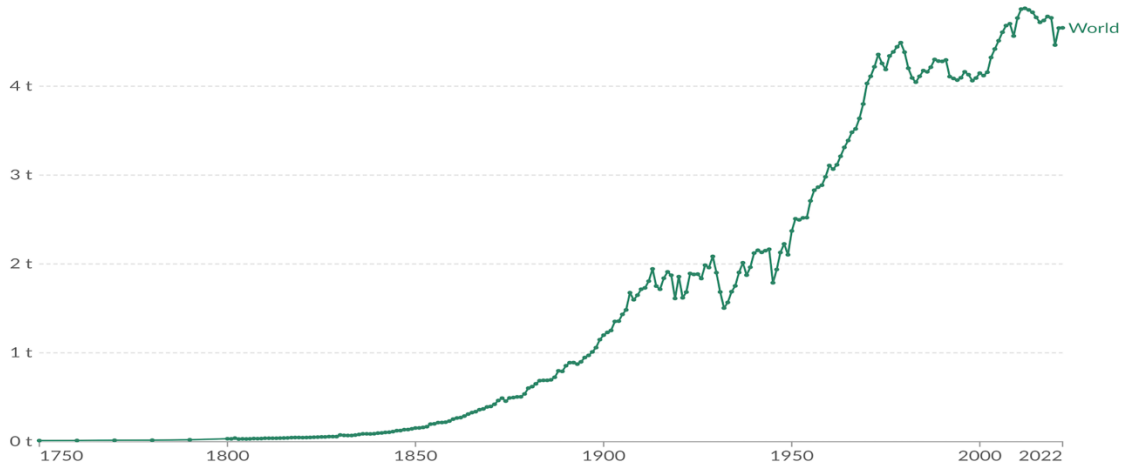

Fig. 1

Source: Our world in Data (Global Carbon budget, 2023)

According to the Third Assessment Report on Climate Change of the Intergovernmental Panel on Climate Change, scientists have found that the concentrations of CO_2, nitrous oxide, and methane have increased by 30%, 50%, and 17%, respectively, in the last century, leading to a warming of the planet, commonly known as global warming. Different factors can be identified as the main drivers of the exponential growth of GHGs. Firstly, the intense use of fossil fuels, such as coal, gas, and oil, remains a prominent factor, particularly needed for the energy and industrial sectors. Fossil fuels are essential for the functioning of these industries, specifically for the generation of power, transport, and manufacturing processes, causing enormous quantities of carbon dioxide emissions. Secondly, food production represents another sector heavily responsible for CO_2, methane, and other GHG emissions. In particular, the use of fertilizers for agriculture, deforestation for the creation of new crops and arable land, and digestion by animals, used especially for meat production, are all factors contributing to climate change.

The severe consequences of climate change are currently affecting nature, which is passively suffering from it, and, human beings, which are the main responsible and the ones who will bear the greater cost. Nowadays, it is impossible not to witness this phenomenon's environmental, social, and economic impacts. The most manifest and touchable factor is the increase in temperatures worldwide, with some regions currently experiencing peaks in temperatures never reached before, proved by the fact that ten of the warmest years recorded, have occurred in the past twelve years. The rising temperature brings with itself more catastrophic consequences, as the increasing spread of diseases, forest fires, a constant risk of water scarcity, and the reduction of harvests. The following chart shows the global average increase in temperatures (fig.1) relative to the 1961-1990 average temperature baseline.

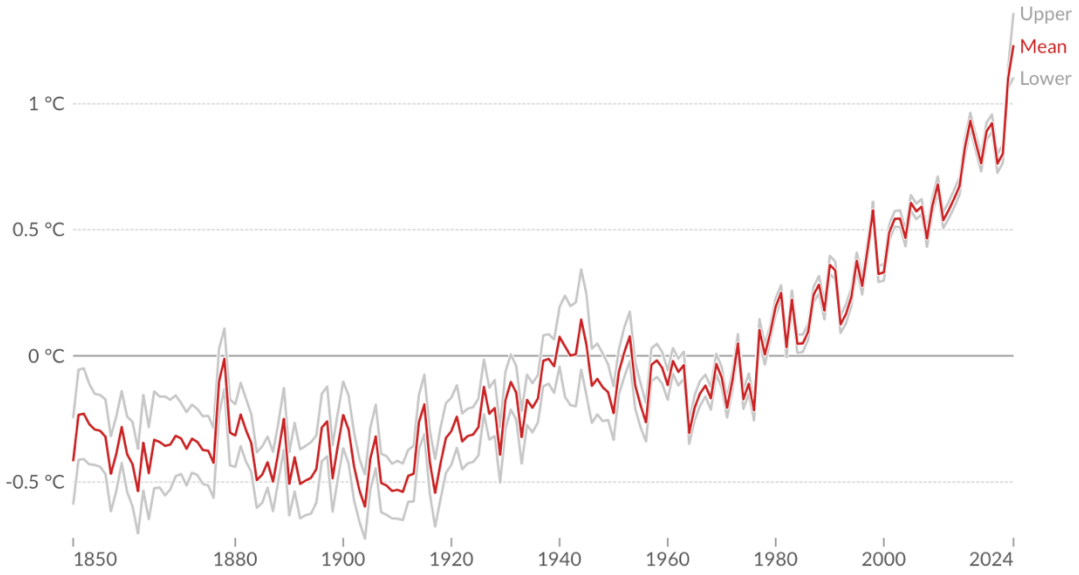

Fig. 2

Source: Our World in Data (Met Office Hadley Centre, 2024)

Precipitation patterns have also been dramatically altered, as well as the trend of the seasons, causing shifts in the distribution of rain, with regions either hit by unexpected periods of rainfall or drastic droughts. Another alarming consequence is the rise of sea levels, arising from the polar ice melting and the retreat of glaciers, with islands and coastal areas risking terrible inundation and at worst, the disappearance of the island itself, leaving entire communities without their land. Climate change is also responsible for the increasing frequency of extreme events, like wildfires, hurricanes, and widespread diseases, causing deaths, destruction, and severe economic damage. In the long run, climate change has already threatened the biodiversity of entire ecosystems: many species are risking extinction, as they are struggling to find strategies that allow them to adapt to changing conditions, with ecosystems being destroyed and degraded. Climate change will also be responsible for the increase in food prices and market volatility, due to a general output decrease reducing food access and exacerbating the already existing inequalities among and within different countries.

1.1. History of the Climate Change Regime

Concerns related to the relationship between human beings and their habitat and the impact of human life on the environment, have existed for as long as humans have inhabited the Earth, (as scientists have found proofs of human induced animal and plant extinction, that date back to 50 thousand years ago). Looking at the first forms of civilization, several examples can be found: the Indus civilization was already aware of the dangerous effects of pollution on human health, the Greeks had noticed how copper miners suffered from respiratory diseases due to acid contamination, as well as communities in India, China, and Peru who had studied the issue of soil erosion and were able to leverage it by using crop rotation and by building terraces. The earliest book related to human ecology was "*De aere, aquis et locis"* (Air, water and places), written by Hippocrates, who was already aware of the difficult relationship between humans and the environment. In the following centuries, especially between the 14th and 17th century, pollution was identified as one of the main causes responsible for the spread of epidemic illnesses all over the European continent, especially up to the period of the Industrial Revolution, when it was understood that uncontrolled and unregulated economic development was guilty of the destruction of natural resources and public health crisis. In the 18th century, modern environmental rights, as we know them today, were born. In the United States, thanks to philosophers like Giffor Pinchot, John Muir and Aldo Leopold, the concept of conservation, intended as the efficient use of resources, started to emerge, linked to the new concept of "land ethic" coined by Leopold, who claimed that human beings should identify themselves as inhabitants of nature instead of predators of it. At the same time, on the other side of the world, in Britain, Jeremy Benthy and Thomas Malthus were writing, respectively, about animal rights and human overpopulation leading the way to ecological disasters. (*Encyclopedia Britannica, 2024)*

However, knowledge related to global warming, one of the main visible effects of climate change, started to emerge 200 years ago, in 1824 precisely, when, scientist Baptiste Fourier, first labeled what is known as the greenhouse effect. He was interested in studying the system regulating the atmospheric temperature, as it prevented the thermal energy coming from the sun from escaping back into space, allowing the creation of perfect conditions favorable to the existence of life. Through his famous experiment, in which the Earth's atmosphere was compared to a box of glass, he understood that as the temperature of the interior of the box rose, the heat coming from the sun could not escape, creating a sufficiently warm environment. This represents an oversimplification of the greenhouse effect, but it proved to be essential in understanding climate change. Following his discoveries, scientists continued to examine the greenhouse gas effect, leading to the acknowledgment that specific gases, such as carbon dioxide, methane, and water vapor, are the

main factors responsible for the imprisonment of heat within the atmosphere, identifying human industrial activity as the main source of CO_2. In this context, it is important to mention the role of the Swedish scientist Svante Arrhenius, who, in 1896, had already forecasted that the constant growth of CO_2 emission would have eventually led to a severe and precarious increase in temperatures, with all the negative consequences related to it. Despite his warnings, his study was not given the importance it deserved, until half of the 20th century, when, firstly the scientific arena, followed by the political one, started to develop concerns about global warming.

The evolution of the climate change regime can be separated into five different periods: the primeval period, the period that goes from 1985 to 1988, in which climate change started to be inserted into policy agendas of states, a pre-negotiation phase from 1988 to 1990 and the last phase of agreements and implementations, that is still in place now.

In the initial phase, the issue of climate change remained mainly confined to the scientific sector: from the 1960s onwards, thanks to the so-called Keeling curve, which clearly showed the increase of CO_2 concentrations in the atmosphere, predictions of global warming acquired more reliance within the scientific community. This curve represents seasonal and annual variations of carbon dioxide concentrations, starting from the first measurement taken in 1958 at the Mauna Loa Observatory, in Hawaii. It is believed that this instrument has been providing the longest and most consecutive recording of CO_2 in the atmosphere (*Encyclopedia Britannica, 2024).*

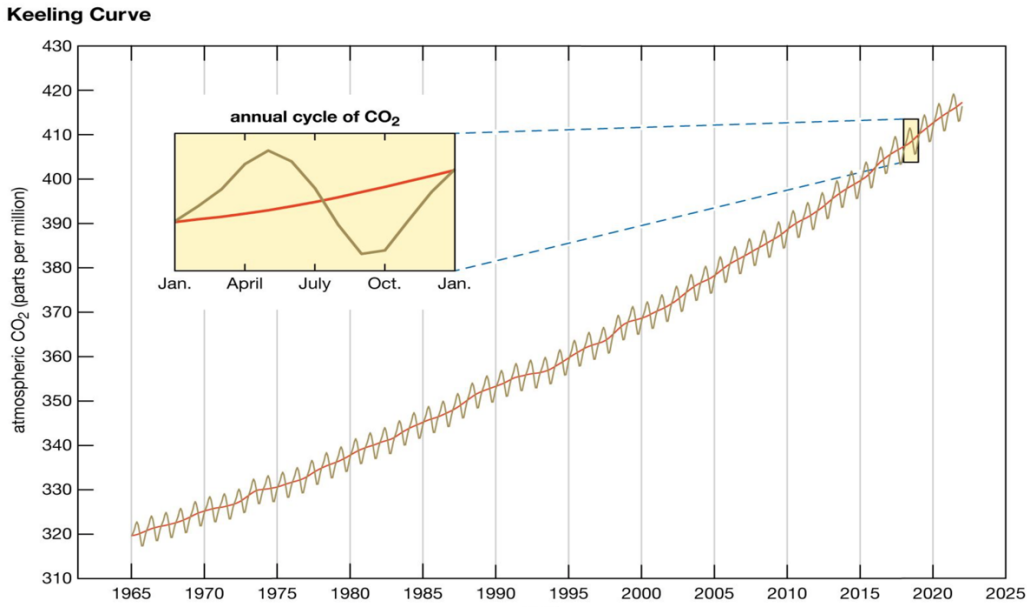

Fig. 3

Source: Encyclopedia Britannica

A U.S. National Academy of Sciences report unquestionably stated: "*There is no reason to doubt that climate change will result and no reason to believe that these changes will be negligible"*.

