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ADAPTATION AND MITIGATION POLICIES IN AFRICA: THE ITALIAN POSITION

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Abstract

The present document explores the dynamics of climate change from its skeptical roots to its dangerous fruits, which now constitute a serious challenge for the international community; the main purpose of this work is to clarify Italian's position in Africa, which is one of the most vulnerable and impacted territories.

The discussion starts with the exposure of scientific evidence that throughout history studied climate change; it is needed to refute the numerous attempts made to discredit not only the validity, but also the existence of global warming, coming mainly from lobbyists, who encourages the business-as-usual practices.

The paper continues with a presentation of the main drivers of changes: anthropogenic greenhouse gases emissions, which are grouped by source, sector, and country, with a special focus on the weight of African contribution; the chapter ends with a brief overview on the impacts caused by climate change, exacerbated by the fragile and unstable African context.

After all of the basic information is provided, the core of the present paper is introduced: ministerial projects that Italy has currently in place in Africa in order to help it cope with climate change.

The aim of the thesis is to expose the Italian commitment to this cause, to underline the importance of international cooperation in such important global concerns, summarizing in the conclusions the amount of funds Italy is allocating and the common strategies that it is using in all the African countries in order to make these projects effective.

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INTRODUCTION

Climate change. This phrase has been popping up more frequently over the last few years. Although it may seem to be a recently coined term, it all started back in the time of the first industrial revolution.

In the 1700s, the English started utilizing coal to produce a fuel that burned hotter and released more energy than wood charcoal. However, it was the massive need for energy of the new technologies invented during the Industrial Revolution that gave the real opportunity for coal to fill its first role as a global leading energy supplier. In North America, commercial coal mines started operation during the 1740s in Virginia. The Industrial Revolution played a major role in diffusing coal as a dominant fuel. At that time, people were not aware about the potentially harmful recourses of uncontrolled mass production fueled by coal. They were not even aware of the positive (or negative) potential of capitalism itself. However, the illusion that this exponential and faster-than-ever growth was carrying no dangerous repercussions, quickly collapsed. From a scientific prospective, the first clue about greenhouse effect was given in the 19th century. From that point onwards, the scientific community deepened its knowledge and ideas such as greenhouse gases, CO2 concentration in the atmosphere, and anthropological influence on climate and environmental pollution grew in popularity through all a century and more, driving worldwide policy leaders to the point of reaching diverse international agreements to tackle the problems deriving from the so-called climate change. The last most important global effort is the signature of the Paris Agreement of 2015, which will be explained more extensively in the final part of the first chapter of this thesis.

However, coal relates to the first issue in addressing global warming: energy. Energy production was, historically, the principal cause of the rise in atmospheric concentration of CO2 and consequently the increase in average temperature worldwide. This has begun with the first industrial production, run by coal as fuel, in fact, all current concentration and temperature targets are currently defined by comparing them with pre-industrial levels. Nonetheless, capitalist production system and energy revolution are not the only actors in the global warming apocalypse. With improved living conditions for an enormous number of people (compared to those of pre-industrial levels) life expectancy has increased, together with the global

population growth. To clarify, the latter has never been as high as the 20th century rates, and it is still growing worldwide, with the African Continent in the first place. According to the United Nations, African population is going to reach 2.5 billion people by 2050, more than 4 billion by 2100, with a strong chance that a third of all people in the world is going to be African. Therefore, more people means more energy consumption, and more general consumption as well (bearing in mind that goods are produced by spending energy too); considering the current practices and the terrific reliance on fossil fuels, increased demand turns into more global pollution, more CO2 atmosphere concentration and thus heavier climate change impacts. Moreover, these two concepts are to be combined with the present food production methods, resulting in even more dangerous consequences. Consequently, urbanization, growing incomes and population growth all together pose extraordinary challenges to food, water and agricultural systems, considered that the natural resources required to support global food and other agricultural-related production will not grow. Driven by the robust demand of an emerging worldwide middle class, diets are geting richer and extremely diversified, with an increased demand in animal protein: the demand for milk and meat in 2050 is expected to grow by 58% and 73%, respectively, from their levels in 2010 *(FAO, 2011).* The natural resources to support that growth are stressed. Presently, agriculture represents a significant actor in global ecological problems, such as climate change, water pollution, land degradation and loss of biodiversity. Within agriculture, the livestock sector has become increasingly important because of its huge impacts on the environment. Conventionally, livestock was supply driven by and used to convert waste material and other materials with limited alternative use into comestible products and other services. Its size was relatively small and so were the ecological impacts. Nevertheless, since the livestock sector has been shifting into a demand-driven sector, development has been extremely fast and it is currently competing with other sectors for natural resources, with increasing ecological impacts.

The big challenge, is that climate change impacts will become increasingly extensive, likely beyond any previous historic experience. Societies will be, and already are, being confronted with complex events and processes about which nothing can be known. Concerns are expressed especially towards LDCs (Least Developed Countries), as they are not able to promptly recover from

climate stresses and their economic growth is highly dependent on climate-sensitive sectors. Although these countries differ notably in terms of economic profiles and exposure to climate risks, they share many weaknesses regarding climate impacts: agriculture under pressure, freshwater supplies, health, energy access and extreme weather hazards. Within this thesis, we are going to analyze in higher detail several aspects of the climate change discussion, from a scientific, economic and political perspective, focusing on the increasing needs of the African Continent and the Italian effort to invest and help it dealing with new born uncertainties.

1. GREENHOUSE EFFECT AND GLOBAL WARMING

1.1. Introduction: the Anthropocene Age

Climate change is one of the main challenges the international community is facing nowadays.

During the Holocene age, starting 12.000 years ago with the end of the last ice age, various favorable conditions took place and allowed the development of ancient peoples. These conditions were an unusual terrestrial orbit and stable average temperature values. For the scientific community these optimal components were meant to last at least for another 50.000; however, the massive increase of intensive human activities seriously affected the delicate balance putting an end to this period. Indeed, the last twenty years led scientific experts to classify the current period as the "Anthropocene Age", focusing on the existent relation between global warming and GHG concentrations in the atmosphere, caused by the burning of fossil fuels, intensive cattle farming, deforestation, use of particular fertilizers and gases. More specifically, attention was drawn to the effects of the "Great Acceleration" that took place in the period 1950 – 2010, where most of the population growth has been in the non-OECD world but the world's economy (GDP), and hence consumption, was (and is) still strongly dominated by the OECD world. "One feature stands out as remarkable. The second half of the twentieth century is unique in the entire history of human existence on Earth. Many human activities reached take-off points sometime in the twentieth century and have accelerated sharply towards the end of the century. The last 50 years have without doubt seen the most rapid transformation of the human relationship with the natural world in the history of humankind." (*Steffen et al., 2004*)

On global scale, population tripled as well as water consume, GDP incremented seven times, energy consume quadrupled and the use of fertilizers grew ten times as much.

Scientific debate about global warming is complex and, based on latest reports, in the period 1880 – 2015 global average temperature has increased about 0,85° C with respect to the levels of the end of 19th century. Experts all over the world believe that global temperature will further increase within the range of 1,4°- 5,8° C before 2100. It does not seem much, but just to make

an example, during the last ice age global temperature was just 5° C lower than current measurements, and at that time Europe was covered in ice. How is it possible?

1.2 The discovery of the greenhouse effect's mechanisms

JOSEHPH FOURIER

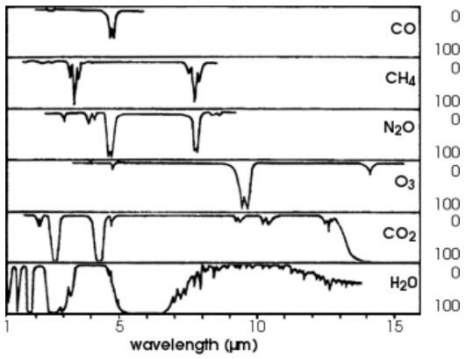
Joseph Fourier's famous article of 1827, *'Memoire sur les temperatures du globe terrestre et des espaces planemires',* has been mentioned, repeatedly and not randomly, as being the first reference in the literature to the atmospheric 'greenhouse effect'.
In the article, Fourier begins with the statement that the Earth, situated at this distance from the Sun, should be far colder then it actually is. He discovers that the heating of the planet can be divided in three different sources: solar radiation, which is unequally distributed over the year and which produces the diversity of climates; the temperature communicated by interplanetary space irradiated by the light from innumerable stars; and heat from the interior of the Earth.
As Fourier puts it, energy in the form of visible light from the Sun penetrates the atmosphere to reach the planet's surface and heat it up, but heat cannot so easily escape back into space.
In simple words, Earth's atmosphere absorbs Sun invisible heat rays ("infrared radiation") rising from the surface. The warmed air radiates some of the energy back down to the surface, helping it stay warm.
However, the data available to 19th-century scientists were far too poor to allow an accurate calculation; but the observation was extremely right.

JOHN TYNDALL

Fourier's research has been continued by John Tyndall, who wonders how this heat could be trapped, if there was any gas present in the atmosphere that could reflect it (radiant heat).
In 1859, Tyndall begins by studying the absorption properties of various gases. Part of his analysis includes the construction of the first ratio spectrophotometer, which consists of a long tube that is capped at both ends, through which various gasses are released.

Then radiation is emitted into the tube to interact with the gasses. The instrument then measures temperature and the intensity of the radiation (*Oxford University Press, 1998*).

Table 1: Absorption property of atmosphere's gases



The above graphs show the percentage of radiation that gases found in the Earth's atmosphere absorb. Methane (CH_4,) carbon dioxide (CO_2,) and water vapor (H_2O,) absorb strongly in the thermal infrared (4–100 µm.) (Figure from Valley, 1965)

Source: https://www.researchgate.net/figure/Infrared-absorption-spectra-for-various-atmospheric-gases_fig11_282393775

The outcome of Tyndall's experiment finds that elementary gases such as hydrogen (H), nitrogen (N) and oxygen (O) abilities can hardly even be measured. However, water vapor (H2O) and carbon dioxide (CO2) have proved to have high absorption rates and are able to hold and transmit the radiation, creating, again, what we now call the greenhouse effect. Their molecules are the best absorbers of heat radiation, and even in small quantities, these gases absorb much more strongly than the atmosphere itself.
This experiment explains the way the gases of Earth's atmosphere work, how they interact with each other and external sources. Water vapor is the strongest absorber of radiant heat and is therefore the most important gas controlling Earth's surface temperature; without it, the Earth's surface would be "held fast in the iron grip of frost."
However, in the 19th century, before the Industrial Revolution's effects in play, the surface warming of the earth by radiation was viewed as a positive thing.

SVANTE ARRHENIUS

The Swedish Nobel prize winning physicist Svante Arrhenius, still following this direction, sees carbon dioxide as the key element.

Why focus on that rare gas rather than water vapor, which is far more abundant in the atmosphere? Until today, this question has often been asked, and it is a common misconception in the debate regarding global warming.

While water vapor may be the most dominant greenhouse gas by mass and volume, its amount in the atmosphere fluctuates daily, depending on temperature. On the other hand, the level of CO2 is (without human activity), set over a geological timescale by emissions from volcanoes. Its increase in the atmosphere slightly changes the global temperature, but therefore the air is able to hold more water vapor. Subsequently, water vapor traps more heat and further warms the atmosphere, bringing further changes through its own greenhouse effect.

In the end of 19th century, even if less precisely, Svante understands that the level of CO2 acts as a regulator of water vapor, and ultimately determines the planet's long-term equilibrium temperature.

In 1896 Svante measures and analyses the cycle of carbon dioxide through its natural geochemical processes, including emission from volcanoes, uptake by the oceans, and so forth; however, when calculating the amount of CO2 that is emitted by factories and other industrial sources, the result is that human activities were adding CO2 to the atmosphere at a rate roughly comparable to the natural geochemical processes that emitted or absorbed the gas. The added gas was not much compared with the volume of CO2 already in the atmosphere, but it could have mattered if portrayed long enough. By recent calculations, the total amount of carbon laid up in coal and other fossil deposits that humanity can readily get at and burn is some ten times greater than the total amount in the atmosphere *(NASA, 2018)*

Svante assumes that doubling the amount of carbon dioxide in the atmosphere, the Earth's average temperature would raise by 5-6°C. The lack of proper instruments and equipment play a fundamental role in the inaccuracy of the results, but the intuition has been verified years later, with more precise data. Anyway, temperatures a few degrees higher still do not sound like a bad idea.

1.3 Skepticism

The theories of these early scientists do not obtain any notable merit during the 20th century, as the consensus of the scientific community and public opinion is the one represented in official authoritative works as the *American Meteorological Society's 1951 Compendium of Meteorology*, which means that, this crazy idea of carbon dioxide's amount in the atmosphere related to eventual climate changes has never been accepted at the time, and has soon been abandoned.

During the 1950s, there were obvious reasons to deny any greenhouse effect in the foreseeable future. Not taking into account the contributions of carbon dioxide released by human activity, still not considered much, the main reason of disbelief was represented by the strong conviction that the planet could almost automatically regulate itself. More specifically, scientists sustained the theory that the oceans would absorb any excess amount of gases present in the atmosphere, determining the equilibrium concentration of CO2, which would not easily stray from the present numbers.

If the oceans failed to stabilize the system, land and forests were other good candidates for providing what was defined as "homeostatic regulation." Just as sea water would absorb more gas if the concentration increased, so would plants grow more lushly in air that was "fertilized" with extra carbon dioxide. Inaccurate calculations seemed to confirm the comfortable myth that biological systems would stabilize the atmosphere by absorbing any surplus. One way or another, then, whatever gases humanity added to the atmosphere would be absorbed and the equilibrium would automatically restore itself. "The self-regulating mechanisms of the carbon cycle can cope with the present influx of carbon of fossil origin."(*George Evelyn Hutchinson, 1948).*

1.4 Further observations and more precise data

GUY STEWART CALLENDAR

In 1938 an English engineer tries to revive the old idea. After compiling measurements of average temperatures from the 19th century onwards, he finds a clear warming trend, with a concentration of carbon dioxide in the atmosphere increased by about 10% over the past century. Why the big oceans have not absorbed the surplus?

Callendar's explanation is that, with this big concentration of CO2, the thin layer of ocean's surface waters would quickly saturate, and it would take thousands of years for the rest of the ocean's mass to turn over and be exposed to the air again; on the other hand, the actual turnover rate of the oceans was still inaccurate. They would have had time to manage with any extra gases, even with industrial emissions increasing every day.
Scientific community refers to Callendar's data as old and untrustworthy; furthermore, measurements can easily vary with every change of wind that brings emissions from some factory. In conclusion, there is still uncertainty about carbon dioxide increase at all.