Constant warnings from the scientific community represented a pivotal stimulus for the growth of political interest on the matter, but three other factors proved to be essential: firstly, the role of a group of scientists, who, through meetings, conferences, and events, were able to transmit the critical issue of climate change to policymakers; secondly, the discovery of the Ozone hole and the subsequent demonstration that it was caused by human activities raised awareness on the matter and, thirdly, the summer of 1988 which was characterized by extremely high temperatures and droughts, especially in North America.

Because of all these factors mentioned above, 1988 turned out to be the turning point year, as climate change became common knowledge as an intergovernmental problem, which led to the beginning of the negotiation phase, in which, not only nongovernmental actors but also state governments, started to play a further active role. As a consequence, the Intergovernmental Panel on Climate Change (IPCC) was established, and, in 1990, it produced its first scientific report, which proposed limitations and targets on emissions of gases to maintain stable carbon dioxide levels in the atmosphere. States were divided and showed different attitudes towards the rules that were presented by the IPCC: The United States, Japan, and the Soviet Union were not in favor of them, supporting the idea that the goals set were too rigid and did not take into consideration domestic politics; on the other hand, European countries and other states such as Canada and New Zealand were more supportive of the implementation of specific targets. At the same time, developing countries, which had, until that time, been marginalized within that context, started to request a greater representation. They were able to move the negotiations from the IPCC to the UN General Assembly, where the urgency of financial assistance and technology transfer was recognized. Simultaneously, states like Brazil, China, and India, which were starting to develop economically, feared the violation of their sovereignty and firmly insisted on the responsibility of Northern countries for creating climate change, therefore, it was their duty to solve it.

Although it had become clear that climate change needed to be tackled with concrete actions, until that point, customary international law was the only one explicitly addressing atmospheric pollution. On that account, negotiations for the stipulation of a new treaty commenced, lasting for three years. In December 1990, the UN General Assembly instituted the Intergovernmental Negotiating Committee (INC) for a Framework Convention on Climate Change (FCCC). During the initial phase, difficulties in finding compromises were visible, as states were firm in their positions; however, in light of the fact that the convention had to be ready for the June 1992 United Nations Convention on Environment and Development (UNCED), held in Rio, governments started to put in place general obligations and agreed to set up an institutional structure for future developments. The establishment of targets and timetables, as well as the development of a financial mechanism, were the most divisive matters within the context of the INC, especially among developed and developing countries. However, the FCCC was able to find

compromises and be a starting point within the negotiation process. Conferences of the parties (COPs) started to be held regularly: especially COP-3, which was held in Kyoto, represented an important landmark. First and foremost, it restated the necessity of establishing "quantified emission limitation and reduction objectives" (QELROs); secondly, from this moment on, it was decided that there was no longer the need for consensus to make decisions, as majority voting proved to be sufficient, especially when there were minorities preventing progress. To solve the problem that was first mentioned, the Kyoto Mechanisms were adopted, consisting of mechanisms of flexibility, which included trade of emissions and plans for emission reduction in both developing and developed countries. However, the Kyoto Protocol entered into force only in February 2005, when more than 55% of countries had ratified the agreement, including the USA and Russia. From this moment, negotiations followed two linear paths: the Kyoto One, which had the objective of continuing the commitment to the Kyoto Protocol, and the "UNFCCC", which was more concerned with long-term developments.

In 2009, after the COP-15 in Copenhagen, a change in the approach to the international climate change regime can be observed: in fact, it was decided to launch a more hybrid system, which took into consideration both national targets and a top-down system that had to overview the whole regime. This new set-up led to the adoption of the Paris Agreement at COP-21 in Paris in 2015, which, at the time, represented a major success. The majority of states were in favor of submitting targets of INDCs (*Intended Nationally Determined Contributions)* at the national level, and a global mitigation target was instituted, as well as climate finance, loss, and damage. Two weeks after the beginning of negotiations, the first "Universal Climate Treaty", which established the need to limit temperatures "*well below 2°C above pre-industrial levels*", was adopted. Although the agreement is legally binding, however, it does not have strong enforcement mechanisms, rather has it a system of periodic reviews to evaluate progression, at the individual and collective levels. As already stated, this Agreement probably represents one of the most important achievements, even though two remarkable issues have weakened its efficacy: firstly, the withdrawal from the agreement of the second country most responsible for the emission of GHG, the USA, and, secondly, the constant disagreements among states for the implementation of specific guidelines to pursue the goal of carbon neutrality. To sum up, the Paris Agreement has set the right path that needs to be followed to have a global response to climate change, insisting on the importance of acting through cooperation, with the idea that sustainable development and the fight against climate change are linked to each other, as they both produce positive side-effects to each other. On one hand, addressing climate change is fundamental for the achievement of sustainable development; on the other hand, reaching sustainable development goals is a path to address climate change.

1.2. Definition and principle of sustainable development

The notion of sustainable development is a complex concept that embodies the need to address the intricate interdependence between economic growth, social equity, and environmental stability of people and communities while promoting social justice and equal access to opportunities as well as tackling the issue of climate change. In 1987, a report by the World Commission on Environment and Development, known also as the "Brutland Commission", issued the first widely accepted definition of sustainable development which defines it as "*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs".* This definition highlights the importance of balancing the current needs of both developing and developed countries while protecting the environment in the long term, for the future of the planet and of the people. This focus on the idea of intergenerational equity is what makes sustainable development policies different from traditional environmental policies.

In order to achieve sustainable development, three main dimensions need to be taken into analysis: economic development, social inclusion, and environmental protection. Within this context, economic development coincides with the idea of promoting economic growth through the efficient use of resources, innovation, and the creation of new opportunities that lead to the reduction of poverty and inequality. Secondly, social inclusion is meant as the equal possibility, for all individuals, regardless of gender, culture, and origin, to have access to indispensable services, such as healthcare and education. Lastly, environmental protection entails the protection of natural resources, the reduction of pollution, the importance of biodiversity, and the protection of ecosystems.

These three main targets started to be firstly discussed in 1992, with the adoption of Agenda 21, a global plan adopted by more than 178 Governments, which consisted of actions aimed at reducing the negative impacts caused to the environment. There were many subsequent Summits and Conferences, but the most important and recent, which is worth mentioning, is Agenda 2030 for Sustainable Development, adopted in 2015 at the UN Sustainable Development Summit. The agenda's core consists of the 17 Sustainable development goals (SDGs) that provide a framework for integrating the three interlinked dimensions of sustainable development: economic, social, and environmental. The key goals are the following: the eradication of all different forms of poverty, the achievement of food security and the promotion of sustainable agriculture, the promotion of well-being for all, equal access to education and learning opportunities, the achievement of gender equality and the reduction of the gender pay gap, the availability of water and sanitation for all,

the reduction of inequality within and among countries and the need to take urgent action to fight climate change and its impacts (*United Nations, Department of economic and social affairs).* The overall goal of achieving sustainable development is clear only when governments agree to integrate economic, environmental, and social concerns into all levels of the decision-making process, emphasizing a holistic approach. Every year, a "SDG Progress report" is produced to provide a general overview that analyses the progress that has been made at the regional and global level since 2015. According to the 2024 report, for what concerns the area of climate, GHG emissions are still rising and have hit records, despite a reduction of emissions in some developed countries. However, some positive aspects are visible: the reduction of global infant mortality, a decrease in HIV infections, and an increase in the number of people who have access to clean water and energy sources. Nonetheless, the essential elements required to achieve any of the goals mentioned are peace and stability; merged with the need to financially support developing countries by applying effective changes to the institutional framework that governs the flow of finance. Overall, the 2024 assessment unquestionably reports that the world is far from being close to fulfilling the 2023 goals of the Agenda; in fact, only 17% of the targets are expected to be reached by 2030, while almost 40% are either on a phase of regression or stabilization. In the context of climate change, the concept of sustainable development is strictly interlinked with the strategies of mitigation and adaptation, which will be explained in the following section.

1.3. Mitigation and adaptation as strategies to achieve sustainable development

The challenges and consequences of climate change urge immediate actions that need to be aligned with the goals of sustainable development. Traditional approaches were useful as they were able to specifically identify and quantify the effects that climate change would have on the different sectors in the long run, portraying trends and statistical data that would explain the different interactions between the ecosystems; however, they did not represent a plausible solution. Nevertheless, the UNFCCC has recently proposed two new paths of development: mitigation and adaptation, two strategies that are strictly linked to each other, as they represent two opposite sides of the same coin. On the one hand, mitigation refers to all the actions that aim to reduce climate change by limiting or preventing the emission of Greenhouse Gases, while, on the other hand, adaptation consists of a series of adjustments that try to alleviate and minimize

the already existing and future impacts of climate change. In the past, mitigation strategies were considered pivotal and the majority of scientific debates were devoted to them; however, in recent years, the IPCC started to put a major focus on the importance of adaptation, and, specifically in its Third Assessment Report, it has stated the urgency of inserting adaptation strategies within its priorities.

As stated before, mitigation is a more proactive strategy that specifically targets the root causes of climate change through human interventions. According to the UNFCC, each state member of the convention has to report its GHG emissions through national assessments and propose and formulate strategies for different mitigation scenarios. Usually, a mitigation scenario has the scope to project how GHG can be limited, by being able to compare how GHG emissions would be in the absence of policies that reduce them. The most common strategy is the one that aims to reduce fossil fuels through a transition to modern renewable energy sources, such as solar, wind, and hydropower energy, especially in the transport sector. This transition would not only reduce the quantities of GHG in the atmosphere, but it would also create new job opportunities generated from the new energy sectors. The reduction of pollution would have consequently positive consequences on the levels of clean air, favoring better health conditions and a better life quality. Other sectors, worth of being analyzed, are the building and industry sectors, which account for almost 30% of global GHG emissions. By improving efficiency in industries with technologies that use energy-efficient systems and improving buildings' thermal integrity, energy costs and emissions would be reduced. There are currently many governments that are favoring this transition by giving incentives to firm owners. Sustainable agriculture represents another key strategy in the pursuit of sustainable development: in particular, the use of natural fertilizers would decrease the emissions of N_2O gases, and crop rotation instead of intensive agriculture would improve agricultural productivity as well as preserve biodiversity. Other practices such as reforestation and protection of already existing forests would be fundamental in the reduction of the production of CO_2 in the atmosphere. In the last few years, significant progress has been made, however, mitigation strategies face remarkable barriers which are mainly economical, especially for developing countries, but also technical and political. Each country, according to its specific characteristics, should be able to identify and analyze these barriers and include mitigation strategies within national development projects.

A different approach is the one that started to give prominence to adaptation strategies that focus on already existing vulnerabilities exacerbated by climate change and try to “adapt” to the stimuli by presenting adjustments in ecological, social, and economic systems. This new strategy is worth of consideration for several reasons: firstly, despite already existing mitigation strategies, their effects will be visible in the long term, while consequences of adaptation actions occur almost

with immediate effects; secondly, adaption can be applied more at the local level and the effects are directly dependent on those actions.

Adaptation strategies can be of different types depending on the time of their application, the objective, and the rationale behind them. They can either be reactive or anticipatory; private or public depending on the entity that is responsible and lastly, planned or autonomous, the former happening after the decision to implement a specific policy and the latter referring to changes in a specific system that are independent from projects or policies.

Some concrete examples of adaptive strategies include the building of infrastructures that limit or avoid damages in case of extreme events such as floods and hurricanes, preventing loss of lives and disasters that may have economic impacts within already vulnerable communities. These kinds of investments might also have positive effects in the long term, contributing to achieving sustainable development as well.

2. Vulnerability of Africa and the importance of sustainable development in the African context

Climate change is affecting everyone, its consequences are manifest and they are having negative impacts that are no longer negligible. However, climate change is not having equal impacts on the whole planet, in fact, there are countries, communities, and sectors that, due to their specific vulnerabilities, are suffering the most from it. The most prominent example and the main focus of discussion of this thesis is Africa, which is the continent that accounts for only 10% of GHG emissions but is the one that is already experiencing the most severe damages, and it will continue to follow this path unless an urgent sustainable development pathway is undertaken. To a better understanding of the role that climate change plays in the context of sustainable development, it is worth clarifying the concept of vulnerability. According to the IPCC, vulnerability has been defined as "*the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change, including climate variability and extremes*". It is an "*a priori condition of a household or community that is determined by socio-economic and political factors*" (*WHO*). Usually, a country or community that is particularly vulnerable is characterized by a low capacity for adaptation, a limited set of choices, and a high degree of marginalization.

Within the African continent, there are differential vulnerabilities, which are strongly dependent on the characteristics of the societies exposed to it, but also on the uneven distribution of resources and the different natural peculiarities of the area. Africa is one of the most vulnerable areas due to the presence of several factors: it faces the problem of overpopulation concerning the current level of available resources and productivity, it is a land that is strongly dependent on sectors such as agriculture and fisheries, highly reliant on the variability of climate, and the level of wealth in unevenly distributed, granting access to resources only to a small sector of the population. Socio and cultural aspects, characterized by weak and corrupted governmental structures merged with the unavailability of financial and technical resources represent other causes that hinder strategies of adaptation. Climate change represents therefore a considerable threat and probably one of the major challenges that the African Union needs to face. Its consequences are having impacts on several different sectors, in particular, environmental, economic and social impacts.

2.1. Environmental impact of climate change

Climate change is having extremely severe impacts on the African environment, with a variety of regional areas being affected by an alteration of precipitation patterns, unpredictable rising or decreasing temperatures, and the intensification of the presence of significantly extreme events. According to *"The State of the Climate in Africa"* report by the World Meteorological Organization, the two key factors that need to be firstly analyzed to portray the current climate situation in Africa are temperature and precipitation patterns, which have impacted the conditions of entire African communities. It has been estimated that, in the past two decades, the global mean surface temperature has been constantly increasing, reaching, in 2019, a 1.1°C increase above the pre-industrial level, with the last 5 years being the warmest years that have ever been registered. The African continent is nowhere far from this, in fact, temperatures have been constantly rising, at a rate that is even faster than the global average. To cite some numbers, until 1981, there was an increase rate of 0.12 °C per decade, while, from 1981 up to now, temperature rose at a rate of 0.31 °C per decade. (*IPCC, 2022*) 2010, 2016, and 2019 still represent three of the warmest years that have ever been registered (*National Center for Environmental Information*). Scientific trends and projections clearly state that, due to temperature increase, the frequency and intensity of heatwaves, have also escalated, particularly in Northern, Southern, and Eastern parts of Africa. Studies suggest that, throughout the whole 21st century, this particular phenomenon will take place with even more frequency and with a longer duration, not only in Africa but also worldwide. The temperature rise is correlated with an important variation of precipitation patterns, characterized by periods of droughts and rainfalls in seasons different from what is normally expected. For example, in 2015 and 2016, Kenya, Somalia, and Ethiopia were hit by extreme droughts which had devastating impacts on more than 15 million people, who were affected by food shortages and water scarcity. If the situation persists, studies believe that a process of desertification will occur, with already existing deserts increasing their size and expanding. The tropics have faced incredible expansion in the last 40 years, affecting the quality of life of millions of people, whose land productivity has diminished. On the contrary, some areas have experienced periods of rainy seasons that were above common expectations, leading to floodings that hit specifically the Southern part of Africa. These events led to the paradox that some regions had to go through periods of droughts and terrible rainfalls in short periods, with particular implications in the agricultural sector and the management of water resources. In West Africa, the rainy season has become very unpredictable, leading to floods in countries like Nigeria, Ghana, and Sierra Leone. The consequences are often worsened by a poor capacity of urban planning and adaptability. The

flooding not only causes casualties, but it creates permanent damage to infrastructure and lands which are already in poor conditions.

Although they occur with less frequency compared to other extreme events, tropical cyclones are affecting the African continent with devastating consequences. Cyclones are usually formed in the Indian Ocean when the water temperature is particularly high, at about 27°C, and they often consist of torrential rains and strong winds that usually hit the Southern Eastern part of Africa, in particular, Mozambique, Zimbabwe, and Madagascar. A representative case is that of cyclone Idai, one of the worst tropical cyclones that, in 2019, impacted Malawi, Mozambique, and Zimbabwe. It had disastrous impacts on more than 100.000 homes and it caused the death of about 1200 people while leaving in terrible conditions those who had survived *(State of the climate*, *2020*). Many cases of cholera and diarrheal were also registered.

The anthropogenic nature of climate change also poses significant threats to the natural environment: according to the UNFCCC climate change represents one of the major threats to biodiversity and ecosystems of the African continent. It is therefore fundamental to understand the interconnections between biodiversity, ecosystems, and climate change. Africa is particularly known for its rich abundance of biodiversity: in fact, it is home to one-fifth of mammals living on earth, and one-fourth of the world's bird species, as well as hosting the most diverse ecosystems that can be present in one single continent, such as Savannahs, tropical forests, wetlands, coral reefs, and mountains. Due to rapid changes in temperature and variations in precipitation patterns, many species were forced to migrate to geographic ranges that were more suitable for them, leading to changes in ecological assets and alteration of species distribution, which created competition among species due to the presence of limited resources. According to a study, it was found that plants and animals were migrating to higher elevations like in the case of the Ethiopian Highlands, as well as moving to higher latitudes in search of more favorable conditions. One emblematic example of a species that is particularly vulnerable to climate change is the Ethiopian wolf (*Canis simensis),* an endangered species that is suffering from low availability of water resources and unfavorable hunting grounds, therefore risking its extinction. A study published in "*Nature"* suggests that more than a million species will have a high probability of facing extinction in the next 50 years (*Nature, 2004*).

The increasing temperature of the seas is also affecting Africa's marine ecosystems, in particular reefs and corals, which supply a home to a variety of species, such as fish and mollusks, with consequences that have a reflection on communities living there. Africa's forests are also going through the same pattern: deforestation, increasing temperatures, and changes in precipitation are provoking degradation. For example, the Congo basin, known for hosting 10000 animal species and several tree species, as well as being an important resource for carbon storage, is at significant risk.

As already stated, biodiversity is not only fundamental for animals and plants, but it is also essential for the fact that the richness of ecosystems grants benefits to entire African communities who rely entirely on the services that allow them to meet human needs and sustain livelihoods.
At least 80% of the African economy is dependent on the variety of biological resources granted by the ecosystem service, so that, any decline in biodiversity can have severe impacts on human society, human health, and economic development (Travis 2003), leading to an increase in vulnerability.

2.2. Economic impact of climate change

In the last decades, the majority of African countries have registered an increase of growth of about 5%, due to factors such as increased macro-economic output, better economic governance, improvements in living conditions, and decreasing levels of poverty, which have led to the general concept of development (*Addison, 2017*). Future projections state that many African countries will have the capacity and the potential to achieve development, shifting from being low-income countries to becoming middle-income ones by 2050. An example is given by Ghana and Ethiopia, which have respectively recorded economic growth of 7.3% and 10.5% in 2013 (*World Bank data)*. Data from the World Bank state that a fundamental reduction in the distribution of poverty has occurred, as between 1996 and 2010, the percentage of Africans living in poverty conditions went from 58% to almost 48%. However, in parallel to positive signs of development, climate change impacts on the continent have also increased, threatening the already existing vulnerabilities, with the risk of terrible consequences on economic stability, growth, sustainable development, and people's livelihood. Africa's vulnerability is highly strengthened by the fact that most economies depend on natural resources, the majority of which are extremely sensitive to climate. The link between climate and development is rather complex, as well as the measurement and quantification of the economic consequences related to climate, due to the lack of appropriate facilities and resources to analyze data. Globally speaking, some evidence suggests that at the world level, the situation might remain stable for what concerns agricultural production. This is due to the fact that climate change will eventually create some sort of compensation, meaning that the rise in temperatures will extend the plating seasons at higher latitudes, increasing crop productivity also in areas that were previously affected by the risk of frost in colder seasons. On the other hand, regions which are located at lower latitudes might face the opposite problem:

an ulterior increase in temperatures might drastically reduce crop production, due to the inability of species to adapt to rising temperatures. However, by putting a focus only on the African region, climate change is having mostly negative impacts and it is currently exacerbating the already precarious economic situation.

African economies display different macroeconomic structures depending on the area of the continent they are located, therefore, climate change has different impacts on Gross Domestic Product growth. Generally speaking, the agricultural sector represents almost 25% of the whole continent's GDP, employs over 60% of Africans, and is responsible for producing 50% of total export value. It is also the sector mostly affected by climate change because its capacity to produce services relies on precipitation, rainfalls, and variations in temperatures. To cite some numbers, 95% of Africa's agriculture is entirely dependent on precipitations (*Journal of Sustainable Development, 2016*) with an expected decrease in agricultural productivity of up to 50%. Production of maize and beans will decrease respectively by 20% and by 50%. However, as previously mentioned, depending on the geographical location and other factors, the impacts are different even within the same African continent. In particular, four main areas of analysis can be identified: the Sahel region, Eastern Africa, Western Africa, and Southern Africa.

The Sahel region, which includes nine countries proximate to the Sahara Desert and the Equator, is the region with the highest degree of vulnerability: it is already subject to high temperatures, overpopulation, and an economy that is mostly based on agriculture. Data from previous studies (*Regional Environmental Change, 2010*) state that more than half of the population works in the agricultural sector, which accounts for 50% of the Gross Domestic Product of the region. An ulterior negative pressure on the economy is given by rapid population growth which is confronted with a constant decrease in arable land available and a strong deprivation of soil, reducing its fertility and its production capacity. This reduction in agricultural productivity consequently affects the incomes of farmers, who already find themselves in situations of poverty and hunger, with prices increasing as well as inflationary rates. Trends estimate that the decrease in precipitation, which started in the 1960s, is currently continuing its path, with critical impacts on the availability of water and the living conditions of inhabitants and farmers.