THE SECOND WORLD WAR AND THE COLD WAR

Concrete results come after the Second World War and during the Cold War, which, for security reasons, require research progresses in various fields, including the absorption of IR, the atmosphere and oceans.
Steps ahead are made regarding the structure of terrestrial atmosphere. It pops up that the most important carbon dioxide absorption lines do not lie exactly on top of water vapor lines. Instead of two overlapping bands, atmosphere is composed by two sets of narrow lines, with spaces for radiation to slip through. As a result, even if water vapor in the lower layers blocks any radiation that can be absorbed by CO2, this do not keep the gas from making a difference in the upper layers, which contain very little water vapor anyway.
Would surface temperature be affected by adding carbon dioxide in the upper layers of the air? The answer arrives with the development of digital computers, which, with detailed computations, point by point across the infrared spectrum and layer by layer through the atmosphere, find that doubling the level of carbon dioxide would result in a 3-4°C average temperature rise. With only human emissions increasing at the current rate (1960s), the average global temperature would raise at the rate of 1.1° C per century.
"If at the end of this century the average temperature has continued to rise," the physicist Gibert N. Plass wrote, "then it would be firmly established that CO2 could cause climate change". Even if none of these studies countered the argument that the oceans would absorb all the CO2 derived from human activities, the main scientific opinion shifted and started to take this issue more seriously.

ROGER REVELLE, BERT BOLIN, ERIK ERIKSSON

The 1960s begin with an important discovery about oceans capacity to absorb and storage carbon dioxide in their depths. The scientist Roger Revelle, expert in oceans chemistry, asserts that oceans are not simply salt water, but a complex mix of chemicals, which create a peculiar buffering mechanism that stabilizes the acidity of sea water. This mechanism prevents the water from retaining all the extra CO2 it takes up; the surface layer cannot absorb much additional gas, barely one-tenth the amount a rough calculation would have predicted. Revelle's final opinion notes that the greenhouse warming effect "may become significant during future decades if industrial fuel combustion continues to rise exponentially."

However, it is in Sweden that a small team of meteorologists, Bert Bolin and Erik Eriksson, catches on. Their main observation is that, although sea water rapidly absorbs CO2, most of the added gas promptly evaporates back into the air before the slow oceanic circulation sweeps it into the abyss; the chemistry of air and sea water would reach an equilibrium just in thousands of years.

However, in the 1960s, further measurements in more areas covering a greater number of years, were necessary to define exactly and in a reliable way carbon dioxide concentration in the atmosphere.

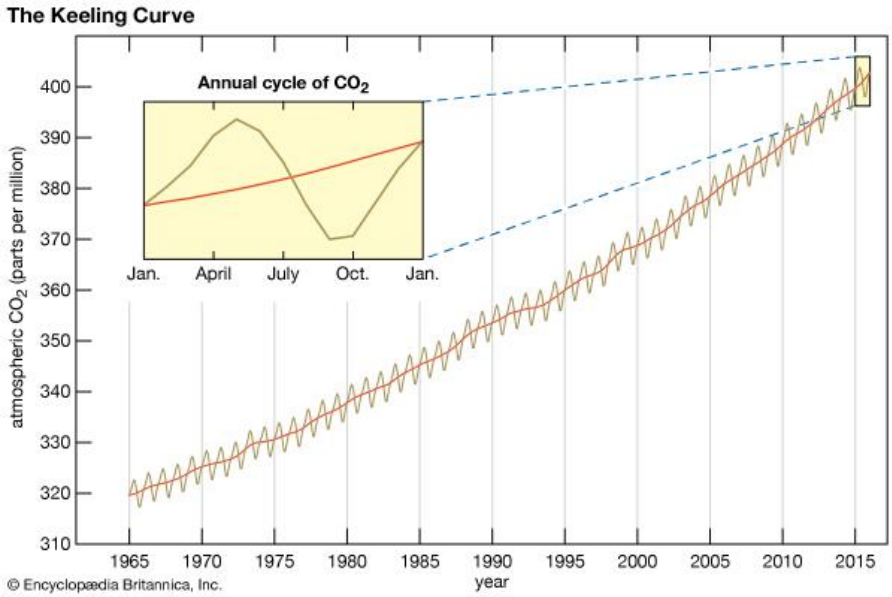
CHARLES DAVID KEELING

Charles David Keeling, with technical progresses in infrared equipment, is able to develop a more precise measurement of gases such as carbon dioxide. With meticulous measurements in the unpolluted air of Antarctica and Mauna Loa volcano in Hawaii, he portrays a stable baseline level of CO2 in the atmosphere. After only two years of Antarctic data in hand, Keeling asserts that the level of carbon dioxide has increased. Furthermore, as its record extends, it becomes increasingly impressive, each year noticeably higher. In a little while, Keeling's curve, jagged but systematically rising, is widely cited by scientific expertise as the primary icon of the greenhouse effect. The reason why the curve is jagged, is because plants in the Northern Hemisphere absorb CO2 as they grow in spring and summer and release it as they decay in autumn and winter.

Keeling warns that by the middle of the next century (2050), apart from the oceans, also plants could probably reach their limit in taking up CO2.

Analyzing his data over a long term, the rise of carbon dioxide is clearly undeniable and, most important, inexorable.

Table 2: The Keeling Curve



Source: www.britannica.com

COMPUTER MODELS

Another crucial element that helps scientists gain reliable data about what is happening in the atmosphere is the development of more precise computer models.

Indeed, a calculation published by Princeton computer specialists in 1967 produces a model that simulates roughly the actual climate of the planet, with deserts and sea ice and trade winds all in the right places. Out of curiosity they double the amount of CO2 in their simulated atmosphere and the simulated global temperature rises a couple of degrees.

At the end of 1970s the ever more powerful computers confirm that it is impossible to construct a model that can reproduce the current climate and that temperature does not warm up a couple of degrees if the level of the gas is almost doubled.

Moreover, in the 1980s international economic statistics yield reliable figures for how much CO2 humanity put into the air each year from burning fossil

fuels, and the measurements of the annual increase by Keeling show that less than half of the new carbon emitted is found in the atmosphere. Where is the rest? Oceanographers start to calculate how much of the gas the oceans absorb, while other scientists calculate how much the biosphere takes up and emits. The numbers do not coincide and some of the carbon is "missing." Years later, in 1990s, after further calculations this absent amount is finally located, with gradually increasing precision, in rapidly changing forests and forest soils, along with other biological reservoirs. Furthermore, it is found that also other gases emitted by human activity, even tens or hundreds of times far more dangerous than CO2, such as methane, influence and worse the greenhouse effect.

Table 3: Scientific Community statement in 1970s

The effects of CO_2 may not be detectable until around the turn of the century. By this time, atmospheric CO_2 concentration will probably have become sufficiently high (and we will be committed to further increases) that a climatic change significantly larger than any which has occurred in the past century could be unavoidable. To avert such a change it is possible that decisions will have to be made (for example, to reduce anthropogenic CO_2 emissions) some time before unequivocal observational 'proof' of the effects of CO_2 on climate is available.

Source: https://arxiv.org/ftp/arxiv/papers/1510/1510.02503.pdf

VOSTOK TEAM

Concerns are sharpened after analyzing new evidence from holes drilled into the Greenland and Antarctic ice caps; the long cylinders of ice contain in fact tiny bubbles with samples of ancient air, which preserves CO2 intact.
In the mid 1908s, a French-Soviet drilling team at Vostok Station in central Antarctica succeeds to produce an ice core that carries a 150,000-year record, a complete cycle of warmth, cold and warmth.
The CO2 levels in their record get as low as 180 parts per million (ppm) in the cold periods and reaches 280 in the warm periods, never higher. But in the air above the ice, which represents the current period, the level of the gas reaches 350 ppm, far above anything seen in this geological era and still climbing.

Table 4: CO2 concentrations over the last three glacial cycles

Source: Reconstrution from ice cores by NOAA, National Oceanic and Atmospheric Administration

The Vostok core shows that in order to achieve further progresses climate and the carbon cycle have to be treated as parts of the same global system rather than separate entities. In fact, the rise and fall of terrestrial temperature is tied up in a complex way with cycles involving not just the mineral geochemistry of CO2 in air and sea water, but also methane emissions, the growth and decay of forests and bogs, changes of the plankton population in the oceans, and still more features of the planet's biosphere.
Nevertheless, no universal consensus about the causes of these grand shifts is found, and a minor part of the scientific community still wonders if the cause are anthropogenic emissions of CO2; in fact, nobody could reliably measure the atmosphere many millions of years back. Notwithstanding, evidence regarding CO2 levels has never been so elevated during the great warm eras of the past, so disclaiming the theories that such levels are simply caused by the natural process.

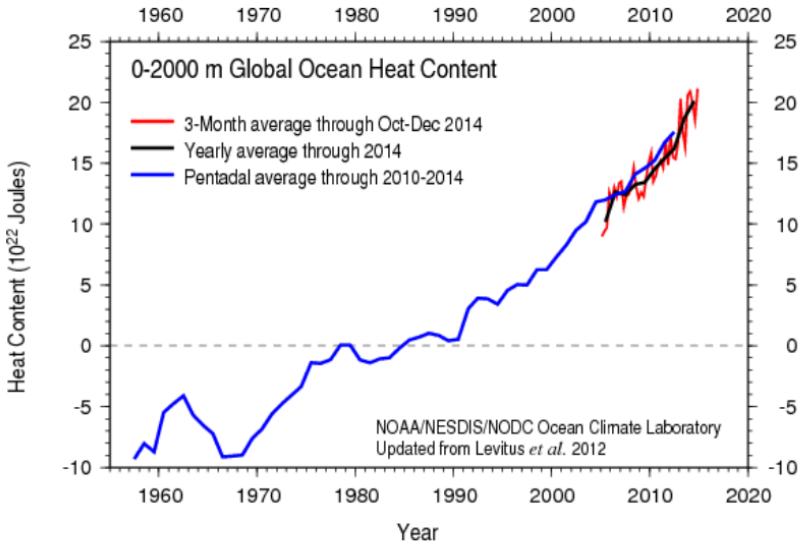
GLOBAL OCEAN'S HEAT CONTENT

At this point, the greenhouse effect starts to be taken very seriously, as is the carbon dioxide's cycle through living systems, which, as a result, is finally considered the main driving force to global warming.

Furthermore, a final proof for skeptics comes in 2005, when precise long-term measurements of temperatures in all the world's ocean basins are compiled.

Table 5: Global ocean's heat content

The heat content of the upper layers of the world's oceans is the most comprehensive measure of changes in the temperature of the planet. For as new heat is added, far more goes into the oceans than into the thin atmosphere. Several independent analyses of hundreds of thousands of measurements show that the ocean heat content began a steady rise i the 1970s. That was just when greenhouse gas levels reached a level high enough to be important. The hiatus some claimed to see in the rise of surface air temperature ca. 2000-2013 is not seen here. (For latest updates see NOAA's ocean heat content site.)



See Levitus et al., *Geophysical Research Letters* **39** (2012): L10603 [doi: 10.1029/2012GL051106].

Source: https://arxiv.org/ftp/arxiv/papers/1510/1510.02503.pdf

After a comparison between air and sea temperatures, the result shows that, while air temperature is almost the same since the late 1990s, in the massive oceans the added heat could possibly still warm their temperature; findings show that over many decades the planet's content of heat-energy has risen and rises still.

According to the measurements, in each separate ocean basin there is a close match between the pattern of rising temperatures measured at each location and depth and detailed model calculations of where the greenhouse effect warming should appear.

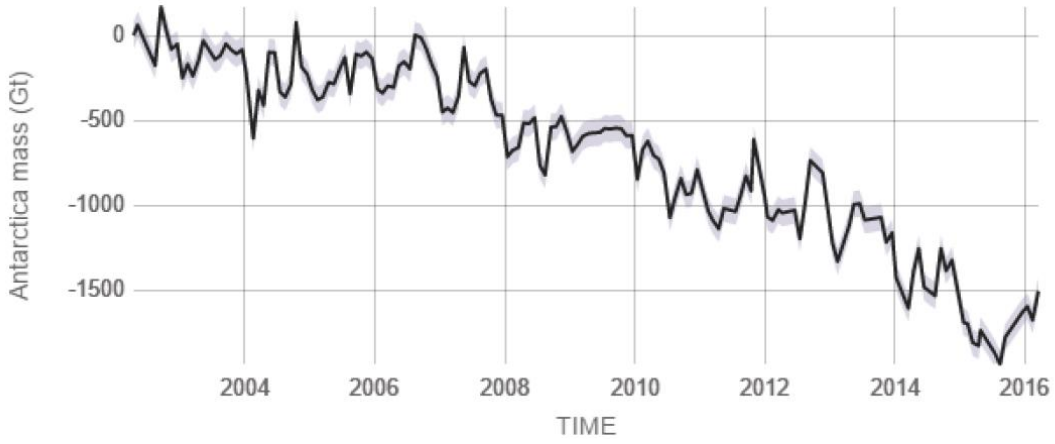
An eventual warming from other sources, such as a change in the Sun's output, would not produce these patterns and the same results.

Overlapping further studies in other fields, such as the study of plant species, final considerations regarding species such as magnolia, which has changed little since the rise of the dinosaurs, show that if you expose it to a higher level of CO2, the structure of its leaves changes.
Furthermore, several kinds of chemical studies of ancient rocks and soils help pin down how the level of the gas has swung widely over geological ages, and the temperature too.
About this issue, which is a very important finding, after a long effort made by many geochemists, data about the "climate sensitivity" in past eras, that is, the response of temperature to a rise in the CO2 level, pop up. Over hundreds of millions of years, a doubled level of the gas has always gone along with a temperature rise of three degrees, give or take a degree, in perfect agreement with the numbers coming from many computer studies.
It was (and is) not reassuring to see what the climate looked like in the ancient eras when CO2 had stood at a high level, a level that humanity would eventually reach if all the available oil and coal on Earth are burnt. To be clear, it would take many thousands of years to melt entire polar ice caps. But in the meantime, even a modest sea-level rise would disrupt humanity's teeming coastal populations. And as many scientists point out, if humanity's emissions continued, they seemed bound to bring not only "a warming unprecedented in the past million years," but changes "much faster than previously experienced by natural ecosystems."