Moving to the Eastern region, which includes countries like Somalia, Kenya, and Ethiopia, the situation is far from being more positive. As in the case of the Sahel region, agriculture plays an important role, with shares in GDP ranging from 22% in Kenya to 35% in Ethiopia, with 65% of the population employed in the agricultural sector. As stated by the IPCC in 2001, economies in this region, as well as in the majority of the African continent, rely on rain-fed agriculture, therefore impacting food security. Studies have analyzed that the length of the rainy season has been altered, in particular in Uganda, where rainfalls become rarer and unpredictable, with negative consequences on the living conditions of pastors and farmers. The strong inverse

relationship between climate change and GDP growth is visible and statistical data confirm it: for example, after the period of extreme droughts of 1983 that characterized the Eastern region, GDP and agricultural GDP declined respectively by 6.3% and 12.5% (*Keys to climate action, 2023*), causing the spread of a terrible famine, the initiating factor of a civil revolution that lead to the end of the regime portrayed by the emperor Haile Selassie, highlighting the fact that climate change can also have political consequences indirectly. The region mentioned relies heavily on the exportation of primary goods, such as coffee and tea, which, if produced in lesser quantity, negatively affect revenues from exportation, trade, and therefore the overall macro economy. The rising temperature has also impacted the fishing sector: migratory routes of fish have been altered, changing their availability on the market and therefore limiting food access to populations that relied on it. In case of the persistence of this kind of scenario, the already existing inequalities are expected to widen, with a gap between low-income countries and high-income countries in constant growth.

Climate change effects on Western Africa mostly follow the same path as the other African regions. Countries like Burkina Faso, Gambia, Guinea Bissau, Niger, Togo, and Senegal have all been individually analyzed in a study conducted by Jalloh et al., in 2013, where some important concepts were brought to light. Firstly, with no difference from other regions, 60% of the working population is dedicated to agriculture, which, by itself, accounts for 35% of the GDP of the region. In line with general trends, temperatures have risen and will continue to do so, and the probability of the occurrence of extreme weather events has also increased. By 2050, crop yield is expected to lose between 5% and 25%, in parallel to a population that is growing at fast rates. To cite an example, in Ghana, 96% of agriculture depends on rainfall, with farmers living on subsistence, therefore without possessing the necessary means to invest in adaptation strategies.

Last, but not least, Southern African countries, such as South Africa, Lesotho, Zimbabwe, Tanzania, and Namibia, are also becoming drier and hotter, with shorter rainy seasons, and more frequent droughts, that have impacted the already precarious situation of water scarcity. The situation in Namibia is concerning: the economy depends heavily on the agricultural and fishery sectors, which employ more than 50% of the Namibian labor force. Temperatures are expected to rise at a rate that is three times greater than the global rate, with an increase of about 0.2 °C for every ten years. Higher temperatures are deteriorating the arable land, with a process of desertification starting and impacting the land used for crop production. Due to a low adaptive capacity, the farming sector is expected to suffer from economic losses that vary between 40% and 80%.

Another sector that plays a relevant role within the African economies is tourism, a sector that is in constant growth and is receiving funds from governments, as it has been identified as part of a growth strategy that contributes to development. Tourism not only represents a source of

development in the third sector but is also a catalyst for industries and secondary employment, as tourists induce a redistribution of money within the country and can unlock new economic opportunities. However, this sector is not immune to climate change, it is in fact affecting the tourism industry in several ways. Tourism in national parks and wildlife is probably the most diffuse, as Africa hosts the world's biggest national parks where millions of animal and plant species live. Due to changes in rainfall and temperatures, habitats have also been altered, causing the migration of species that were no longer visible in parks, creating negative revenues for the communities. Coastal tourism has also been affected, especially in countries like Madagascar, Mauritius, Kenya and Tanzania, where sea level rise and the disappearance of beaches, cause a major loss of revenues, as tourists are no longer attracted.

This paragraph has clearly highlighted the general negative economic impact in Africa, with some areas being affected more than others. For many countries, protecting the tourist and agricultural sectors with new imminent mitigation and adaptation strategies is crucial to maintain stability and achieve sustainable development.

2.3. Social impacts of Climate Change

As already stated, climate change is posing threats to human health all over the world, however, the country that will bear the greatest cost is Africa, where the political, social, and economic conditions are already precarious.

The Intergovernmental Panel on Climate Change (*IPCC*) and the World Health Organization (*WHO*) have stated that the African region is vulnerable to climate-sensitive diseases, such as malaria, pneumonia, and water-borne infections, aggravated by existing malnutrition problems.

Data from the IPCC report that more than ten million Africans are already suffering from the negative consequences of climate change, in the form of heat stress, extreme weather conditions, natural disasters, and an increasing spread of infectious diseases. However, even given the gravity of the situation, not many researchers and studies have been conducted regarding risk management and prevention.

The last report of the IPCC related to Africa contains a section specifically focused on this matter. Generally speaking, the health sector is strongly affected by a series of interconnected factors called "the social determinants of health" which are defined as "*the conditions in which people are born, grow, live, work and age",* merged with already existing socio and economic circumstances as well as environmental and geographical factors. Clear evidence supports the

thesis that impacts on health due to climate change are particularly severe in Africa, where the already present and severe inequalities have widened. The categories of people that are more affected are children, women and pregnant women, elderly, and individuals already affected by illnesses, especially those who are part of rural communities, struggling to have access to health care. Consequences are already visible, however, with a constant increase in global warming and without immediate strategies for adaptation and mitigation, the burden on health systems will only increase.

The rise in temperatures and the variation of rainfall patterns are changing and mostly widening the territories in which diseases like malaria, dengue fever, diarrheal, HIV, and other similar diseases can be transmitted. Malaria, for example, is transmitted through mosquitos, whose habitat is characterized by warm and wet conditions, which means that malaria is now diffuse in territories that previously did not possess the necessary requirements for mosquitos to survive.

An area of around 11 million km^2 that comprises sub-Saharan Africa and some coastal areas in Western and Eastern Africa is currently suitable for the transmission of the disease. In East Africa, for example, several cases of malaria have been registered, due to increases in rainfall and extreme weather events, with negative impacts on the health system of the region. The conduction of studies regarding possible future projections of the spread of the malaria disease is quite challenging, due to the presence of some factors such as population growth and trends of development that are difficult to predict with certainty. However, some available models have predicted that by 2030, the presence of malaria hotspots is expected to rise if the average increase in temperatures is between 2.2 °C and 3.7 °C, with about 60 million people at risk of contracting the disease. (*IPCC AR6*). The countries that are expected to witness the worst impacts by 2023 are Angola, Tanzania, and Uganda. In parallel, some African countries will be witnessing a decrease in the spread of malaria by 2030, due to unfavorable changing conditions. These countries are Western African countries such as Burkina Faso, Cameroon, Nigeria, Ghana, and Ivory Coast.

The increasing number of floodings has also caused an increase in waterborne illnesses such as cholera and diarrheal, with many sources of drinkable water being polluted. Globally speaking, diarrheal disease is the third cause of death in children under 5 years of age and it is responsible for the death of about 450 thousand children every year. Africa accounts for the highest number of deaths due to diarrheal, often caused by contaminated food or water, terrible hygiene conditions, and problems of malnutrition. In the Eastern and Southern parts of Africa, due to increasing numbers of cyclones, cases of cholera have also increased. Future predictions state that ulterior decreases in the availability of water will worsen the situation, with an increase of 25.000 deaths of children caused by the spread of diarrheal.

According to the United Nations Aids Programme, levels of HIV infections have steadily decreased not only worldwide, but also in Africa; nevertheless, more than a million people still contract HIV each year in the African region. However, in this particular scenario, climate change is not directly responsible for the spread of the disease: in fact, the transmission of the infection is due to increased cases of transactional sex, caused by high levels of poverty. HIV-infected people already possess a fragile immune system which might be worsened by nutritional deficits and problems of malnutrition, therefore heightening the probability of death and the ulterior burden on the health sector.

Higher temperatures have also direct consequences on mortality records: recent data report that 43.8% of mortality (*IPCC AR5*) due to heat registered in South Africa was due to the anthropogenic nature of climate change. Projections affirm that Africa is the continent with the highest percentage of predicted mortality due to global warming, with a range of about 150 to 200 days exceeding lethal heat conditions in the scenario of an increase of 4°C. Temperature heat stress is expected to have more severe consequences in urban areas compared to rural ones, due to the presence of buildings such as slums and poor settlements fabricated with unappropriated materials, that do not prevent outside heat from remaining confined outside. Urban workers who work daily in the cities are the ones mostly exposed to urban heat, however, women, children, and imprisoned people are also at risk.

As stated previously, health-related diseases are exacerbated by already existing problems of malnutrition and food insecurity: more than 250 millions of Africans do not have sufficient food necessary for subsistence and expectations are that by 2030, 433 million Africans will be in the same situation (*IPCC AR5*).

Climate change is also one of the main drivers responsible for the forced displacement of communities. In 2020, more than 75% of new displacements were due to natural disasters induced by climate change, with a population of 30 million affected (Answan Forum). Estimates report that, by 2050, 216 million people will be forced to emigrate, most of which are in sub-Saharan Africa. The existing competition over natural resources that causes violence and instability, is further worsened by climate change, as it puts additional pressure on widespread poverty and on the capacity of governments and communities to find efficient solutions to adapt to climate change. In Somalia and Ethiopia, for example, periods of protracted droughts have induced displacements of entire rural communities, forcing them to migrate to refugee camps where living conditions are unsustainable.

To cite some numbers, 95% of African displacements were set off by internal civil conflicts in countries classified as severely exposed to climate change (*Global Report on Internal Displacement, 2021*), and 90% of displacements caused by disasters were due to floods, extreme rainfalls, and droughts. Entire communities are witnessing the terrible consequences of climate

change, however, some specific categories are bearing the greatest burden. Gender represents a discriminatory factor: women and young girls are the ones with the greatest vulnerabilities, as they often do not possess the economic resources needed to escape, with a high possibility of being exposed to human trafficking and gender-based violence.

It is undeniable that the social impacts of climate change are far-reaching, however, the unavailability of research and reliable data on climate displacement is preventing governments and international organizations from properly intervening and addressing the challenge. It is nevertheless worth noticing that, according to The Global Compact on Refugees, climate change is not to be identified as the main source responsible for the refugee crises, but it is, among other factors, contributing to the problem.

2.4. Case study of South Africa: impact of climate change on agricultural crops

This last section of the chapter will be focused on analyzing the specific case of South Africa, based on a study conducted by the Development Research Centre of the University of Cape Town. It is important to clarify that the majority of studies that have been conducted to calculate the economic and social consequences of climate change have been based on a division between market and non-market impacts, as shown in the following table.