1.5 Current situation: Earth's climate is warming

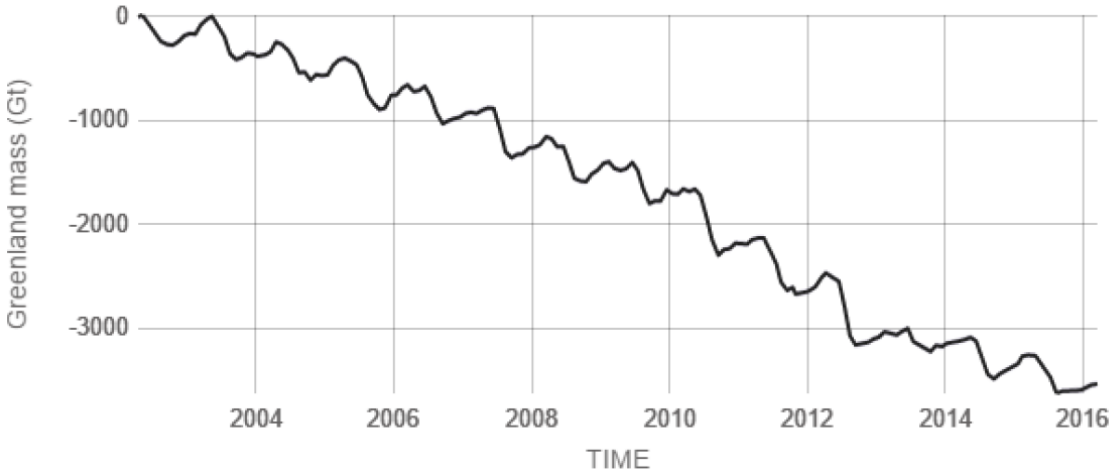
From the 20th century onwards, an increasing number of experts started to predict that effects on climate would become clearly visible around the year 2000, and they were right; global society entered the 21st century accompanied by a rising level of CO2 in the air, with an even faster rate than anyone had expected. In fact, in the last sixty years, humanity's output of carbon dioxide released in the atmosphere has quadrupled.
As predicted, the world has begun to suffer historically unprecedented heat waves, droughts, floods and storms. The sea level rises while mountain glaciers, the Greenland and Antarctic ice sheets, and Arctic sea ice melt back, all at accelerating rates.

Table 6: Antarctica mass variation since 2002



Source: Ice mass measurement by NASA's GRACE satellites

Table 7: Greenland mass variation since 2002



Source: Ice mass measurement by NASA's GRACE satellites

Important ecosystems show signs of stress; worse, field evidence show that the expected feedbacks are kicking in. The world's plants are taking up more CO2, but their capacity to absorb is waning; warmer oceans are absorbing less CO2. In sum, global warming has started to lead to more greenhouse emissions, which have led to more warming... and the story repeats.

Scientific evidence shows that the temperature of the upper layers of the ocean (0–700 m in depth) has been increasing, and that the global mean for sea surface temperature (SST) has been changing at a rate just behind that of global mean surface temperature (GMST). The surfaces of three ocean basins has warmed over the period 1950–2016, more precisely by 0.11°C, 0.07°C and 0.05°C per decade for the Indian, Atlantic and Pacific Oceans, respectively; (*Hough-Guldberg et al., 2014),* with the greatest changes occurring at the highest latitudes. *(IPCC Special Report, Ch. 3, 2018).*

The rapidity of these changes is to attribute to the use of ancient fossil fuels, which have released in the atmosphere a huge quantity of emissions, just in a few decades. According to the latest special report of the IPCC, these emissions are absorbed within clouds (47%, which is equal to 17.3 GtCo2/yr), forests (30%, which means 11.2 GtCO2/yr) and oceans (23%, 8.7 GtCO2/yr). Moreover, the biosphere of the Earth is buffering the world from even worse effects caused by these emissions.

Efforts to reduce the use of fossil fuels have had an effect, and by 2016 global emissions reported by national authorities were rising more slowly. However, even with a steady level of human emissions, carbon dioxide continues to accumulate rapidly in the atmosphere.

In fact, the report published in 2014 by the Intergovernmental Panel on Climate Change (IPCC) states that, "While more than half of the CO2 emitted is currently removed from the atmosphere within a century, some fraction of emitted CO2 remains in the atmosphere for many millennia." This implies that a large part of global warming will dwindle away within a few centuries after emissions cease. Temperatures will continue to creep upward until the ocean depths and their chemistry reach equilibrium with the heated air, until biological systems finish adapting to the new conditions, and until Arctic icecaps melt back to their own equilibrium.

“At a time where science is critical to the future of humanity, it's important that we all agree on the facts. We may disagree on policy, on the best course of action for society or the world, or on which concern is most paramount in terms of importance. But we have to agree on the same facts as a starting point.” *(Ethan Siegel, 2017)*

1.6 Greenhouse effect as a natural cycle

As noticeable, Earth's surface temperatures are relatively stable and mild, allowing various species, including human species, to develop their lives in a sustainable environment. This is possible because terrestrial atmosphere, with its layers and its gases, cloaks and protects the planet from solar impact. The moon, for example, which has almost no atmosphere, in its dark side "enjoys" the temperature of minus 53 degrees Celsius; Venus, on the other hand, has such a dense atmosphere that traps solar radiation that the temperature on its surface reaches 462 degrees Celsius.

Indeed, Earth enjoys a very delicate balance that acts everyday all across the planet, involving the radiation it receives from the Sun and the radiation it reflects back out to space.

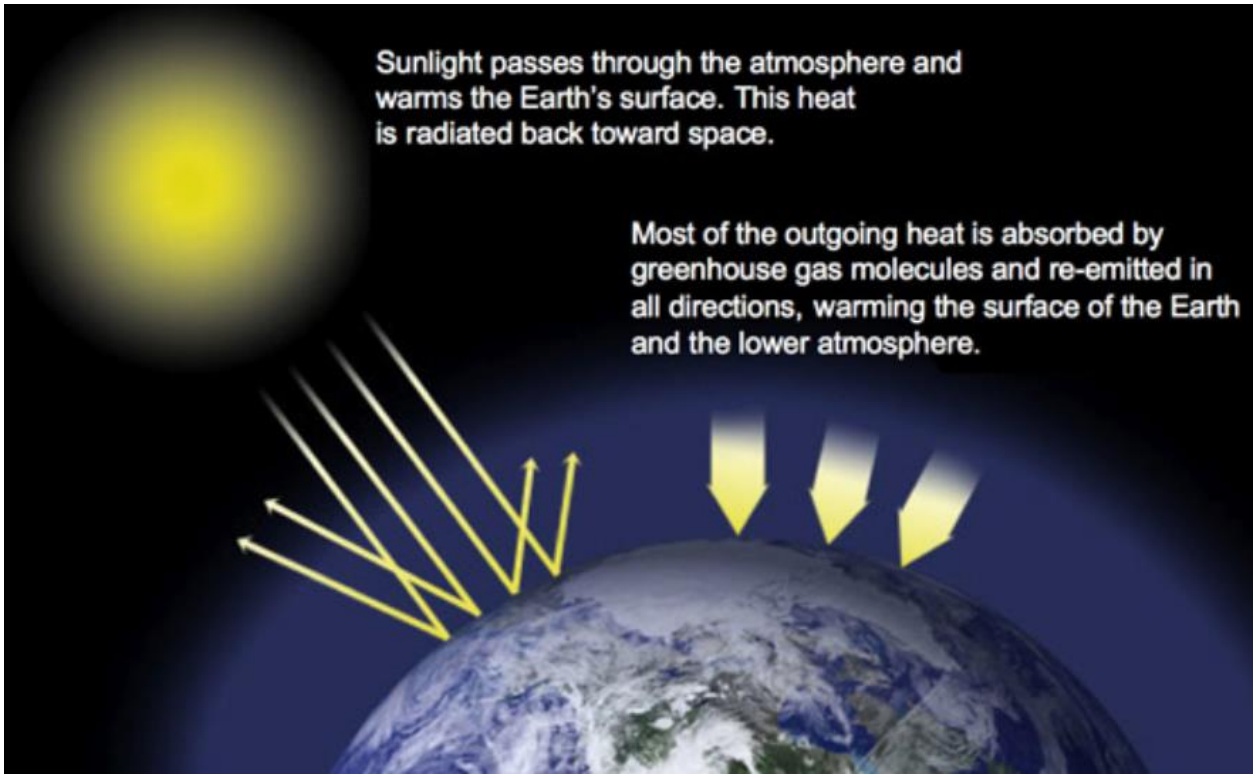
Solar radiation strike Earth's atmosphere in form of visible light, ultraviolet rays (UV) and infrared rays (IR), which are invisible to the human eye. UV radiation have shorter wavelength and higher energy level that visible light; on the contrary, IR radiation have longer wavelength and weaker energy level.

According to NASA studies, 31% of incoming solar radiation is directly reflected back to space by clouds. The remaining 69% is absorbed by the atmosphere (20%) and the remaining 49% is absorbed by oceans and land, which subsequently release heat in the form of infrared radiation, which are re-emitted into space.

According to the scientist John Tyndall, "The solar heat possesses the power of crossing an atmosphere; but when the heat is absorbed by the planet, it is so changed in quality that the rays emanating from the planet cannot get with the same freedom back into space. Thus the atmosphere admits the entrance of the solar heat, but checks its exit; and the result is a tendency to accumulate heat at the surface of the planet."(*Oxford University Press, 1998)*

This exchange of incoming and outgoing radiation is referred to as the greenhouse effect, with the absorption of the heat done by the so-named greenhouse gases. This natural process is what allows Earth's temperature to sustain life, and even with small changes, the altered equilibrium can have very strong impacts on its inhabitants and natural ecosystems.

Table 8: The greenhouse effect



Source: https://climate.nasa.gov/causes/

1.7 Greenhouse gases (GHGs)

As stated above, greenhouse gases play an important role in the greenhouse effect; indeed, carbon dioxide and the other greenhouse gases act like a blanket, absorbing IR radiation and preventing it from escaping into outer space. The net effect is the gradual heating of Earth's atmosphere and surface, a process known as global warming. (*Marc Lallanila, 2018)*
Which are these gases?

<u>WATER VAPOR</u>

Water vapor (H2O) is the main GHG present in the atmosphere and changes in its concentration are also a reflection of climate responses to global warming. As the atmosphere's temperature grows, more water evaporates from ground

storage, such as rivers, oceans, reservoirs and soil. Since the air is hotter, the absolute humidity can be higher (i.e. the air is capable of retaining more water when it's warmer), leading to more water vapor in the atmosphere. What makes it a greenhouse gas is the fact that higher is its concentration in the air, more thermal IR energy is absorbed and remitted by the Earth, and warmer is the atmosphere, and so on, as a cycle, which is called: positive feedback loop. Nevertheless, scientific doubt exists in depicting the magnitude and importance of this feedback loop. As water vapor's concentration grows in the atmosphere, more of it will transform into clouds, which can then reflect more incoming solar radiation (hence permitting less energy to spread on the planet's surface and warm it up). In the near future, the study of atmospheric processes involving water vapor will be critical to wholly understand the responses of the climate system leading to global climate change. Although there are good atmospheric measurements of other GHG as carbon dioxide and methane, worse measurements for global water vapor are available. There is a lack of confidence on how much its atmospheric concentrations have increased in the latest decades and centuries; however, satellite measurements, combined with balloon data and some ground measurements indicate overall positive trends in global water vapor increase.

CARBON DIOXIDE

Carbon dioxide (CO2), which will be further analyzed in Chapter 2, is an important heat-trapping (greenhouse) gas, which is released through human activities such as deforestation and burning fossil fuels, as well as natural processes such as respiration and volcanic eruptions. The usual cycle of carbon dioxide is realized through the terrestrial biosphere and the ocean. Nevertheless, by consuming oil, natural gas, coal and wood since the industrial revolution, humankind has transformed the natural carbon cycle. CO2 was the first greenhouse gas verified to be growing its concentration in the atmosphere with the first certain measurements. Preceding the industrial revolution, concentrations were stable at 280ppm. Nowadays, they are about 410ppm, a rise of over 35%.

METHANE

Methane (CH4) is an enormously actual absorber of radiation, even though its concentration in the atmosphere is of small amounts and its lifetime is just

(10-12 years) compared to other GHG. Methane comes from either natural or human activities: from biological processes in low oxygen environments (as in swamplands); and during the last 50 years, from anthropological activities such as rice production, livestock, usage of natural gas and coal have added additional methane to the atmosphere. Direct measurement of methane, available since the 1970s, have shown a rise of about 1 percent per year until1990.

TROPOSPHERIC OZONE

Tropospheric ozone (O3) has always been present in the atmosphere, collected in a wide band called "ozone layer"; it is made by the merging of sunlight ultraviolet radiation with oxygen. A tiny portion of this ozone naturally drops away to the surface of the planet. However, over the 20th century, ozone created by human processes has been added to the natural tropospheric ozone. The emissions from vehicles and factories (as well as deforestations) induce larger concentrations of carbon and nitrogen in the lower part of the atmosphere which, by interacting with the solar radiation produce ozone. Therefore, ozone is more abundant in and around cities than in lightly populated areas, but it is transported by wind. Ozone is a significant contributor to urban smog. Even though ozone has a short lifetime and consequently does not mix so well in the atmosphere, there is a band more concentrated during northern hemisphere spring and summer between latitudes 30°N and 50°N, a resultant of the more urban and industrial activity in this band. IPCC considers ozone to be the most significant GHG after methane and carbon dioxide because has increased significantly in its concentration since the pre-industrial period.

NITROUS OXIDE

The amount of nitrous oxide (N2O) in the atmosphere has been increasing since the first industrial revolution and comes from microbial processes in soil and water, inclusive of the reactions happening in fertilizers with nitrogen. The overall concentration of nitrous oxide has risen due to extensive use of fertilizers in agriculture during the last century and in diverse industrial processes (fossil fuel-fired power plants, nylon production, nitric acid production and vehicle emissions) also has contributed to its growth in the atmosphere.

CHLOROFLUOROCARBONS

Chlorofluorocarbons (CFCs) are not natural gases, but are completely synthesized for various uses such as refrigerants, aerosol propellants and cleaning solvents. Since their creation in 1928, the amount of CFCs dispersed in the atmosphere has been increasing significantly. When it was discovered that these gases were capable of destroying the ozone layer, the worldwide effort to stop their production was commenced. The effectiveness of this effort can be noticed by the systematical decline of CFCs concentration in the atmosphere until today. Still, their atmospheric lifetime are about over 100 years. This is a huge concern based on their properties of absorption. More groups of synthesized GHGs with a long lifetime in the atmosphere are CF4 (carbon tetrafluoride) and SF6 (sulfur hexafluoride).

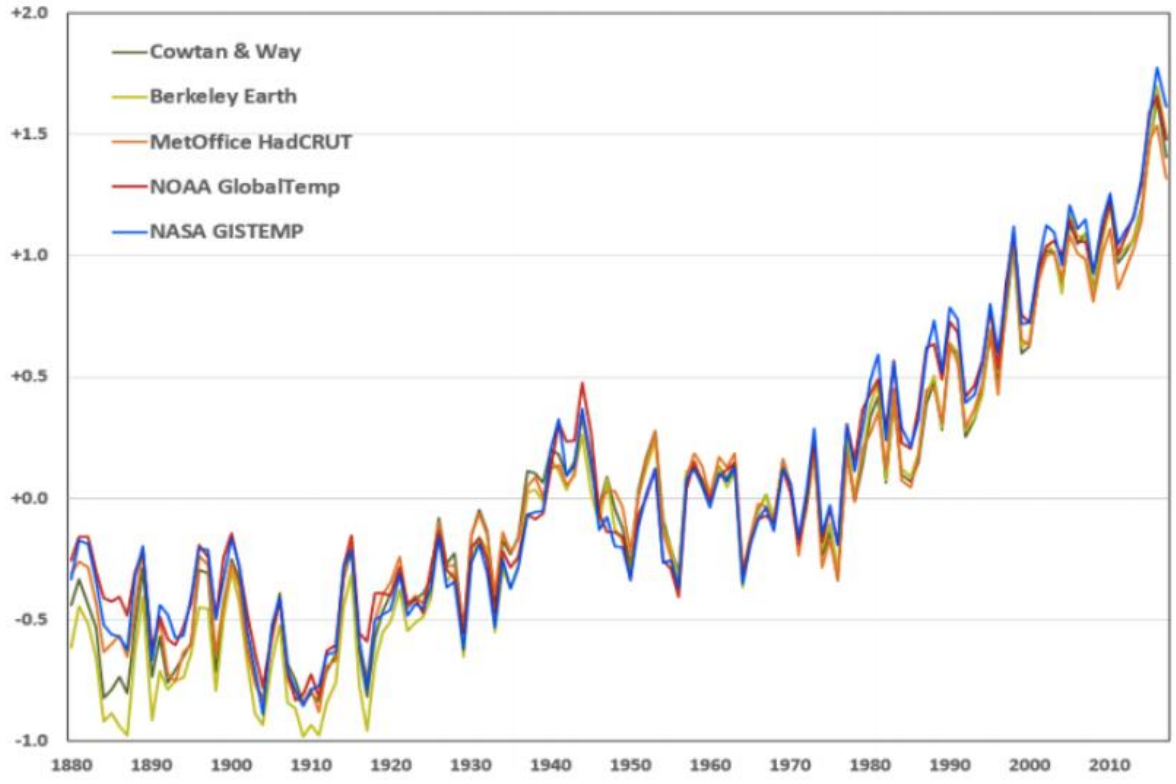
CARBON MONOXIDE AND OTHER REACTIVE GASES

Even though carbon monoxide (CO) is not a GHG since it does not absorb enough of Earth's thermal energy, is a proactive modulator of methane and tropospheric ozone. Since at least half of the CO emissions are generated by anthropological activities located mainly in the northern hemisphere, this region holds around twice the amount of CO than that in the southern hemisphere. Because of its huge spatial variability, it is hard to compute the global concentrations of this gas. Nevertheless, they seem to have been increasing until the late 1980s and since then have been declining to some extent. One reason is probably the decrease in carbon monoxide emission due to the diffusion catalytic converters in modern motor vehicles. As CO, Volatile Organic Compounds (VOCs) also have a slight effect as GHG, because of their capacity of modulating ozone emanation. These include non-methane hydrocarbons (NMHC), and oxygenated NMHCs (i.e. alcohols and organic acids), all coming from mainly natural sources. Also anthropogenic emissions increase these gases by. vehicle emissions, fuel production and biomass burning.

1.8 Human activity

"Climate, if it changes at all, evolves so slowly that the difference cannot be seen in a human lifetime." That was the opinion of most people, and nearly all scientists, through the first half of the 20th century. People expected that after a few years "the weather" would automatically drift back to its "normal" state, the conditions they were used to. The planet's atmosphere was surely so vast and stable that outside forces, ranging from human activity to volcanic eruptions, could have no more than a local and temporary effect." *(Joseph E. Postma, 2015)*

Table 9: Global temperature measured by the most reliable scientific sources



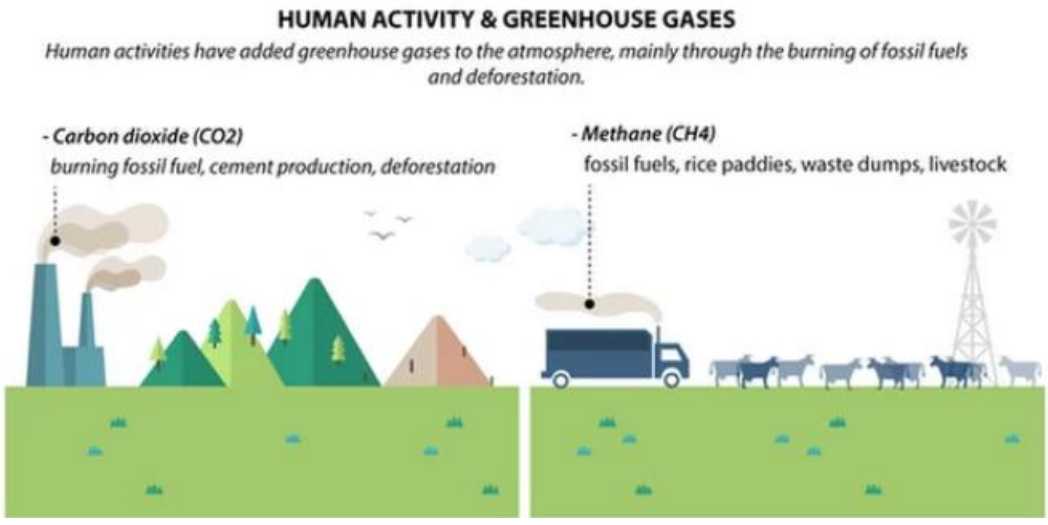
Source: https://climate.nasa.gov/scientific-consensus/

A fast look to the graph above, which shows the global temperature measurements by the most reliable scientific sources, with no doubt disclaims the innocence of human activity. As the 97% of the scientific community

states, after a study made by 1300 experts for the Intergovernmental Panel on Climate Change (IPCC): climate-warming trends over the past century are extremely likely due to human activities. In addition, most of the leading scientific organizations worldwide have issued public statements endorsing agreeing with this position." *(John Cook, 2016)*

It is true that the Earth, due to changes in its orbit (Milankovitch cycles), goes through natural cycles of temperature increase and decrease. On the other hand, since the 19th century, the increase in global temperature by about 0.6°C is considered by the IPCC to result mainly from increased greenhouse gas concentrations. From the period going to 1750 until the year 2001, there was an increase of 31% carbon dioxide, 150% methane and 16% nitrous oxide concentration in the atmosphere. This can be attributed to the massive burnt of ancient fossil fuels, change in land use and agriculture, and decrease of carbon sinks such as forests through deforestation. However, human emissions will be detailed discussed in Chapter 2.

Table 10: Main activities and main GHGs released in the atmosphere



Source: https://www.livescience.com/37743-greenhouse-effect.html

1.9 Climate diplomacy and International Agreements

Table 11: Climate Negotiations Timeline

1979 - First World Climate Conference.

1988 - The Intergovernmental Panel on Climate Change (IPCC) is created; it expresses the need of a global treaty on Climate Change.

1992 - At the Earth Summit in Rio, the UNFCCC is opened for signature along with the Rio Convention, the UN Convention on Biological Diversity and the UN Convention to Combat Desertification.

1994 - The UNFCCC enters into force.

1995 - First Conference of the Parties (COP 1) in Berlin.

1996 - The UNFCCC Secretariat is set up to support action under the Convention.

1997 - The Kyoto Protocol is formally adopted in December at COP3.

2001 - The rules for implementation of the Kyoto protocol are expressed at the Marrakesh Accords and subsequently adopted at COP7, setting up new funding and planning instruments for adaptation and establishing a technology transfer framework.

2005 - Kyoto Protocol enters into force. The first Meeting of the Parties to the Kyoto Protocol (MOP 1) takes place in Montreal.

2007 - IPCC's Fourth Assessment Report is released, projecting Climate science into popular consciousness. At COP13, Parties agreed on the Bali Road Map, which charted the way towards a post-2012 outcome in two work streams: the AWG-KP, and another under the Convention, known as the Ad-Hoc Working Group on Long-Term Cooperative Action Under the Convention.

2009 - At COP15 the Copenhagen Accord is drafted. Countries later submitted emissions reductions pledges or mitigation action pledges, all non-binding.

2010 - The Cancun Agreement is drafted and largely accepted by the COP, at COP16. Countries made their emission reduction pledges official, showing the largest collective effort the world has ever seen to mutually reduce emissions.

2011 - At COP17 the Durban Platform for Enhanced Action drafted and accepted.

2012 – The Doha Amendment to the Kyoto Protocol is adopted by the CMP at CMP8. It included new commitments for Annex I Parties to the Kyoto Protocol who agreed to take on commitments in a second commitment period from 1 January 2013 to 31 December 2020; a revised list of greenhouse gases to be reported on by Parties in the second commitment period;

2015 - COP21 or CMP11 held in Paris, France in December.

2016 - COP22 held in Marrakesh.

2017 – COP23 held in Bonn, Germany; parties continued to negotiate the finer details of how the Paris Agreement will work from 2020 onwards.

2018 – COP24 held in Katowice, Poland; the IPCC releases a new special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways,

Source: slightly adapted from UNFCCC website

During the 21st century, international efforts in addressing climate change have been made by the majority of world coutries. All the governments, the major scentific societies and other bodies representative of scientific expertise agreed that current society is facing a serious problem; as a consequence, strict policies to restrict GHG emissions have to be adopted. However, the implementation of these policies, often going against economic interests, is not always easy.

The fundamental agreement about climate change is the United Nations Framework Convention on Climate Change (UNFCCC), which, as the above table states, represents one of the three Conventions adopted in Rio, 1992. Today, it is subscribed by 197 parties (196 countries and the European Union). International negotiations about climate change refer to this agreement as a framework for multilateral cooperation, as it gives the guidelines in order to address climate impacts on ecosystems and individuals. UNFCCC's aim is to stabilize GHG emissions in the atmosphere in order to prevent dangerous consequences for the planet as a whole, due to dangerous anthropogenic interferences. The Conference of the Parties (COP), is the decisional body of the UNFCCC, and it annually reunites Member States in order to monitor and implement their environmental policies.

In 1997 the Kyoto Protocol, which introduced juridically binding emissions reduction, was subscribed by 37 Countries and the EU. The Protocol had the objective to reduce GHG emissions by 5% regarding 1990 levels. It entered into force in 2005, after Russia's subscription, however, it was not as effective as everyone expected. Its main limit was that the action was required only by developed countries; furthermore, it applied just to 14% of global emissions, as the United Stated refused to sign, Canada retired and Russia, Japan and New Zeeland did not take part to the 2nd commitment.

As evidence shows, the international arena can be very difficult to manage, most of the time States do not agree with each other and implement actions of this size can be very tricky and useless if not done in the right way. Politics and economy enter the game, and even if the scientific expertise keeps on sustaining the view that actions have to be taken now in order to avoid a catastrophe, it is not always so easy. However, there are technical aspects and fundamental elements that are shared among countries, and the main are: the need of adaptation and mitigation strategies; pre-2020 actions; transparency; long term objectives; climate finance; technology transfer; capacity building;

legal and institutional aspects; monitoring activities of climate damages and losses; market mechanisms and emissions management; compliance control.

From Paris Agreement to COP24

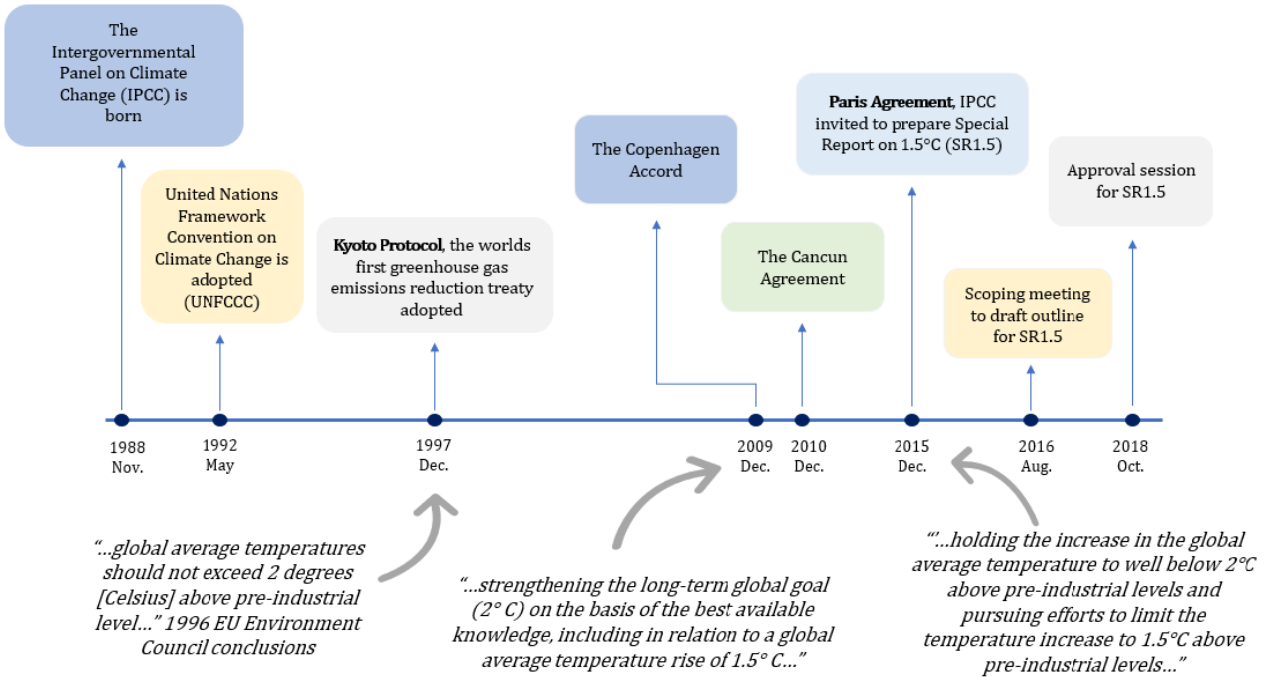
At COP 21, which took place in December 2015, 195 States signed the Paris Agreement, first-ever universal, legally binding global climate agreement.
It has marked an important point as, contrary to the Kyoto Protocol which required efforts just for industrialized countries, almost every UN Member State showed specific commitment in reducing GHG emissions (National Determined Contributions, also known as NDCs). They consist in national plans that have the aim to reduce emissions, revised every 5 years.
Indeed, the Agreement's main objective is to contain global temperature rise under 2°C regarding pre-industrial levels, requesting additional commitments for a further decrease to 1.5°. However, announced national plans are not enough to achieve this aim, so an increase in policy implementation procedures will be needed in the future.
Another important point that the Paris Agreement considers important is States capacity to face climate impacts. The main shared points about this issue are: mitigation (emissions reduction), adaptation (strengthen capacities to face the impacts), new technological and capacity building approach, transparency (report progresses and actions taken to fulfill the objectives of the agreement), climate finance (financial support should be provided by industrialized countries).
Developed countries, under the application of "shared but differentiated responsibilities" principle, will have to reach their peak of emissions as soon as possible, for starting, in the second half of this century, a situation of decrease of anthropogenic emissions.
This accord also provides a strong monitoring and reporting mechanism, in which every party has the duty to detail periodically (every 5 years), its pursued progresses and efforts to implement NDCs.
The Paris Agreement entered into force the 4th of November 2016 with an unprecedented rapidity, and with 183 States ratifying it directly.
The consequent negotiations, COP22, COP23 and COP24, allowed the establishment of a detailed "Paris Work Plan", which comprises all the necessary rules to its effective actuation. In Marrakech, at COP23, significant procedures were drafted, especially regarding mitigation and adaptation

mechanisms, climate finance and transparency. Another important achievement, always at COP23, has been the "Tanaloa Dialogue", which will provide, with an inclusive approach, the implementation and enhancement of NDCs. In fact, at COP26 (2020), States will be called for the first time to report their efforts in achieving the plans reported at COP21.
The Global Alliance to Power Past Coal has been launched, with more than 20 countries adhering to it, including Italy.
From all the cited initiatives, an optimistic picture emerged, together with an increasing consciousness about the importance of the current global situation.