Table 1. Typical classification of the economic impacts of climate change

Market impacts	Primary sector impacts	Agriculture
		Forestry
		Fisheries
	Other sector impacts	Water supply
		Energy demand
		Leisure activity
		Insurance
		Construction
		Transport
		Energy Supply
	Property loss	Dryland loss
		Coastal protection
		Urban infrastructure
	Damage from extreme events	Hurricanes, droughts, storms, floods, etc
Non-market impacts	Ecosystem damage	Wetland loss
		Forest loss
		Species loss
		Other ecosystem loss
	Human impacts	Human life
		Air & water pollution
		Migration
		Morbidity, physical comfort
		Political stability
		Human hardship
	Damage from extreme events	Hurricanes, droughts, storms, floods, etc

Fig. 4

Source: IPCC WGIII (1995)

Market impacts directly affect the GDP of the country in question, as they are related mostly to the primary sector; on the other hand, non-market impacts are more concerned with environmental aspects, as well as impacts on human health. However, both damages are strongly interlinked and they are all affecting our planet.

The sector that will be deeply analyzed is the one regarding the economic impact of climate change on agricultural crops and the production capacity of rangeland. Although the agricultural share of GDP in South Africa is relatively low compared to other African countries, as it accounts only for 2.6% of GDP (World *Bank, 2023),* it still plays a crucial role in providing income for millions of people, especially in rural areas.

South Africa is constituted of around 122.3 million hectares of land, out of which, 16.7 million of potentially cultivable land (13.7%), 90 million hectares of land for pasture (68.6%), and the remaining 17.7% is used for other scopes such as forests and conservation (*Economic impacts of*

climate change in South Africa). In total, the agricultural production, in relation to the degree of contribution to the GDP, is divided as shown in the following pie chart.

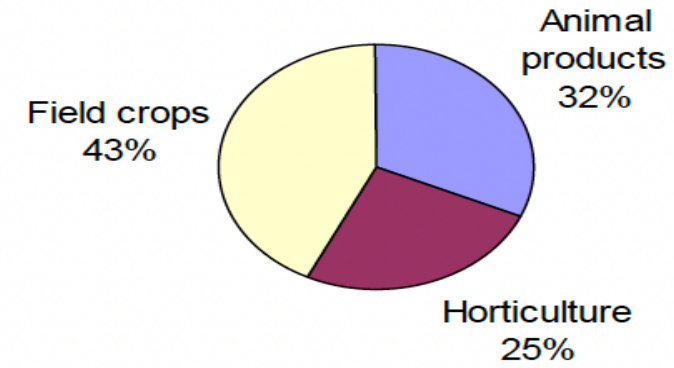

Fig. 5

Source: Economic impacts of climate change in South Africa

If we take into account only field crops, the division is as follows: 36% is used for the production of maize, 20% for sugar cane, 11% for jay, 10% for wheat, 10% for sunflowers, and the remaining share for other types of products (*National Development Agency).*

In 2021/21 South Africa accounted for the production of about 14 million tons of maize, the largest producer of maize in Africa and the ninth in the world (*Data from the Department of Agriculture).* According to the study, a large proportion of maize could be no longer produced due to climate change. This study does not take into consideration the so-called CO_2 fertilization effect, according to which, if there are increased levels of CO_2, plants can become more productive, as the rates of assimilation of carbon dioxide would increase. This scenario is not considered as the effects have not been precisely quantified nor confirmed. Maize is cultivated mainly in two areas: a small one in the western part of the country, but the largest amount is grown in the Eastern part, mainly in the regions of Mpumalanga (23%) and Free State (43%),(*Department of Agriculture).* In the presence of a decrease in rainfall, as well as water availability in the soil, the western part is expected to become unsuited for cultivation. To calculate the value of crop production and therefore the economic cost, the concept of gross margin is introduced. It is defined as the subtraction between Gross Production Value and variable costs such as fertilizers, labor of workers, machinery, etc. When the gross margin is multiplied by the maize crop production lost, the economic value of climate change impacts is obtained. Overall, calculated in current Rands, the South African currency, the value from the loss of maize production is of about 681 million Rands.

A specific study has been conducted only for maize production; therefore, other data have not the same degree of certainty. For example, wheat production in 2021 was approximately of about 2.3

million metric tons, with a gross value of 6 million Rands. By 2050, losses due to damages from climate change would amount up to a range between 60 million Rands to 120 million Rands.

3. Opportunities for sustainable development

Climate change is a worldwide process that is currently negatively impacting entire ecosystems, economies, and communities around the world. As many reports of the IPCC have demonstrated, climate change is starting to be considered one of the major present and future challenges, with its negative costs affecting economic growth, health, living conditions, and hunger, as well as presenting substantial risks for migrants and refugees. As already stated, the worst consequences are expected to be witnessed in the geographical areas with the highest distribution of lowest incomes, which, not surprisingly, also coincide with the vast majority of African countries.

Within the challenges that climate change poses also lies an unprecedented opportunity to initiate a path that aims at the achievement of sustainable development, that is not only concerned with present threats but also tries to set up the pillars needed for a process of long-term prosperity, social equality, and economic growth. In this context, Africa and the rest of developing countries should be placed at the center of this challenge, for several different reasons.

First of all, a moral imperative hinges on us: there is a need to address the necessities of the most vulnerable countries, which are the ones experiencing the worst consequences, albeit contributing less to the problem. Because of reasons that have a historical and geographical nature, people living in proximity to the tropics are facing the most severe consequences. Moreover, a strategic reason is also important: developing countries, by 2040, will be responsible for the emission of almost the majority of greenhouse gases. It is therefore fundamental for emerging countries to align to the goals indicated in the Paris Agreement, as well as Agenda 2030 and Agenda 2063. Despite differences among emerging countries and also within African countries in terms of food, education, gender inequality, access to health, and climate variability, what emerges is the concept of climate justice that needs to become the main driver.

The notion of Sustainable Development takes a central role in Africa's reaction to the climate crisis: the continent needs to embrace solutions that aim at the promotion of environmental sustainability while pushing for economic growth and improvement of living conditions. The issue of climate change can therefore be identified as an opportunity for development rather than an obstacle: it must be used as a catalyst for a path towards sustainable development.

This chapter's goal is to investigate Africa's response to climate change, having the ability to come up with solutions that will drive the economic and social development of the continent. It will focus on the numerous advantages that renewable energies present, highlighting the potentialities of solar, wind, and geothermal resources. The function of smart agriculture and

green farming will also be taken into analysis, looking at how, by innovating in these sectors, food security could be slowly achieved. Instead of being a mere victim of climate change, Africa needs to be able to portray itself as a world leader that calls for sustainable development, climate change mitigation and adaptation, economic growth, and innovation. In order to do so, Africa has committed its intent to align itself with the United Nations Sustainable Development Goals and placed full commitment to the African Union's Agenda 2063.

3.1. Agenda 2063

During the 2013 African Union Summit, Agenda 2063 - "The Africa We Want"- was adopted. This agenda represents the first attempt by the African Union to actually present a strategic framework that aims at the transformation of the continent through sustainable development and economic growth. African Heads of State and Governments stated their full commitment to the achievement of this goal. It is a guide for policymakers and citizens for individual and collective actions that have a vision of "An integrated, prosperous and peaceful Africa; an Africa driven and managed by its own citizens; and representing a dynamic force in the international arena" (*First Continental Report on Agenda 2063, 2020*). Another important Agenda, that as well represents an urgent request for action, is the Sustainable Development Goals Agenda, adopted by the UN in 2015. As mentioned in the first chapter, the Agenda put in place 17 SDGs that are constantly being monitored by UN member states. Many useful linkages exist between the African Agenda and the UN Agenda, such as the aim of ending poverty and inequality while fostering improvements in health and education. However, many critics believe that the SDGs agenda often mirrors Global North's values and ideas, with policymakers that tend to concentrate on development without having a clear notion of the structural and local causes that hinder development, especially in developing countries. It is important to have a universal agenda that sets the general framework within which development needs to be achieved, yet, local needs have to be acknowledged and integrated within policies.

The 2063 Agenda was instituted firstly by the African Union, with the cooperation of several stakeholders such as Institutions of Research, Think tanks, civil society organizations, and the Forum of former African heads of state. This vision of the African continent is strongly supported by Pan-Africanism, a philosophical framework that believes in Africa's transformation through unity and cooperation among member states. In order to achieve "The Africa We Want", a long-

term 50-year road map was developed, envisioned to be updated and monitored every ten years with a Ten-Years implementation plan. Within the Agenda, the goals are fixed but "the priority areas and their associated targets can change over the various ten-year plan cycles". (World Development Sustainability, 2020). A specific structure to monitor the progress made is composed of The African Union Commission, The African Union Development Agency, the Africa Peer Review Mechanism, and the Sustainable Development Goals Centre for Africa. Differently from the structure of the Sustainable Development Goals agenda, in which each of the 17 goals identified has a specific number of targets attached; the 2063 Agenda has a different structure. The format is composed of 7 Aspirations, 20 goals, and some priority areas that can be modified by each country according to its specific needs and areas of development.

Aspiration 1 focuses on a social and economic transformation of the continent, through inclusive growth and sustainable development. The goals associated consist of improvements in the standard of living, better access to health care and education, especially for women, industrialization, and an increase in agricultural productivity, as well as management of biodiversity and exploitation of the blue economy. Aspiration 2 is more concentrated on the idea of Pan-Africanism, with the idea of establishing a united continent, politically and economically independent, free of any legacy of colonialism, built on self-determination. Aspiration 3 is instead based on the necessity of building a continent founded on democracy and on the principle of good governance, with particular attention to human rights and equal access to fair justice. Aspiration 4, instead, gives priority to security and peace, with a first step cantered on the resolution of already existing conflicts and then focused on prevention mechanisms that foster peace and reconciliation. Aspiration 5 emphasizes the cultural identity of Africa, its values, and its history, with particular attention on the specific regional heritage of each country or area. On the other hand, Aspiration 6 regards the active involvement of the African people, especially youth and women, in the decision-making process. Particular attention needs to be given to the elimination of any form of discrimination, granting gender equality in any sphere, whether it's economic, political, or social. Finally, Aspiration 7, takes into analyses the importance of presenting Africa as an influential world player within the system of international institutions, strengthening its political and economic role. (*Agenda 2063, 2013*)

Every ten years, an assessment that monitors and coordinates the performance of the African continent, is produced. The first one was drafted last year, in 2023, and it contains a first analysis of the assessment both at the regional and continental levels. For what concerns the 2063 Agenda Aspirations, the continent experienced rather good progress, with a total score of 32%. The aspirations that registered a better performance were Aspiration 4, 2, and 6, with relative scores of 48%, 44%, and 38%. (*First continental report of Agenda 2063, 2023*). Africa's performance in relation to "*A peaceful and secure Africa*" was explained by the establishment of mechanisms and

peace councils that were particularly efficient in the achievement of their goal. A strong performance was also given in the attainment of the African Continental Free Trade Area. Nevertheless, weak performances were also registered in the rest of the 4 Aspirations, in particular, the continent performed rather negatively in the pursuit of good governance and democracy, mainly because of corruption, and low degrees of accountability for the governments and institutions. The regions that witnessed a better overall performance were Eastern and Western Africa, with East Africa achieving the best performances in the majority of the seven Aspirations proposed.

A specific mention worth noticing is the ratification of the majority of African states to the African Continental Free Trade Area, achieving 92% of the targets that were set for 2019.

Progress has been achieved in specific areas, while others are rather distant from the goals proposed and necessitate more effective effort, both at regional and continental levels.

3.2. Renewable energies

Aspiration 1 of Agenda 2063 specifically calls for the need to build *"A prosperous Africa based on growth and sustainable development" (Agenda 2063, 2013),* highlighting the importance of developing a new system based on the efficient and responsible use of natural resources, through a process that leapfrogs traditional fossil fuels resource and operates a green transition towards renewable energies, with the potentiality of becoming a world leader in the sector.

Africa is a continent with plentiful renewable energy resources, many of which remain largely untapped. With extensive sunlight, powerful winds, and geothermal energy, the continent would have renewable power potential that is way larger than the current one and it would have the capacity to satisfy the power consumption of the whole continent in the next century. Nonetheless, various difficulties limit its ability to harness this potential, mainly of an economic nature. Currently, almost 600 million people lack access to electricity, the majority of which are situated in Sub-Saharan Africa (*ISPI, 2021).* The key renewable energy sources in Africa are the following:

Solar Power: Africa, also known as "*The Sun Continent"* receives some of the most intense sunlight globally, which would provide a consistent and reliable source of energy. Solar photovoltaic (PV) technology is rapidly expanding across the continent, providing electricity to both urban and rural areas. According to the "*World Sunshine Map*", Africa receives many more

hours of bright sunshine than any other continent of the earth. Therefore, solar power gives to Africa a distinct opportunity to provide affordable, dependable, and sustainable electricity to a large part of its population, especially in rural and remote regions where access to the grid is still scarce. In addition, adopting solar energy can help reduce the continent's dependence on fossil fuels, which currently account for 79% of its electricity production, while also facing issues related to greenhouse gas emissions and climate change. This type of power can be decentralized because solar panels can be set up in various locations, including remote areas, providing electricity to communities that are not linked to the grid. Obviously, many economic benefits can be identified, such as creating new jobs, stimulating economic growth, and reducing dependence on imported fossil fuels. However, the development of new solar power infrastructures can represent a challenge for some regions of Africa, as it requires a substantial amount of capital, representing a barrier for many African countries. Many PV projects that have been developed until now, have shown benefits mainly to people with high levels of income, leaving the majority of Sub-Saharan Africa without renewable energy infrastructure.

Wind Power: Coastal regions and mountainous areas offer excellent wind resources. For example, in 2020, the continent's wind resources were estimated to be sufficient to meet the continent's energy demand 250 times over. (*ISPI, 2021).* Several African regions, particularly along the northern, southern, and eastern coastlines, benefit from strong wind currents, making them perfect for capturing wind energy. However, the wind potential in Africa remains largely unused despite the continent's vast natural resources, mainly due to several logistical, economic, and geopolitical barriers that have slowed progress in exploiting this potential. Nevertheless, in recent years, there has been incremental progress in wind energy development in Africa, with several countries launching wind farm projects.

An example is Kenya with The Lake Turkana Wind Power Project which represents one of the largest wind farms in Africa, providing a significant portion of Kenya's electricity supply. Its success has increased the country's renewable energy ambitions. South Africa has also made significant progress with its Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), resulting in various operational wind farms, particularly in the Western Cape, one of the windiest regions of Africa. On the other side of the continent, Morocco has been also investing heavily in renewable energy, including wind, intending to produce 52% of its electricity from renewables by 2030.

Hydropower: Africa has numerous rivers and lakes suitable for hydropower generation, with countries like Ethiopia and Zambia possessing a significant hydropower capacity, even though less than 7% has been utilized. Many plans are underway to exploit some of this potential. Mozambique, for example, is undertaking feasibility studies on the construction of a large hydroelectric dam on Zambezi River, with a planned capacity of the dam of 2000-2500 MW

(*Renewable Energy Development, 2003*). The Inga River hydroelectric project in the Democratic Republic of Congo (DRC) is also a massive potential power project for Africa. The Inga Dam is part of the Inga Hydroelectric Complex on the Congo River, one of the most ambitious energy projects in Africa, whose goal is to expand power generation to serve not only the DRC but also many other African nations, addressing a significant portion of the continent's energy deficit. Ethiopia's GERD (Grand Ethiopian Renaissance Dam) is another major project that, once fully operational, will be the largest hydropower facility in Africa. It has the potential to generate 6,000 MW of electricity, significantly increasing the power supply for Ethiopia and its neighbours.

Hydropower has several advantages: It is a clean and emission-free electricity generation technology, encouraged as an environment-friendly energy option. However, hydropower projects in the region are associated with huge loans, which lead to very high external debt levels. Due to the large amounts of capital involved in hydro projects, these projects are characterized by accusations of corruption. Another disadvantage associated with hydropower development is due to the variation of precipitation patterns that have already reduced hydropower capacity in several regions.

Geothermal Power: Regions with volcanic activity, such as East Africa, have unexploited geothermal energy potential. The East African Rift System is particularly rich in geothermal resources due to its tectonic activity, which can provide a steady supply of electricity. Geothermal energy is the natural heat from the earth’s interior stored in rocks and water within the earth’s crust that constantly flows from the earth’s interior or to the surface. This heat creates molten rock, or magma, beneath the surface crust with volcanoes, geysers, and fumaroles being the tangible signs of a vast reservoir of heat, which lies within and beneath the earth’s crust. Unlike other renewable sources like solar or wind, geothermal energy offers a steady, 24/7 supply of electricity because the heat from the Earth's interior is continuously generated. This makes it a reliable base-load power source and it is considered highly sustainable and low-carbon, as once a geothermal plant is established, the environmental impact is minimal, since it generates minimal emissions in comparison to fossil fuels.

Kenya is the largest producer of geothermal energy in Africa and one of the top producers globally. The *Olkaria Geothermal Plant*, located in the Rift Valley, is among the largest geothermal power plants in the world. Kenya generates over 800 MW of geothermal power, accounting for almost half of its electricity production (*ISPI, 2020)*. Ethiopia possesses an enormous geothermal potential as well, especially in the Afar Region, where volcanic activity is high. The government has launched initiatives to utilize these resources, with geothermal energy expected to play a key role in the diversification of the country’s energy mix alongside hydropower. The country has initiated a series of projects to allow the expansion of geothermal capacity as part of its strategy to achieve greater energy security and reduce reliance on fossil fuels. Geothermal plants provide

a consistent, reliable source of energy, which is crucial for regions that suffer from energy instability and irregular power supplies. Geothermal energy in East Africa provides significant potential to generate a steady, sustainable supply of electricity. Countries like Kenya are paving the way, but with greater financial investments and technological evolution, other nations in the Rift Valley could follow the same footsteps.

Biomass: Biomass energy is derived from organic materials such as plant and animal residues, agricultural and forestry products, and even municipal solid waste. It is considered a renewable energy source because the carbon dioxide (CO_2) released during its combustion is almost equivalent to the CO_2 absorbed by the plants during their growth, making it part of the natural carbon cycle. Biomass can be converted into various forms of energy, including heat, electricity, and biofuels, through processes like combustion, gasification, and fermentation. Biomass is the form of energy in Africa that is most widely utilized, in particular in rural areas where access to modern energy services is limited. According to the *International Energy Agency* (IEA), biomass represents a substantial part of the continent's energy usage, especially for cooking and heating. Nevertheless, its capacity for wider energy applications, including electricity generation and transportation fuels, remains largely unexploited. Biomass energy plays a significant role in the possible ways of producing renewable energy in the future, even though challenges related to problems of finance and investments need to be overcome.

Renewable Energy Technologies, known by the acronym NETs, do not have the power to solve African underdevelopment, but they represent an unexploited resource that could help African countries with their constantly growing needs of energy requirements. Although there is widespread recognition of the importance of the development of RETs, investments, and policies related to the matter are still not enough, especially compared to the resources dedicated to traditional ways of producing energy. One of the barriers to the adoption of renewable energies consists in the lack of specific governmental policies and the inability of governments to attract investors, leaving space for rhetoric rather than concrete actions. Another problem is related to the fact that the budget allocated to renewable is very little; for example, in Ethiopia, investments in coal and petroleum have increased in the last decade, while expenditures dedicated to RETs are decreasing. A third barrier, which is of a different nature, is related to the technical skills and expertise needed for the functioning of renewable technologies. The absence of trained personnel is one of the reasons responsible for the underdevelopment.

3.3. Smart Agriculture in Africa

An ulterior area targeted by Agenda 2063 is that related to Sustainable Agriculture, in particular, Goal 5 of an ulterior area targeted by Agenda 2063 is that related to Sustainable Agriculture, in particular, Goal 5 of the agenda is focused on the role of agriculture in driving growth and improving food security. Agriculture plays an essential role within the majority of African economies: without any improvement in adaptation strategies, the agricultural system will not be able to cope with the increasing population growth, therefore increasing the already existing food insecurity. Agriculture is responsible for the production of 25% of worldwide GHG emissions (*World Bank Group, 2016)*, but it also has the ability to propose a solution, with the Climate-Smart Agriculture approach, whose aim is the reduction of GHG emissions (mitigation) and increased productive capacity. Smart agriculture projects could be a solution for improving the life level of African people, as studies suggest that crop productivity is projected to decline by approximately 5 percent for each degree of warming beyond historical levels.

Without measures to enhance agricultural resilience, a 2°C rise in average temperatures by mid-century could lead to yield reductions of up to 20 percent. Further temperature increases would result in exponentially greater damage. Irregular rainfall intensifies temperature-related risks, and the resulting droughts could lead to famines. CSA is not only a framework of practices, but "*an approach to develop the technical policy and investment conditions to achieve sustainable agricultural development for food security under climate change" (African Union Development Agency, 2023).* Climate-smart agriculture can take place at different levels, such as farm level, landscape level, market level, and finally through policies that can either be implemented at regional, national or international levels. Specifically, seven types of interventions are identified, each one characterized by different methods and technologies. The seven types of interventions are: crop management, which mainly consists of the ability to apply crop variation and rotation; management of pasture and fisheries, management of soil and water, specifically through a good usage of irrigation and storage systems and finally energy management.

For the efficient development of climate-smart Agriculture, four areas urge action: the development of policies coordinated among private and public actors, the active role of institutions, the planning of projects that incorporate CSA objectives, and targeted flows of finance for that specific goal.

Successful CSA projects typically include a range of action-oriented solutions supported by enabling policies and environments. The World Bank is actively working to expand the adoption of CSA technologies and practices across Africa through the Africa Climate Business Plan.

There are several examples of successful CSA projects that were implemented in the African continent in recent years.

For example, in the valley of Nyando, located in Kenya, a lot of people suffer from hunger several months per year, as they are unable to produce enough food, mainly due to climate change variability. To address these challenges, many farmers have begun implementing CSA practices, such as utilizing climate-smart species and cultivars, along with climate information services. After receiving specific training on the matter, farmers collaboratively choose which climate-smart techniques to adopt through an inclusive process that grants an important role also to women and other marginalized groups. Building on their training, they were able to successfully turn their land into productive. Many farmers are now implementing these new techniques, with the introduction of livestock and crops that are more resilient compared to the previous. They have evolved and are now able to recognize what kind of activities have the potential to foster resilience to climate change, increase yield productivity, and reduce the carbon footprint. This approach has enhanced food security and resilience in climate-smart villages, providing smallholders options for adapting their agricultural practices.