1.10 Italian Position

Italy is currently playing a leading and ambitious role within the European Union regarding environmental policies, especially referring to excellent performances in energy efficiency and development of renewable energies. Indeed, it has already reached a few objectives the Union projected for 2020. In the national context, Italy has good relationships with third countries, in particular with developing countries, with which it has a special cooperation regarding overall financial measures, capacity building, personnel training and technological support. In particular, the African Centre for Sustainable Development deserves a mention; it is located in Rome, and its main task is to provide information regarding initiatives about climate change, energy, energy efficiency and sustainable development in Africa.
After the ratification of the Paris Agreement Italy did not miss the chance to show its engagement in this cause as it increased its climate finance contribution, reaching 4 billion $ for the period 2015 – 2020. These resources will be provided by both public and private subjects, both bilateral and multilateral. To reach this challenging aim, Italy raised public climate expenditure of 70% with respect to the preceding biennium (2013-2014). For instance: it will contribute with 92 million € to the 7th "replenishment of the Global Environment Facility (GEF)", for the period 2018-2022. Meanwhile, in the period 2018 – 2020, Italy will donate over 361 million € to various Development Banks, adding also 760 million € to the World Bank and 10 million € for IFAD. In addition, it will participate to the Multilateral Fund (MLF) with 28,3 million $, which will be used to implement the Kigali Amendment (avoid up to 0.5% temperature increase by the end of the century).

Table 12: Main steps to the 1.5° C purpose



Source: Personal elaboration based on IPCC Special Report (2018)

2. EMISSIONS

2.1 Natural emissions

As stated in the previous chapter, GHG emissions present in the atmosphere derive from both natural and anthropogenic sources. It is important to understand, in order to avoid further damages to the planet, which one contributes most to climate change and in which manner. Evidence shows that GHG human emissions upset the balance in the carbon cycle that has always worked according to a delicate equilibrium among sources and sinks. Before anthropogenic influence in fact, carbon dioxide and other GHG levels were quite steady because natural emissions were almost completely offset by natural sinks.
According to a recent Chinese study, GHG natural emissions have been measured, in order to understand their impact and peculiarities.

FOREST FIRES

Forest fires are one of the major natural contributors of GHG emissions, with approximately 90% of released gases composed of carbon dioxide. Both at global and regional scale various researches have been conducted, with the support of various techniques, and, the estimated annual GHG emissions caused by forest fires range between 7 – 16 Gt CO2 – eq.

OCEANS

On the contrary, oceans represent the biggest carbon sink of the planet; and by sink meaning that they absorb more carbon than they release. Indeed, the carbon content present in the oceans is 50 times that of the atmosphere and 20 times that of the biosphere. Oceans play a very important role in regulating GHG concentrations in the air, and various researches have been portrayed in order to fully understand their impact. The results showed that the North Atlantic and coastal Norway - Greenland oceans are strong CO2 sinks. Nonetheless, the North Pacific serves as CO2 source in winter and CO2 sink in summer, meaning that in winter it releases more CO2 than it absorbs, due to seasonal variation. Furthermore, in the equatorial Pacific alone, 60% of the total amount of CO2 released by the oceans takes place.

WETLANDS

Wetlands are ecosystems composed by marshes, peat lands and lakes. They represent the biggest carbon pool on Earth, with carbon stocks that account for 15% of the total land surface carbon *(YUE Xi-Liu, 2018).* They are a major source of methane (CH4) emissions, and their intensity and variation, apart from seasonal changes, is influenced by hydrological conditions and rising temperatures. Methane annual emissions emitted by wetlands represent approximately the 15 – 30% of the total CH4 natural emissions. Studies show that global GHG emissions from wetlands are 2.4 – 7.5 Gt CO2 – eq per year.

PERMAFROST

Permafrost, a permanently frozen layer of soil beyond the surface at variable depth located mostly in Siberia, Canada and Alaska, has also been subject of studies in order to understand its contributions regarding emissions of CO2 and CH4. While frozen, the northern permafrost soils represent the largest terrestrial organic carbon pool on Earth. However, recent observations and projections of future soil warming and permafrost thaw suggest that permafrost soil carbon will be increasingly vulnerable to decomposition by microbes that generate carbon dioxide and methane. Recent measurements show that its emissions range between 2.3 and 7.8 Gt CO2 – eq per year. However, its stability is put at risk by the rising temperatures of the planet, with consequences of releasing even more methane and carbon dioxide.

VOLCANOES

Volcanoes eruption release a huge quantity of gases in the atmosphere, mostly methane and carbon dioxide, but, as they occur abruptly and destructively, on site monitoring is very difficult, and as a consequence, measurements are limited and spotted. However, the little data available shows that their emissions are slower, but last longer in the atmosphere, releasing high levels of GHG. It has been proposed that intense volcanic emissions of carbon dioxide cause global warming, constituting also a scientific debate in the present. However, present-day subaerial and submarine volcanoes release less than 1% of CO2 currently released by anthropogenic activities.
(https://volcanoes.usgs.gov/vhp/gas_climate.html).

The annual total GHG emissions from volcanoes ranges approximately between 187 and 277 Mt CO2-eq.

MUD VOLCANOES

This type of volcanoes is characterized by the eruption of mud. During their activity they are able to produce and release large amounts of hydrocarbon gas. The main GHG released by these volcanoes is methane, which accounts of 95% of the total hydrocarbon gas, together with small amounts of CO2. Observations about the emission flux during their intermittent and explosive episodes have been made, with the result of their total emissions ranging between 750 Mt CO2 – eq per year.

EARTHQUAKES

Earthquakes constitute a direct source in the release of CO2 from the Earth and from the decay of plants and animals after earthquake events. However, researchers have had a lot of difficulties in measuring the exact amounts of GHG emitted through these phenomena, and as a consequence little evidence is today available.

Table 13: Annual GHGs natural emissions

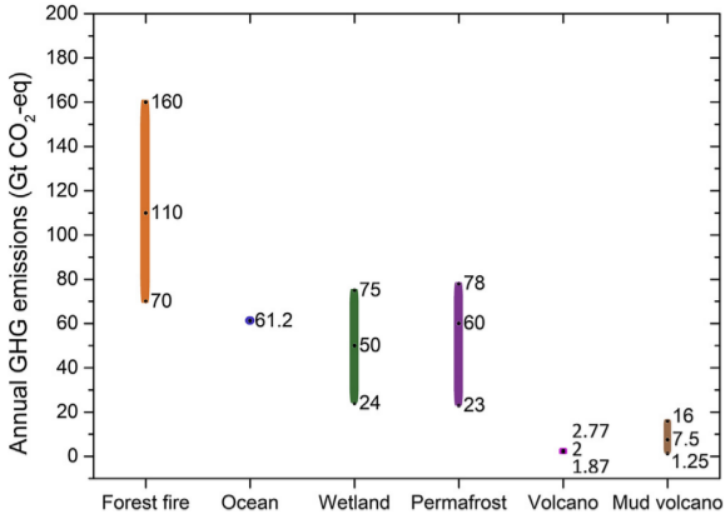


Fig. 1. Global natural source GHG emissions; also shown are the maximum, minimum, and recommended (dark point) values.

Source: www.sciencedirect.com (Report: contributions of natural systems and human activity to greenhouse gas)

The above graph displays the ranges and GHG emissions from natural sources. They range from 18.13 to 39.30 Gt CO2 – eq per year, with a mean value of 29.07 Gt CO2 – eq. Emissions from forest fires cover almost 38%, oceans 21.05%, wetlands 20.64% and permafrost 17.2%. Ultimately, volcanoes and mud volcanoes are much less, ranging from 1 to 3% of the total amount.

2.2 Anthropogenic Emissions

On the other hand, there is plenty of evidence, resulting from decades of various studies, to support the hypothesis of human activity being majorly responsible for the recent warming. The first indicator includes the elementary physical understanding of how greenhouse gases trap heat, how the climate system responds to increases in GHG, and how other human and natural factors influence climate. The second is from secondary assessments of climate changes during the last 1,000 to 2,000 years. Estimates are regularly obtained from living organisms and their residues (like tree rings and corals) which offer a natural record of climate mutations. These indicators express that the current rise in temperature is obviously unfamiliar in minimum the last 1,000 years.

Table 14: Main GHGs global trends

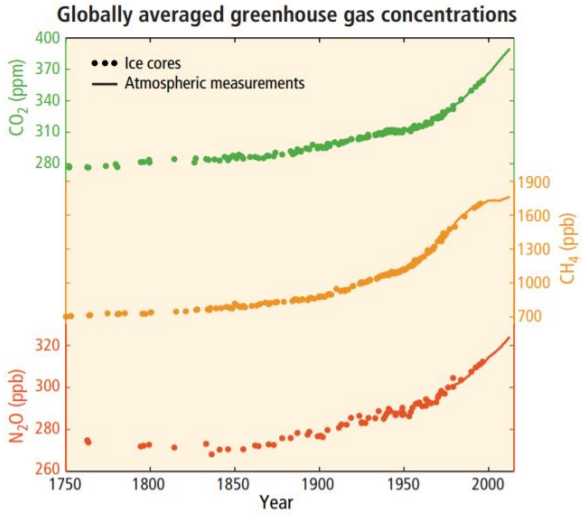
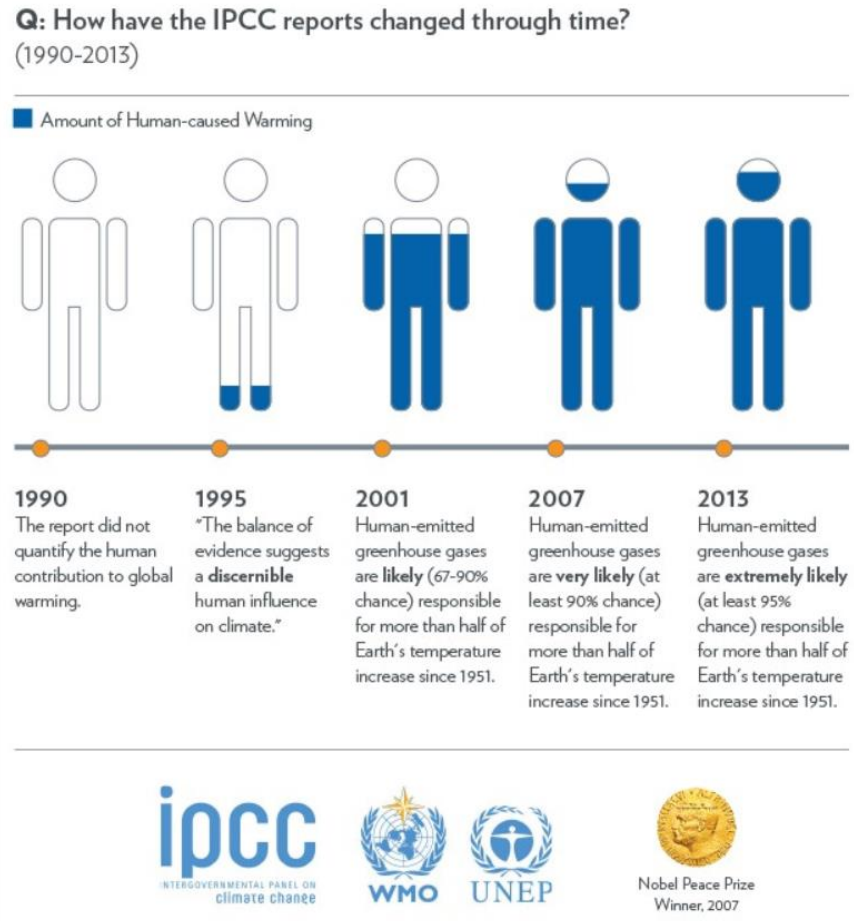


Figure 1.3 | Observed changes in atmospheric greenhouse gas concentrations. Atmospheric concentrations of carbon dioxide (CO_2, green), methane (CH_4, orange), and nitrous oxide (N_2O, red). Data from ice cores (symbols) and direct atmospheric measurements (lines) are overlaid. *{WGI 2.2, 6.2, 6.3, Figure 6.11}*

Source: IPCC Special Report (2018)

The third kind of evidence is grounded in comparisons of real climate with computer models of how we presume climate to perform under some anthropological stimuli. For instance, when climate models are run with historical rises in GHG, they display gradual warming of the Earth and ocean surface, rises in ocean heat content, an increase in global sea level, and overall retreat of sea ice and snow cover. Anthropological deeds are changing the natural greenhouse that is the Earth. During these last centuries, the burning of fossil fuels like coal and oil has inflated the amount of carbon dioxide in the atmosphere. This occurs because the coal or oil burnt in the processes release CO2 into the air. Other activities like the clearing of land for agriculture and industry have significantly augmented concentrations of GHG.

Table 15: Human contributions according to IPCC



Source: https://www.ucsusa.org/sites/default/files/images/2017/07/Humantcontribution.jpg

According to WEO 2018 data, global CO2 emissions rose in 2017 by more than 500 Mt (million tons) after three years of remaining flat. The increase has been caused by a combination of factors, the main one represented by a strong economic growth. The link between economic growth and rising emissions even if it is weakening, is still a positive one. Moreover, low oil and gas prices, and a slowdown in the spread of energy efficiency standards have contributed in the increase of GHG emissions.

However, the upward trend has not been homogeneous around the world. Indeed, energy-related CO2 emissions diminished in the United States, largely thanks to the rising disposal of renewable energies. Nonetheless, emissions increased in most other regions, with 75% of the increase occurring in Asia. The European Union, on the contrary, have implemented been many policies focused on CO2 emissions, especially regarding the EU Emissions Trading System, which represents the biggest world emissions trading scheme. In China, one of the largest emissions contributors on global scale, a national emissions trading system has been also announced in late 2017. Moreover, in Canada, the federal government announced national carbon pricing measures as a backstop for provinces and territories that do not introduce their own measures. An increasing number of countries are also introducing specific taxes on carbon, often in the context of delivering on their pledges to combat climate change. Argentina, Singapore and South Africa have proposed carbon taxes to be implemented in 2019. Argentina's tax targets emissions from transport fuels and coal and aims to cover 20% of the country's GHG emissions, with a gradually increasing tax rate *(WEO 2018).*

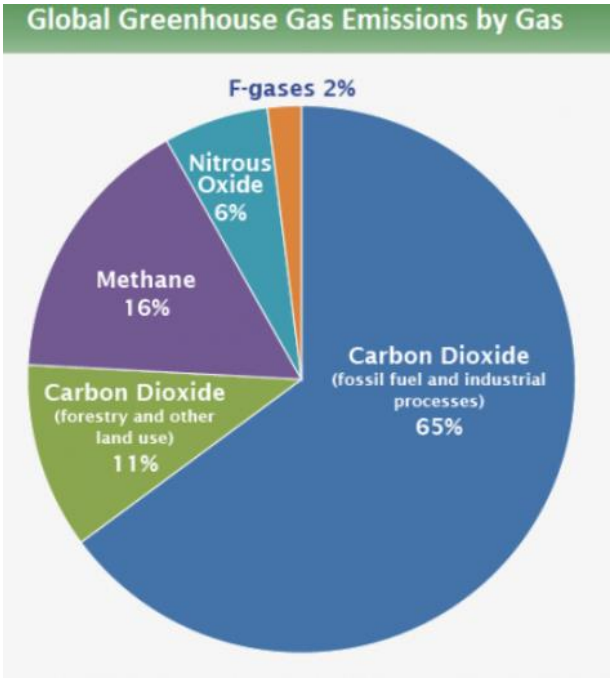
Many other policies indirectly influence CO2 emissions, ranging from subsidies to market mechanisms to regulations. These include demand-side policies, such as for energy efficiency, as well as supply-side technology and market policies, changes in feed-in tariffs and other price support policies.

2.3 Emissions by source

Human caused GHG emissions have increased since the pre-industrial era, caused mainly by economic and population growth, and from 2000 to 2010 emissions were the highest registered in history. Concentrations of carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) have all shown large increases since 1750 (40%, 150% and 20%, respectively). Carbon dioxide concentrations are increasing at the fastest observed decadal rate of change

(2.0 ± 0.1 ppm/yr) for 2002– 2011. After almost one decade of stable CH4 concentrations since the late 1990s, atmospheric measurements have shown renewed increases since 2007. N2O concentrations have steadily increased at a of 0.73 ± 0.03 ppb/yr over the last three decades.

Table 16: Global GHGs concentrations



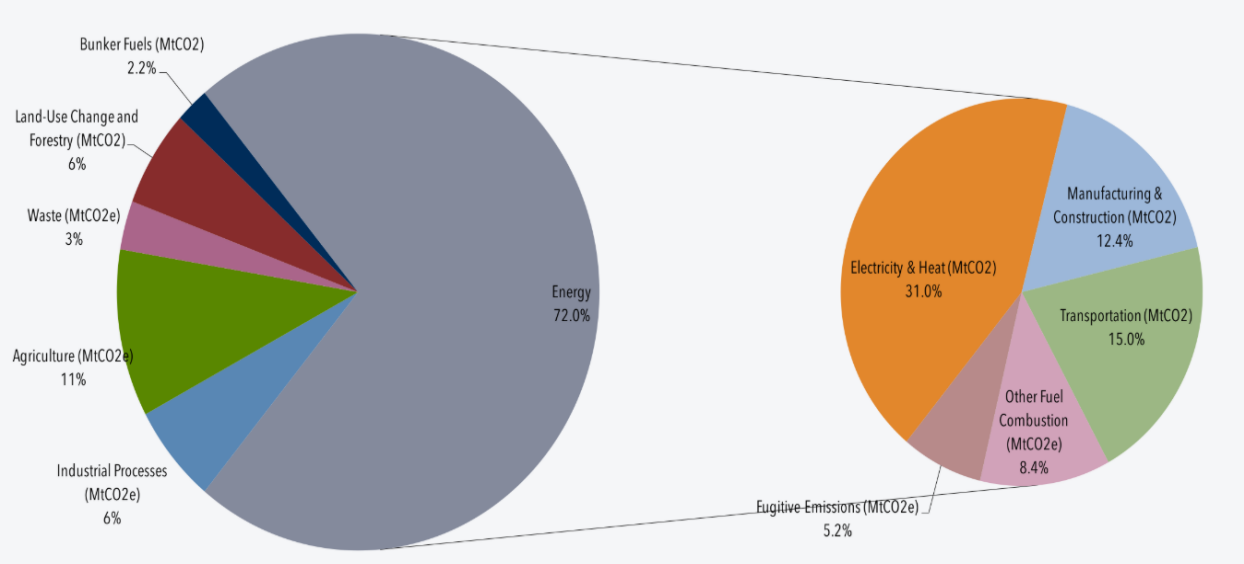
Source: IPCC, 2014

Due to data analysis, this paper mainly focuses on CO2. The pie chart shows in percentage the contributions of each gas to the total amount; it is clear how CO2 is the main driver, as it covers 76% of the entire graph.

2.4 Emissions by sector

As stated throughout this work, most important human activities emit greenhouse gases; activities that now are essential to the global economy and constitute a fundamental part of modern life.

Table 17: Global manmade emissions by sector



Source: https://www.c2es.org/content/international-emissions/

ENERGY

Most GHG contributions are clearly associated with energy (72%), and are emitted when fossil fuels are burned.; they represent the largest single source in producing carbon dioxide among all human activities. The supply and use of oil, natural gas and carbon accounts for three quarters of mankind's CO2 emissions, one-fifth of the methane, and a large quantity of nitrous oxide.

Fossil fuels are mainly composed by carbon and hydrogen; with their combustion, oxygen combines with carbon and forms CO2 and then with hydrogen forming H2O; the amount of carbon dioxide produced depends on the carbon content of the fuel, usually expressed in percentage.

Moreover, extracting, processing, transporting, and distributing fossil fuels also releases greenhouse gases; in addition to this, gases can also be released through accidents, poor maintenance, and small leaks in well heads, pipe fittings, and pipelines.

In order to reduce these types of emissions, a variety of opportunities can be pursued with reference to electricity generation, transmission and distribution. Renewable energies and nuclear energy are surely two of the most efficient measures, as using these types of sources simply eliminates the use of fossil fuels; increased efficiency of power plants and fuel switching can

be another viable solution, as using advanced technologies or substituting fuels that combust more efficiently pollute less. Furthermore, reducing energy demand by increasing energy efficiency can help in reducing emissions. Moreover, capturing CO2 as a byproduct of fossil fuel combustion before it enters the atmosphere, and then transferring it to a long-term storage area, known also as Carbon Capture Sequestration and Storage (CCS), can represent an alternative.

In the African Continent, where a lot of people still do not have access to energy, it is a challenge to meet the growing energy demand while simultaneously try to reduce carbon dioxide emissions. African countries involvement in international dialogues regarding climate change has set out the opportunity, for this continent, to develop and be an example in energy transition to cleaner sources.

AGRICOLTURE

Agriculture, which comprises crop and livestock production for food, has its part in contributing to global emissions (11%); One of the ways this activity pollutes the air is through the poor management of agricultural soils, meaning the use of synthetic and organic fertilizers, the drainage of organic soil, and inefficient irrigation practices, which can increase the emissions of nitrous oxide. Furthermore, the report published by the Food and Agricultural Organization (FAO), entitled *Livestock's Long Shadow*, analyses the global damage done by sheep, chickens, pigs and goats, even if the world's 1.5 billion cattle are the ones to “blame” most. Indeed, livestock are responsible for 18% of the greenhouse gases that cause global warming, mainly methane.

Intensive rice cultivation also releases methane. "Wetland" rice farming produces almost one-quarter of global methane emissions from human activities. Covering roughly 90% of all rice production, wetland rice is grown in fields flooded or irrigated for much of the growing season. Bacteria and other micro-organisms present in the soil of the flooded rice fields decompose organic matter and produce methane.

In order to reach the aims defined by international agreements, opportunities to reduce emissions produced by the agricultural sector have to be implemented; as follows a few strategies that have already given proof to be effective: land and crop management, by adjusting and improving the methods of managing land and growing crops, such as fertilizing them with

the appropriate amount of nitrogen necessary for optimal crop production, without over-applying it; livestock management, which means adjusting practices and methods to reduce the amount of methane resulting from enteric fermentation (cattle's digestive process).

LAND MANAGEMENT

Forests represent an important carbon stock, containing a large part of the carbon dioxide stored on land. Indeed, they stock 283 Gt in their biomass, 38 Gt in dead wood and 317 Gt in soils, with an overall amount of 638 Gt, more than the quantity the atmosphere stores. Also croplands and grasslands play an important role. Through deforestation for agriculture and development, most of the carbon in the burned or decomposing trees escapes to the atmosphere; on the contrary, when new forests are planted, the process is the opposite, and the growing trees absorb carbon dioxide, removing it from the atmosphere; recent net deforestation has occurred mainly in the tropics. With human activities, this balance is altered, affecting changes in carbon stocks among carbon pools of terrestrial ecosystems and the atmosphere. Therefore, a good management of land is essential. According to the IPCC, mitigation of climate change through the role of LULUCF (Land use, land-use change, and forestry), can be very cost-effective; mitigation options could include forest-related activities, such as limiting emissions through deforestation and degradation, using wood fuels and wood products instead of fossil fuels and more energy-intensive materials.

OTHER ACTIVITIES

Minor activities also contribute in polluting the air: transportation, which means the movement of people and goods by trucks, trains, ships, and other types of vehicles, for example. It produces mainly carbon dioxide through the combustion of petroleum-based products in internal combustion engines. The most pollutant means of transport include: passenger cars, light-duty trucks, pickup trucks and minivans; on the contrary, the remaining CO2 emissions are produced by freight trucks, commercial aircrafts, ships, boats, pipelines and trains. In addition to CO2, with transportation activities also small quantities of methane and nitrous oxide are emitted. Through fuel switching, fuel efficiency improvement and reduced travel demand emissions should be reduced, improving also the quality of the business.

The industry sector, through industrial production, emits carbon dioxide in both direct and indirect ways; direct emissions generate with the combustion of fuels for power and heat, and are produced at the facility. Indirect emissions include the ones produced off-site, but can be associated with the facility's use of energy; in order to reduce them, energy efficiency, fuel switching and recycling practices can represent valid solutions. Furthermore, industry creates chlorofluorocarbons (CFCs) through products and industrial processes. Starting from the 1920s, CFCs have been released in large quantities; they have been used as propellants in aerosol cans, in the manufacture of plastic foams, in the cooling coils of refrigerators and air conditioners, as fire extinguishing materials, and as solvents for cleaning. However, their huge impact led to the adoption of the *Montreal Protocol on Substances that Deplete the Ozone Layer* in the 1980s, which stabilized their concentrations, reducing the damage to the ozone layer.
Finally, other activities include the disposal and treatment of garbage and human wastes, and the increased use of certain types of fertilizers.

2.5 Emissions by country

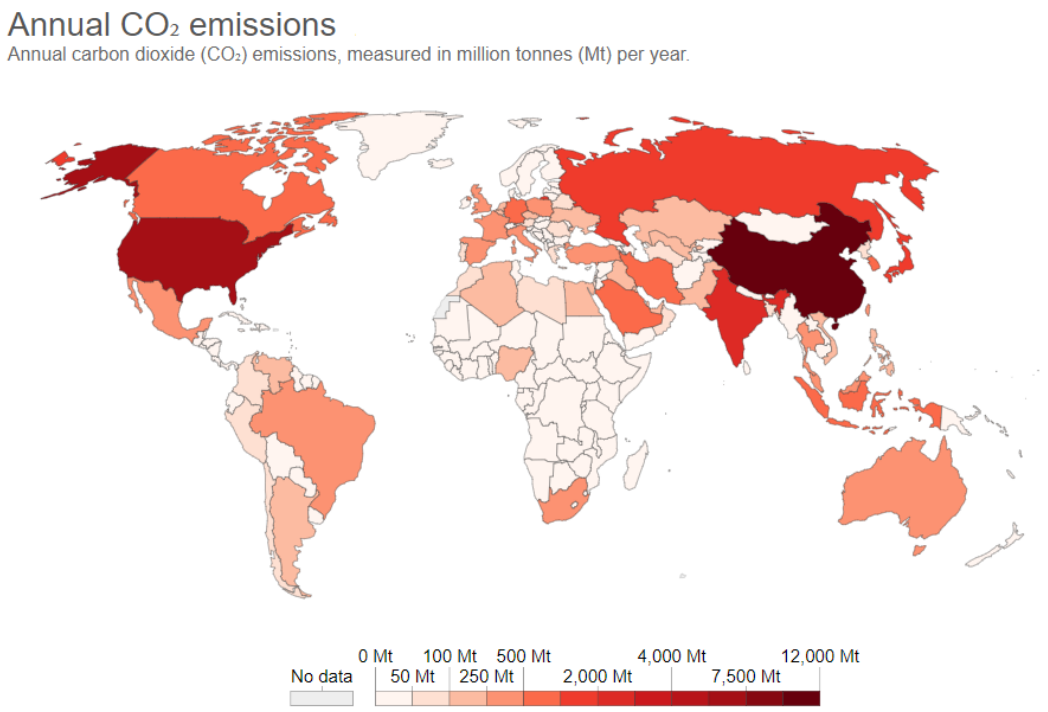
Anthropogenic emissions started to increase during the Industrial Revolution, which took place in the mid-19th century. At that time, the United Kingdom, for obvious reasons, was the first global emitter of carbon dioxide, with its emissions six times higher the ones of the United States, the second top world emitter at the time. Apart from these two countries, the other top 3 main polluters were France, Germany and Belgium, as UK's progresses and inventions spread throughout Europe. In this period, the world experienced growing emissions trends, caused largely to industrialization and population growth. A hundred years later, also China and Russia joined the group of the most pollutant countries, together with their economic expansion. Asian countries started to appear, accompanied by their constant rising emissions, while UK, the once world's highest emitter, stabilized its carbon dioxide emissions.
As stated before, at the end of the 20th century Asia became both the country with the world's largest GDP and the largest emitter of CO2; on the contrary, during the 20th century, the main share of emissions was produced by Europe and North America. However, the emissions of developing countries exceeded those of the industrialized ones, even if per capita emissions in Asia remain