Another interesting case study is that of The Ogiek people of the Mau Forest, which have engaged in beekeeping for generations. Unfortunately, they were not prepared for the advent of several problems such as low production levels, low prices resulting from poor-quality harvests, and insufficient skills in advanced beekeeping techniques. However, with the right technical support, beekeeping practices have improved significantly: honey production has risen exponentially. Unlike traditional farming, beekeeping is not an intensive resource, as once the hives are constructed, farmers can begin the harvest after just six months. From that moment on, beekeepers were suggested to plant more trees, serving mostly for carbon absorption

Uganda is one the African countries that exports the highest quantity of coffee; almost 20% of earnings related to foreign trade is due to coffee. Climate change poses a threat to coffee production and could adversely impact the economy. To tackle this challenge, research institutions are collaborating across the value chain to develop the coffee industry, in a way that entails projects of adaptation that consist of the planting of shade trees that would allow the lowering of temperatures by 2-5°C. Shade trees, such as bananas, can provide an additional 50 percent income for farmers while also sequestering carbon in the soil and mitigating temperature and drought issues. Alongside CSA techniques, models developed by the International Panel on Climate Change (IPCC) in which it was shown where varieties of different coffees could be grown, were used. It was demonstrated that, in the case of maintenance of obsolete systems of production, the areas that are now appropriate for the cultivation of Arabica coffee, will not be adapted for that kind of cultivation, causing an approximate loss of 100$ million each year. In this way, farmers

and industries working in the sector, will have a better knowledge of the possible strategies that could be put into place to foster resilience and invest in sustainable agriculture.

In Nigeria, a cost-benefit analysis was conducted to compare the costs and economic returns of new CSA practices compared to other existing traditional ways systems. Three important indicators were taken into the analysis: The *Net Present Value (*NPV), which establishes benefits deriving from the new practice; the *Internal Rate of Return (*IRR), explained as the discount rate and lastly, the payback period, which consists in the time needed to regain the money invested in the new practice. In the specific case of Nigeria, where the CSA practice consisted of the cultivation of a particular variety of potatoes, which was drought-tolerant, it was observed that an increase of 43% and 32% of capital was required for the installation processes and the preservation (*African Union Development Agency, 2023)*. However, many benefits were visible: management costs diminished and productivity steadily increased, with a 100% yield improvement. The Net Present Value amounted to 6,301$ and the payback period evaluated was of about two years, considered as an investment with moderate risks. Even though CSA proved to be efficient, as the net benefits were more than the costs, the lack of financial support acted as a barrier and forced farmers to withdraw from the practice.

Despite the numerous barriers, mainly of a financial nature, African leaders and institutions have understood the importance of embracing the CSA approach. In fact, in 2014, the African Union implemented the NEPAD (*New partnership for African development),* with a specific mandate that aimed at the development of the African CSA Platform. Another project, named *The Adaptation of African Agriculture Initiative,* gave importance to the development of adaptation strategies in specific key sectors of Africa, with a particular emphasis on the agricultural sector.

According to the Briefing paper of the *African Union Development Agency,* drafted in 2023, several initiatives and regional policies have been implemented, with a good process of review by member states, allowing synergies and coherence in the different initiatives. A leading role is played by the *Southern African Development Community (SADC),* which has established *The Centre for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA)* with the purpose of coordinating CSA both at the regional and continental level.the agenda is focused on the role of agriculture in driving growth and improving food security. Agriculture plays an essential role within the majority of African economies: without any improvement in adaptation strategies, the agricultural system will not be able to cope with the increasing population growth, therefore increasing the already existing food insecurity. Agriculture is responsible for the production of 25% of worldwide GHG emissions (World Bank Group, 2016), but it also has the ability to propose a solution, with the Climate-Smart Agriculture approach, whose aim is the reduction of GHG emissions (mitigation) and increased productive capacity. Smart agriculture projects could be a solution for improving the life level of African

people, as studies suggest that crop productivity is projected to decline by approximately 5 percent for each degree of warming beyond historical levels.

Without measures to enhance agricultural resilience, a 2°C rise in average temperatures by mid-century could lead to yield reductions of up to 20 percent. Further temperature increases would result in exponentially greater damage. Irregular rainfall intensifies temperature-related risks, and the resulting droughts could lead to famines. CSA is not only a framework of practices, but "an approach to develop the technical policy and investment conditions to achieve sustainable agricultural development for food security under climate change" (African Union Development Agency, 2023). Climate-smart agriculture can take place at different levels, such as farm level, landscape level, market level, and finally through policies that can either be implemented at regional, national or international levels. Specifically, seven types of interventions are identified, each one characterized by different methods and technologies. The seven types of interventions are: crop management, which mainly consists of the ability to apply crop variation and rotation; management of pasture and fisheries, management of soil and water, specifically through a good usage of irrigation and storage systems and finally energy management.

For the efficient development of climate-smart Agriculture, four areas urge action: the development of policies coordinated among private and public actors, the active role of institutions, the planning of projects that incorporate CSA objectives, and targeted flows of finance for that specific goal.

Successful CSA projects typically include a range of action-oriented solutions supported by enabling policies and environments. The World Bank is actively working to expand the adoption of CSA technologies and practices across Africa through the Africa Climate Business Plan.

There are several examples of successful CSA projects that were implemented in the African continent in recent years.

For example, in the valley of Nyando, located in Kenya, a lot of people suffer from hunger several months per year, as they are unable to produce enough food, mainly due to climate change variability. To address these challenges, many farmers have begun implementing CSA practices, such as utilizing climate-smart species and cultivars, along with climate information services. After receiving specific training on the matter, farmers collaboratively choose which climate-smart techniques to adopt through an inclusive process that grants an important role also to women and other marginalized groups. Building on their training, they were able to successfully turn their land into productive. Many farmers are now implementing these new techniques, with the introduction of livestock and crops that are more resilient compared to the previous. They have evolved and are now able to recognize what kind of activities have the potential to foster resilience to climate change, increase yield productivity, and reduce the carbon footprint. This approach has

enhanced food security and resilience in climate-smart villages, providing smallholders options for adapting their agricultural practices.

Another interesting case study is that of The Ogiek people of the Mau Forest, which have engaged in beekeeping for generations. Unfortunately, they were not prepared for the advent of several problems such as low production levels, low prices resulting from poor-quality harvests, and insufficient skills in advanced beekeeping techniques. However, with the right technical support, beekeeping practices have improved significantly: honey production has risen exponentially. Unlike traditional farming, beekeeping is not an intensive resource, as once the hives are constructed, farmers can begin the harvest after just six months. From that moment on, beekeepers were suggested to plant more trees, serving mostly for carbon absorption

Uganda is one the African countries that exports the highest quantity of coffee; almost 20% of earnings related to foreign trade is due to coffee. Climate change poses a threat to coffee production and could adversely impact the economy. To tackle this challenge, research institutions are collaborating across the value chain to develop the coffee industry, in a way that entails projects of adaptation that consist of the planting of shade trees that would allow the lowering of temperatures by 2-5°C. Shade trees, such as bananas, can provide an additional 50 percent income for farmers while also sequestering carbon in the soil and mitigating temperature and drought issues. Alongside CSA techniques, models developed by the International Panel on Climate Change (IPCC) in which it was shown where varieties of different coffees could be grown, were used. It was demonstrated that, in the case of maintenance of obsolete systems of production, the areas that are now appropriate for the cultivation of Arabica coffee, will not be adapted for that kind of cultivation, causing an approximate loss of 100$ million each year. In this way, farmers and industries working in the sector, will have a better knowledge of the possible strategies that could be put into place to foster resilience and invest in sustainable agriculture.

In Nigeria, a cost-benefit analysis was conducted to compare the costs and economic returns of new CSA practices compared to other existing traditional ways systems. Three important indicators were taken into the analysis: The Net Present Value (NPV), which establishes benefits deriving from the new practice; the Internal Rate of Return (IRR), explained as the discount rate and lastly, the payback period, which consists in the time needed to regain the money invested in the new practice. In the specific case of Nigeria, where the CSA practice consisted of the cultivation of a particular variety of potatoes, which was drought-tolerant, it was observed that an increase of 43% and 32% of capital was required for the installation processes and the preservation (African Union Development Agency, 2023). However, many benefits were visible: management costs diminished and productivity steadily increased, with a 100% yield improvement. The Net Present Value amounted to 6,301$ and the payback period evaluated was of about two years, considered as an investment with moderate risks. Even though CSA proved

to be efficient, as the net benefits were more than the costs, the lack of financial support acted as a barrier and forced farmers to withdraw from the practice.

Despite the numerous barriers, mainly of a financial nature, African leaders and institutions have understood the importance of embracing the CSA approach. In fact, in 2014, the African Union implemented the NEPAD (New partnership for African development), with a specific mandate that aimed at the development of the African CSA Platform. Another project, named The Adaptation of African Agriculture Initiative, gave importance to the development of adaptation strategies in specific key sectors of Africa, with a particular emphasis on the agricultural sector.

According to the Briefing paper of the African Union Development Agency, drafted in 2023, several initiatives and regional policies have been implemented, with a good process of review by member states, allowing synergies and coherence in the different initiatives. A leading role is played by the Southern African Development Community (SADC), which has established The Centre for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA) with the purpose of coordinating CSA both at the regional and continental level.

Conclusion

This bachelor's thesis aimed to analyze in depth various aspects related to climate change, with a specific view on the African continent. Today, climate change represents one of the most important, urgent, and complex challenges of our time, with devastating impacts manifesting on a worldwide scale.

Each chapter of the thesis has addressed different aspects of the topic mentioned previously. The first chapter has firstly analyzed this phenomenon from a scientific point of view, investigating the different reasons that can be identified as the root causes of climate change, mainly related to man-made activities. Human beings are the ones responsible for climate change and will probably be the ones who will mostly suffer from it. A brief excursus on the history of climate change regime has been proposed to have a better awareness of the issue, as well as the different steps of the process. Within the context of climate change, sustainable development plays a paramount role, as it is the key that links climate change and the need to foster economic growth, taking into consideration not only the present needs but also those of future generations. Mitigation and adaptation strategies need to be implemented into policies that have to be embraced at local, regional, continental, and worldwide levels.

In the African continent, vulnerability to climate-related events is strongly interlinked with already existing socio-economic challenges, requiring urgent actions to be taken, with a specific focus on sustainable development. Negative impacts have been witnessed all over the continent, in particular, three main areas have been analyzed: economic, social, and environmental.

However, through the analysis of the thesis, it clearly emerged how climate change represents not only a threat, but also an opportunity to rethink and redefine development policies and institutional frameworks.

As presented in the chapters, climate change offers many opportunities for sustainable development, with practices such as the use of renewable energies, smart agriculture and green economy taking place. In this context, Agenda 2063 and The Sustainable Development Goals represent an ambitious goal and an important framework necessary to face these challenges, which require to be followed seriously by governments and institutions. It is essential to question ourselves on the actual capacities of government, institutions, and NGOs to put into concrete action the goals we have set, promoting a development that is not only environmentally sustainable but also inclusive. Climate change impact is global, but its consequences are profoundly unequal: it is important to be aware of the fact climate change is also an issue related to social justice and disparity.

Optimism is the key, but it is also a two-edged sword: on one hand, it pushes toward a direction of hope and prosperity; on the other hand, it calls for a real political and financial commitment, from both developing and developed countries.

In conclusion, climate change is not to be conceived only as a threat to the survival of the planet, but as an opportunity to build a future that is based on equality and sustainability.

Bibliography

Abubakar S. Sambo. Africa: Coping with the challenge of climate change on the path to sustainable development. In World Energy Insight 2012 (pp. 26-27). 2012.