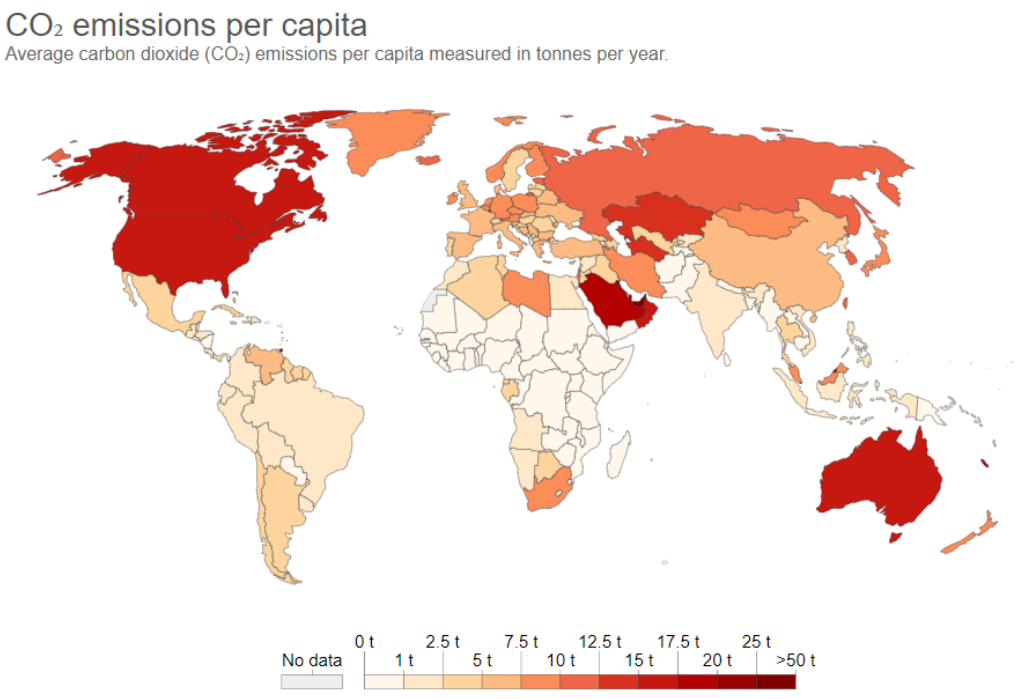
very low even today. Regarding per capita emissions, which means measure the amount of GHG produced per person in every country, industrialized regions achieved to stabilize them in the second half of the 20th century, even with their overall emissions still rising. Furthermore, per capita emissions in regions such North America and Europe were far greater than the ones in Latin America, Asia and Africa.

Today, the top 10 emitters cover 78% of global CO2 emissions; therefore, the issue about differentiated responsibilities rises. Less industrialized countries, such as Africa, which in some charts is not even mentioned due to its little contribution to global emissions, cannot afford to develop and make their economy grow with the newest and less pollutant technologies and techniques available. Thus, their growth is closely related to traditional sources such as fossil fuels, and consequently high GHG emissions. However, the emissions level that characterizes today's world has not been reached homogeneously and without differences among countries. The level of development that industrialized regions claim to have, has been the main cause to the worsening of the environmental situation, with which current society must deal.

The principle of "Common but Differentiated Responsibilities (CBDR)" has been clearly stated in the Rio Declaration and Kyoto Protocol, saying that: "in view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command" (*Principle 7, Rio Declaration*). The principle holds that differences within countries must be taken into account, especially regarding global development programs; in fact, standards which can be valid for the most advanced countries may not fit and be inappropriate for the developing ones. The paradox is that, the greatest impacts of climate change are felt by the most vulnerable ones, such as Africa and Asia.

Table 18 and 19: Annual Global CO2 emissions and CO2 emissions per capita

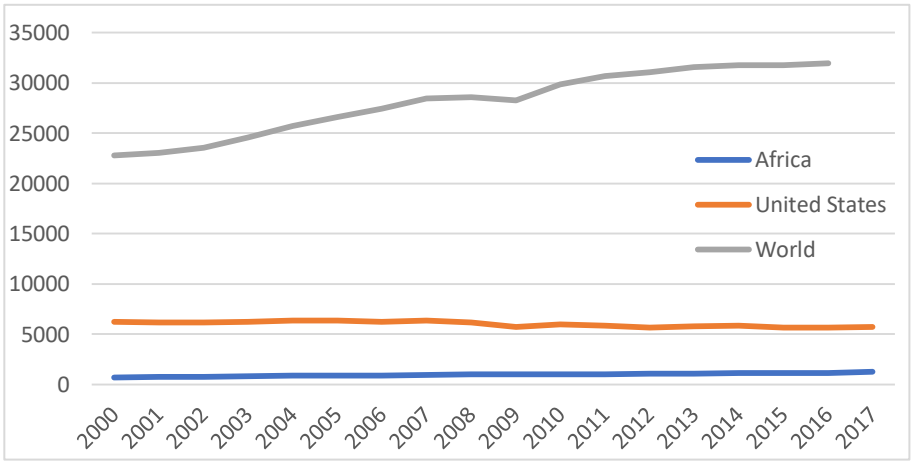




Source: OWID based on Global Carbon Project Gapminder and UN (2016)

2.6 African Emissions

Table 20: CO2 Emissions from fuel combustion



	World	United States	Africa
2000	22758.47	5722.24	683.36
2001	23070.81	5657.11	743.17
2002	23523.96	5642.79	774.95
2003	24586.16	5713.77	809.10
2004	25714.67	5794.74	854.72
2005	26623.40	5809.85	877.08
2006	27448.12	5696.88	892.08
2007	28461.30	5802.10	931.90
2008	28580.22	5589.68	993.47
2009	28253.70	5194.76	983.05
2010	29824.65	5426.29	1020.90
2011	30672.31	5285.40	1022.13
2012	31062.29	5125.18	1082.21
2013	31593.72	5191.40	1106.59
2014	31775.87	5257.63	1142.16
2015	31740.50	5098.90	1147.28
2016	31986.76	5071.41	1155.46
2017	32667.39	5072.86	1250.50

Source: Personal elaboration based on ENERDATA 2018

The graph and the table express the values in MtCO2, which means million tons of carbon dioxide; analyzing these data regarding CO2 emissions from fossil fuels combustion of three different subjects (World, United Stated and Africa), it can be noticed that Africa's emissions are low in both absolute and per capita terms. Total emissions for Africa have increased twelve-fold since 1950 reaching almost 1250 million metric tons of carbon in 2017, still less than the emissions for some single nations including Mainland China, the U.S., India, Russia, and Japan.

Globally, there have been rising emissions, however, with the combination of three factors, which are the slightly lower economic growth, the improved energy intensity and the improved carbon intensity have all to the slower growth in global CO2 emissions.

Regarding the United States, one of the major global economies, the slight decrease in its emissions in the years 2008 and 2009 have been driven by the lower economic growth caused by the global financial crisis that hit the world a decade ago, and, as the world emissions, by the increasing improvements in energy intensity and carbon intensity. The enhancement in carbon intensity has been driven by a shift from coal to gas, with increasingly contributions from the rapid growth in wind and solar. However, with the current Trump presidency, it is unclear if this country is going to meet the NDCs by 2030.

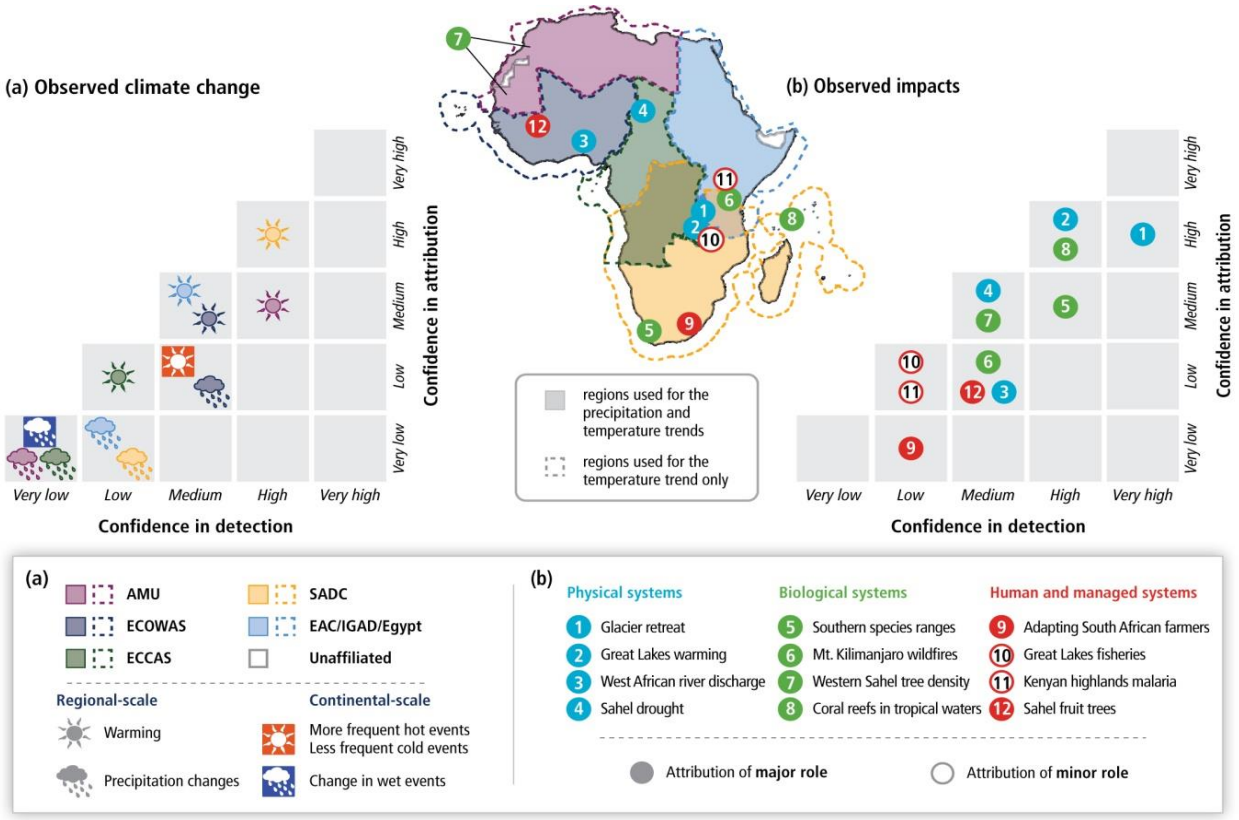
On the contrary, the whole African continent's emissions are very little compared to the developed economy of USA. Africa is currently struggling to develop in a sustainable way in order to adapt to the emergency situation, in fact, also thank to its participation to international climate agreements, knowledge and financial aid have been transferred to various African countries in order to help them both growing economically and dealing with climate change impacts.

2.7 Climate change impacts in Africa

Africa represents the continent that will probably be the most affected by climate change, although it has contributed the least to it. African emissions weight very little compared to the world's ones, however, climate change is already a reality in the Continent. It has been classified as one of the worldwide regions most vulnerable to the impacts of climate change owing to its high exposure and weak adaptive capacity *(Niang et al., 2014).* Countries in Africa are more affected due to their reliance on agriculture as well as their

poor financial, technical and institutional capacity to adapt *(Singh & Purohit, 2014*). Furthermore, the existing link between contemporary disasters and risk to the Continent's economic growth and social progress is very strong, as climate change would intensify the worsening of socioeconomic conditions, underdevelopment and poverty, not taking into consideration the physical effects it produces already. There are prolonged and intensified droughts in eastern Africa; unprecedented floods in western Africa; depletion of rain forests in equatorial Africa; and an increase in ocean acidity around Africa's southern coast. Vastly altered weather patterns and climate extremes threaten agricultural production and food security, health, water and energy security, which in turn undermine Africa's ability to grow and develop. Climate and environmentally related disasters which threaten human security can induce forced migration and produce competition among communities and nations for water and basic needs resources, with potential negative consequences for political stability and conflict resolution.

Table 21: Observed impacts in Africa

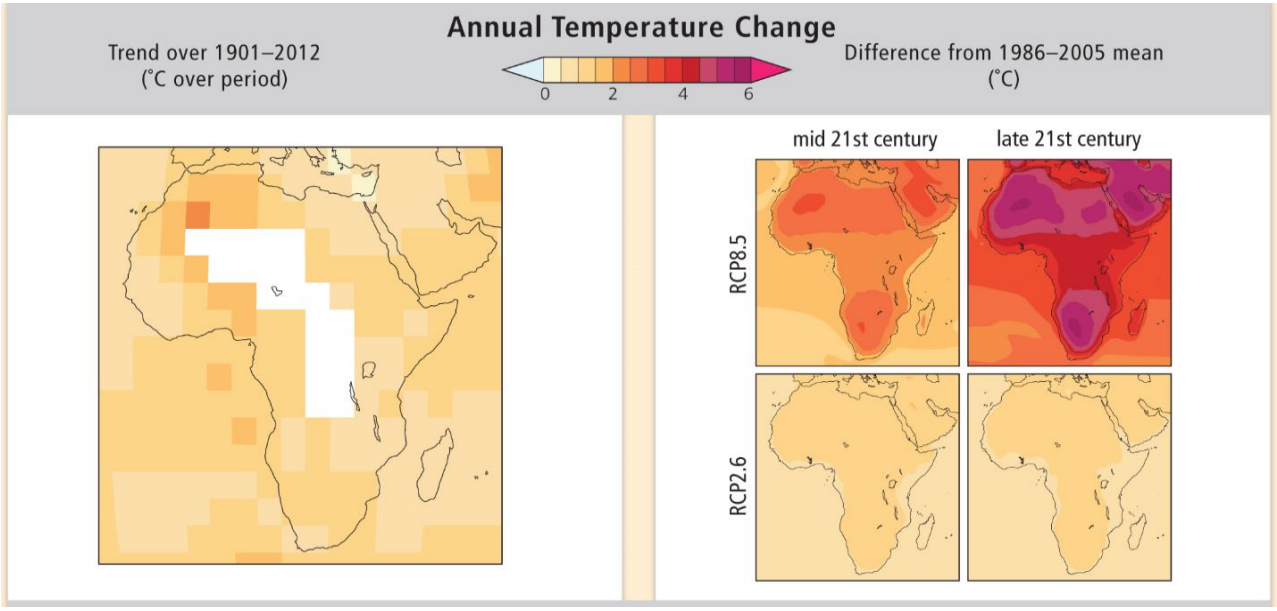


Source: IPCC Special Report on Africa, 2014

TEMPERATURE RISE

Near surface temperatures have increased by 0.5°C or more during the last 50 to 100 years over most parts of Africa, with minimum temperatures warming more rapidly than maximum temperatures *(IPCC, 2014).* Indeed, it has increased over the past century over most of the continent, with the exception of areas intern to the continent, where the data has been determined to be insufficient to draw conclusions. North Africa mean temperature registered a warming trend which is beyond natural forces only, especially in Algeria and Morocco; also West Africa and the Sahel region experience the same kind of trend; regarding East Africa, the States of Ethiopia, Kenya, South Sudan and Uganda have registered an unprecedented increase in mean temperature starting from the beginning of 1980s. Rising temperatures lead to desertification, especially in the Sahel region, in which land is becoming increasingly arid and less livable.