Addison, T. (2017). Thirty years in Africa's development: from structural adjustment to structural transformation

AfDB. Climate Change and Sustainable Development in Africa: An Overview. Background Paper [Seventh African Development Forum (ADF VII)]. October 2010.

Affairs, D. O. E. a. S. (2024). The Sustainable Development Goals Report 2024. Stylus Publishing, LLC.

African Development Forum (ADF-VII): Acting on Climate Change for Sustainable Development in Africa. (2010).

African Development Report 2015. The way forward to achieving sustainable development in Africa. African Development Report 2015 (Chapter 8).

African Energy Policy Research Network (AFREPREN) and Waeni Kithyoma, AFREPREN. Renewable Energy in Africa: Prospects and Limits. 2- 4 June 2003.

African Union. Our aspirations for the Africa we want. (n.d.). https://au.int/en/agenda2063/aspirations

Allen, S. K., Plattner, G., Nauels, A., Xia, Y., Qin, D., & Stocker, T. F. (2013). Climate Change 2013: The Physical Science Basis. An overview of the Working Group 1 contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). AGU Fall Meeting Abstracts, 2013. http://ui.adsabs.harvard.edu/abs/2013AGUFMGC51A0949A/abstract

Amar Bhattacharya, Homi Kharas, John W. McArthur (eds.). Keys to Climate Action: How Developing Countries Could Drive Global Success and Local Prosperity. Brookings. November 2023.

Barry, M., Steyn, H., & Brent, A. (2011). Selection of renewable energy technologies for Africa: Eight case studies in Rwanda, Tanzania and Malawi. Renewable Energy, 36(11), 2845–2852. https://doi.org/10.1016/j.renene.2011.04.016

Bodansky, D. (2001). The history of the global climate change regime. ResearchGate. https://www.researchgate.net/publication/237769103_The_History_of_the_Global_Climate_Change_Regime

Calvin, K., Dasgupta, D., Krinner, G., Mukherji, A., Thorne, P. W., Trisos, C., Romero, J., Aldunce, P., Barrett, K., Blanco, G., Cheung, W. W., Connors, S., Denton, F., Diongue-Niang, A., Dodman, D., Garschagen, M., Geden, O., Hayward, B., Jones, C., . . . Ha, M. (2023). IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland. https://doi.org/10.59327/ipcc/ar6-9789291691647

Change, I. P. O. C., & Ipcc. (2013). IPCC Fifth Assessment Report (AR5).

Climate Change 2021—The Physical Science Basis. (2021). Chemistry International, 43(4), 22–23. https://doi.org/10.1515/ci-2021-0407

Climate Change and Sustainable Development in Africa: An Overview | Department of Economic and Social Affairs. (n.d.). https://sdgs.un.org/publications/climate-change-and-sustainable-development-africa-overview-17299

Climate change impacts, adaptation and links to sustainable development in Africa. (n.d.). https://www.fao.org/4/i0670e/i0670e03.htm

Climate change impacts, adaptation and links to sustainable development in Africa. (n.d.). https://www.fao.org/4/i0670e/i0670e03.htm

Danyang Li, Guosheng He, Hui Jin, Fu-Sheng Tsai. Sustainable development of African countries: minding public life, education, and welfare. Frontiers in Public Health, (Volume 9). 2021.https://www.frontiersin.org/journals/publichealth/articles/10.3389/fpubh.2021.748845/full

Debay Tadesse. The impact of climate change in Africa. ISS Paper 220. November 2010.

Editeur, D. (2019). Africa's critical choices: A Call for a Pan-African Roadmap. Routledge.

European Commission. EU climate cooperation with Africa. https://climate.ec.europa.eu/eu-action/international-action-climate-change/eu-engagement-climate-action-non-eu-countries/eu-climate-cooperation-africa_en

Gary Yohe et al. Perspectives on Climate Change and Sustainability. In AR4 Climate Change 2007: Impacts, Adaptation, and Vulnerability (pp. 810-42). IPCC. 2007.

Global Center on Adaptation. State and Trends in Adaptation Report 2021: Africa. June 2021.

IPCC, 2022: Summary for Policymakers [H.-O. Pörtner, D.C. Roberts, E.S. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem (eds.)]. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-33, doi:10.1017/9781009325844.001.

IPCC. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC (2014)

ISPI. Renewable Energies and Development in Africa: Limits and challenges. ISPI. June 2021. https://www.ispionline.it/en/publication/renewable-energies-and-development-africa-limits-and-challenges-30958

Jackson, Stephen T.. "climate change". Encyclopedia Britannica, 23 Sep. 2024, https://www.britannica.com/science/climate-change. Accessed 23 September 2024.

Julia Kreienkamp. The Long Road to Paris. The History of the Global Climate Change Regime. Global Govenance Institute. November 2019. https://www.ucl.ac.uk/global-governance/sites/globalgovernance/files/the_long_road_to_paris_the_history_of_the_global_climate_change_regime.pdf

Kreienkamp, J. (2019). The Long Road to Paris: The History of the Global Climate Change Regime. Global Governance Institute Policy Brief Series. London: University College London.

Lopes, C. (2018). Africa in transformation: Economic Development in the Age of Doubt. Palgrave Macmillan.

Lorrain Elliott. Environmentalism. Ideology, History, & Types. Encyclopedia Britannica. July 1998. https://www.britannica.com/topic/environmentalism/History-of-the-environmental-movement

M.F.M. Firdhousa, P.M. Karuratanea. A Model for Enhancing the Role of Information and Communication Technologies for Improving the Resilience of Rural Communities to Disasters. 2018. https://acrobat.adobe.com/id/urn:aaid:sc:EU:8903873f-2163-4bdc-9152-5c3c8b84b074

Marie-Louise Barrya, Herman Steyna, Alan Brent. Selection of renewable energy technologies for Africa: Eight case studies in Rwanda, Tanzania and Malawi. April 2011. https://acrobat.adobe.com/id/urn:aaid:sc:EU:d448ab28-00b5-437c-a8ae-239829470b0d

Naghmeh Nasiritousi and Karin Bäckstrand. International Climate Politics in the post-Paris era. Stockholm University, Sweden. 2018. https://nordregio.org/wp-content/uploads/2018/10/International-Climate-Politics-in-the-post-Paris-era_Nasiritousi.pdf

Oli Brown and Alec Crawford. Climate Change and Security in Africa. IISD. March 2009.

Pedersen, J. S. T., Santos, F. D., Van Vuuren, D., Gupta, J., Coelho, R. E., Aparício, B. A., & Swart, R. (2020). An assessment of the performance of scenarios against historical global emissions for IPCC reports. Global Environmental Change, 66, 102199. https://doi.org/10.1016/j.gloenvcha.2020.102199

Philip Kofi Adom. The Socioeconomic Impact of Climate Change in Developing Countries in the Next Decades. Working Paper 681. Center for Global Development. February 2024.

Renwick, N, Gu, J & Xue, L 2018, 'The BRICS and Africa's search for green growth, clean energy and sustainable development' Energy Policy, vol 120, pp. 675-683 https://dx.doi.org/10.1016/j.enpol.2018.05.028

Renwick, N, Gu, J & Xue, L. The BRICS and Africa's search for green growth, clean energy and sustainable development. 2018. https://acrobat.adobe.com/id/urn:aaid:sc:EU:1a47b20c-ae40-4c9a-8d4a-430a1b33fc6c

Scaling Climate-Smart Agriculture for accelerated agri-food systems transformation in Africa | AUDA-NEPAD. (n.d.-b). https://www.nepad.org/publication/scaling-climate-smart-agriculture-accelerated-agri-food-systems-transformation

Schlubach, J. (2023). IPCC 2022 Report Assessment from a Food Security Perspective. International Journal of Environmental Sciences & Natural Resources, 31(5). https://doi.org/10.19080/ijesnr.2023.31.556327

Sissoko, K., Van Keulen, H., Verhagen, J., Tekken, V., & Battaglini, A. (2010). Agriculture, livelihoods and climate change in the West African Sahel. Regional Environmental Change, 11(S1), 119–125. https://doi.org/10.1007/s10113-010-0164-y

Smerdon, J. (2009). Climate change: The Science of Global Warming and Our Energy Future. Columbia University Press.
solidar.org. Sustainable development and international cooperation. Solidar.org. February 2024.

Štreimikienė, D., & Mikalauskiene, A. (2021). Climate change and sustainable development: Mitigation and Adaptation. CRC Press.

The World Bank Annual Report 2010. (2010). In The World Bank annual report/Annual report. https://doi.org/10.1596/978-0-8213-8376-6

Thomas, C. D., Cameron, A., Green, R. E., Bakkenes, M., Beaumont, L. J., Collingham, Y. C., Erasmus, B. F. N., De Siqueira, M. F., Grainger, A., Hannah, L., Hughes, L., Huntley, B., Van Jaarsveld, A. S., Midgley, G. F., Miles, L., Ortega-Huerta, M. A., Peterson, A. T., Phillips, O. L., & Williams, S. E. (2004). Extinction risk from climate change. Nature, 427(6970), 145–148. https://doi.org/10.1038/nature02121

Toulmin, C. Climate change in Africa. African arguments (2009). doi:10.1016/S1575-0922(09)73506-5

UNEP - UN Environment Programme. Africa green economy project. (n.d.). https://www.unep.org/explore-topics/green-economy/what-we-do/advisory-services/africa-green-economy-project

United Nations (2019). "Climate change recognized as 'threat multiplier', UN Security Council debates its impact on peace." 25 January, 2019.

United Nations. (n.d.). From Stockholm to Kyoto: A brief history of climate change | United Nations. https://www.un.org/en/chronicle/article/stockholm-kyoto-brief-history-climate-change

Weyler R. A Brief history of environmentalism - Greenpeace International. Greenpeace International. January 2018. https://www.greenpeace.org/international/story/11658/a-brief-history-of-environmentalism/

Wmo. (2021). State of the Global Climate 2020.

World Health Organization, Republique Gabonaise & United Nations Environment Programme. New and Emerging Environmental Threats to Human Health. in First Interministerial Conference on Health and Environment in Africa: Health Security through Healthy Environments 6 (2008). Xiaoyue Hou, Xenia Zia Morales, Grace Anyango Obuya, Dasan Bobo, and Ademola Braimoh. Climate Smart Agriculture Successes in Africa. World Bank Group. November 2016.

Xolani Thusi, Victor H. Mlambo, Nkosingiphile Mkhize. Challenges of the implementing the Africa Agenda 2063: a synopsis. Prizren Social Science Journal (Volume 8, Issue 1). January-April 2024. https://acrobat.adobe.com/id/urn:aaid:sc:EU:b05a32f0-ddb8-407b-94a9-0d9fc064d432

Yi-Lin Hsieh and Shin-Cheng Yeh. The trends of major issues connecting climate change and the sustainable development goals. Discover Sustainability 5 (Paper 31). March 2024.

Yohe, G.W., R.D. Lasco, Q.K. Ahmad, N.W. Arnell, S.J. Cohen, C. Hope, A.C. Janetos and R.T. Perez, 2007: Perspectives on climate change and sustainability. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 811-841.

Ziervogel, G., & Zermoglio, F. (2009). Climate change scenarios and the development of adaptation strategies in Africa: challenges and opportunities. Climate Research, 40, 133–146. https://doi.org/10.3354/cr00804