Table 22: Temperature patterns in Africa



Source: IPCC, Special Report on Africa, 2014

WARMER AND MORE ACID OCEANS

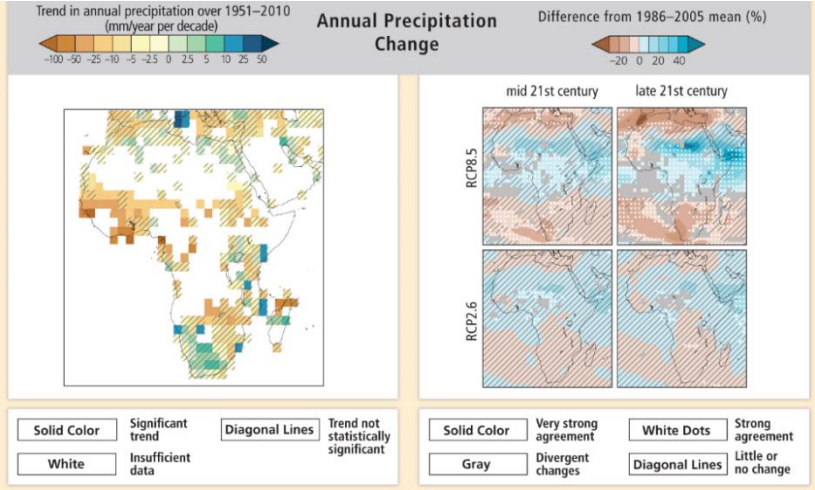
As stated in Chapter 1, oceans are currently absorbing an immense amount of CO2, which is making them warmer every day. The change is most noticeable

in the top layer of the ocean, in which temperature has risen significantly since the late 1800s. Expectations for future developments include a continued warming effect in deep waters and in the top layer: there is such a great amount of greenhouse gases in the atmosphere that even if people stop adding more GHG to the environment, oceans will continue to get warmer for thousands of years, as they would keeping on absorbing the gasses from the atmosphere. Moreover, seawater reacts to carbon dioxide forming carbonic acid, which is causing the increase of acidity in the oceans water. The raised levels of acidity damages all marine ecosystems, such as coral reefs, which constitute a shelter for many sea animals, which with greater acidity show difficulties in building their skeletons.

PRECIPITATION PATTERNS

Worldwide average precipitation frequency has already increased by 6 percent more, even though the effects vary by region and the frequency is expected to increase in higher latitudes and decrease in areas closer to the Equator *(U.S. Environmental Protection Agency, 2016).* Most countries of the African continent do not dispose of enough data in order to clearly state trends about precipitation patterns; however, the general trend, based on countries with reliable data experiences decreases in precipitation over the western and eastern Sahel region in northern Africa and increases over eastern and southern Africa, with North Africa experiencing a strong decrease.

Table 23: Precipitation patterns in Africa

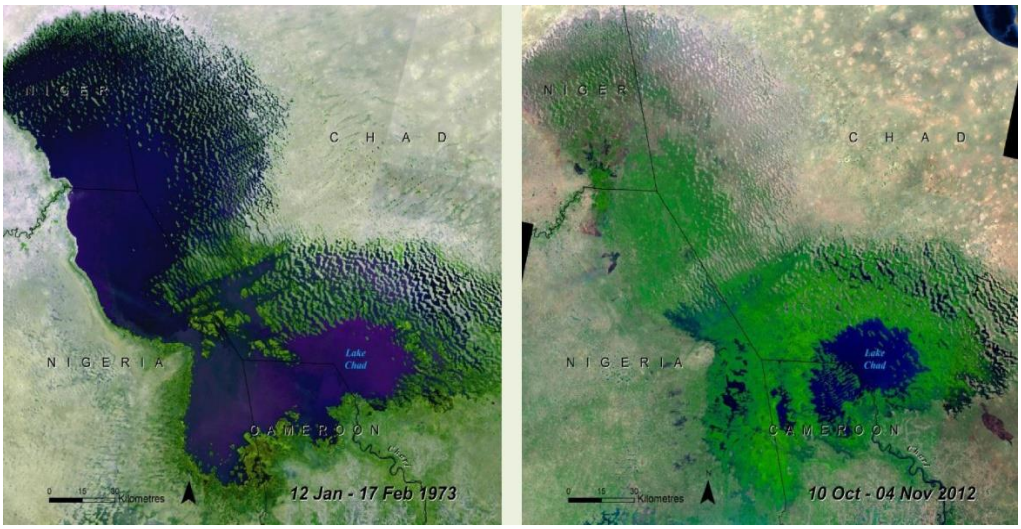


Source: IPCC, Special Report on Africa, 2014

EXTREME WEATHER EVENTS

Extreme weather events increased in both frequency and severity of their impacts; there is an important connection among disasters, security, and economic development, and, in order to achieve effective long-term adapting strategies, a much more comprehensive view of the links is a key element.
More droughts are occurring, especially in the Sahel region; a drought is an extended phase of dry weather, which is caused by insufficient rain or snowfall, caused by a rise in temperatures. A shocking example of these prolonged droughts is represented by the Lake Chad basin. The lake, which originally bordered Chad, Nigeria, Cameroon and Niger, has lost 90 per cent of its surface area due to unsustainable water management and mostly climate change.

Table 24: Lake Chad



Source: wedocs.unep.org

This caused a serious humanitarian crisis as the majority of the population of four States relied on it for agriculture, fishing, water and survival. The UN Food and Agriculture Organization (FAO) has labelled the situation as an "ecological catastrophe," and predicted that the lake could disappear by the end of this century, leaving people into chaos. However, there is a strong determination, both by local and international forces, to implement plans and strategies to replenish the basin and limit further damages.

More heat waves, meaning periods of unusually high temperatures and heat index, are also occurring throughout Africa. Excessive heat usually comes with high level of humidity, but might also be catastrophically dry. They are lesser known as forms of extreme weather, because they are not visible, however, they have the ability to harm populations and through potential dehydration, heat cramps, heat strokes, or heat enhancements.

ECOSYSTEMS

Plants and animals live in areas with very precise climate conditions, such as temperature and rainfall patterns, which enable them to survive. A little change in the climate of a specific area can disrupt the equilibrium of a whole ecosystem. Some species are already answering to hotter temperatures by moving to cooler locations; changing conditions are modifying life cycles of plants and animals, as evidence shows how some animals wake up from hibernation sooner or migrate at different times.
Loss of biodiversity, disappearing habitats, damage to forests, coastal areas and wetlands are all disastrous consequences triggered by environmental manmade conditions.

COASTAL AREAS

Coasts and cities located along them are seriously in danger, as they can be destroyed by the rising sea level; entire islands might be completely underwater and wiped out by strong storms, caused by warmer oceans. Hundreds of millions of people, as a consequence, would lose their homes, works, almost everything. And in Africa this is even more visible due to the vulnerability people have, in a country still uncapable to face such challenges without international cooperation. The complexity of how everything is interconnected gives the idea of how delicate nature's balance actually is, and above all of how difficult is fix it after.

WATER SCARCITY AND FOOD SECURITY

Physical impacts lead to socioeconomic consequences for the whole population. One of the main and most important outcomes climate change has generated in Africa is water scarcity and food security.
Already the least developed country in the world, in Africa difficulties are worsened by the limited sources of water available to provide clean drinking

to the entire population. Surface water is often highly polluted, and infrastructures to pipe water from clean sources to arid areas is too costly. According to IPCC, an additional 80 million to 100 million people will be exposed to water stress by 2025, putting more pressure on already depleted groundwater resources. Only 64% of the potentially available water in Africa has been developed to date, nonetheless, many African countries, will shift from water surplus to water scarcity between now and 2025. The main obstacles are represented by inadequate water storage, inadequate and poorly maintained supply networks, and the vulnerability of many water supply systems to droughts and floods. Even if it represents a serious challenge, putting millions of lives at stake, impacts can be contained and improved by effective financing, public-private partnerships and enhanced focus on rural populations, which are the most vulnerable and uncapable to cope with serious threats.

Furthermore, food security relies on agriculture, as does three-quarters of the African population; however, it is an activity which is mainly rain-fed, and with prolonged droughts, floods, desertification and soil erosion the challenge is turning into a catasrophe. All these elements are reducing agricultural yields, causing crop failure and loss of livestock. The Horn of Africa's pastoralist areas (Ethiopia-Kenya-Somalia border) have been severely hit by recurrent droughts; livestock losses have plunged approximately 11 million people dependent on livestock for their livelihoods into a crisis and triggered mass migration of pastoralists out of drought-affected areas. According to FAO, the impact of climate change could lead to as much as a 50 per cent fall of crop yields by 2020 in some of the poorest African regions.

HUMAN HEALTH

The main health issue climate change is causing is air pollution, with an unprecedented level of lung diseases and cancer. However, in Africa, increases in temperature, increased natural disasters and scarcity of safe drinking water are the major contributors to the spread of infections and diseases. Entire populations are being exposed to malaria, which is already a leading cause of death in Africa. Intensified rains are affecting previously malaria-free areas such as the Kenyan and Ethiopian highlands. A recent joint UNEP-UNAIDS study has established complex links between climate change and the HIV/AIDS epidemic in Africa *(UNEP and UNAIDS).*

Apart from direct effects, climate change worsens human health also through ecosystems degradation, unsafe water and poor sanitation, which contribute to malnutrition, cholera and diarrheal diseases, increasing child mortality; indeed, poor water sanitation accounts for more than 20% of the burden of disease in Africa.

MIGRATION AND DISPLACEMENT

There is no direct link between climate change and migration; however, all the changing conditions the world is experiencing are enough to threaten the lives of millions of people; maybe through water scarcity, which leads to forced migration; maybe through rising sea levels for coastal populations, which are forced to migrate; or maybe through an agricultural activity put at risk by severe weather conditions; there are a lot of indirect effects caused by climate change that force people to look for alternative lives. Not randomly, in 1985 an UNEP expert (Essam El-Hinnawi) defined 'environmental refugees' as: those people who have been forced to leave their traditional habitat, temporarily or permanently, because of marked environmental disruption (natural and/or triggered by people) that jeopardized their existence and/or seriously affected the quality of their life. Should not the international community give them special protection?

Droughts in southern and eastern Africa, floods and rising sea levels in western Africa have induced migration of individuals and communities in search of alternative livelihoods. There are a lot of examples that can be made in order to explain the range of these exoduses: the movement of pastoralist communities of northern Kenya ravaged by both droughts and floods; rural-urban migration in Ethiopia due to adverse environmental changes in its highlands; displacement of population in the flood-prone plains of the river Niger in Nigeria. These people must be protected, this is why they represent a major policy challenge for African governments in terms of humanitarian assistance and sustainable long-term solutions, in addition to national security concerns linked to competition for scarce resources between migrants and local populations.

CONFLICT

The most delicate aspect examined regards the link between climate change and conflict eruption. For all the previous reasons, this phenomenon may

seriously threaten political and economic stability in the most vulnerable societies, as could pose a real threat to peace and security.

In its presidential statement on 20 July 2011 *(S/PRST/2011/15),* the United Nations Security Council, feared "that possible adverse effects of climate change may, in the long run, aggravate certain existing threats to international peace and security." The same concern has also been expressed by the African Union Commission in its *Draft African Union Strategy on Climate Change*, stating that climate change predominantly acts as a multi-dimensional threat multiplier exacerbating conditions and factors that can heighten the risk of conflict, crime and violent extremism; conditions such as poverty, inequality, unemployment, large-scale displacement, heightened refugee flows, and increased scarcity of and competition for livestock. Moreover, it can also affect vital resources such as water, food and land, increasing competition among communities.

In sum, it could easily exacerbate ethnic, social and religious tensions already present. For instance, in the Sahel region, the Lake Chad Basin is a perfect case to show the socio-political tensions worsened by climate change. As stated above, the drought of this region and the fast dissolvement of the lake has affected the livelihoods of millions of people and made local communities more vulnerable to violent extremism and conflict; indeed, it is now the main target of attacks launched by the terror group Boko Haram. In order to address this multidimensional challenge, the United Nations has been working with Burkina Faso, Chad, Mali, Mauritania and Niger (Group of Five Sahel countries, G5 Sahel), in supporting the implementation of a UN Integrated Strategy for the Sahel (UNISS). In addition to addressing security, political, social and economic challenges, the strategy focuses also on promoting environmental sustainability through natural resource management mechanisms and climate change adaptation.

3. ADAPTATION AND MITIGATION IN AFRICA

3.1 Agenda 2030 and SDGs: focus on the environmental dimension

Table 25: UN SDGs

Source: www.unesco.org

Agenda 2030 (UN) and the current international framework about climate change after COP21 focus on the assistance to the most fragile countries in order to help them face real environmental challenges; it is a turning point in the international cooperation field for the global community: explicit commitments regarding mitigation and adaptation strategies in developing countries and larger actions aiming at the preservation of damaged ecosystems have emerged from the Paris Agreement. In the accord, countries explicitly commit themselves to an increase in climate finance reaching 100 billion $ from 2020 to 2025.

On the other hand, the already existing interventions directly aimed at decarbonizing their economies, especially in the energy sector, are not enough to maintain the temperature under 2°C or 1.5°C; furthermore, even with the temperature stable and below the one projected by climate models, climate change impacts will have devastating effects in these countries and not only; just to make an example, even with no increase in temperature, the North Pole will be navigable in a decade in summer months, as all the ice will be melted.

Further progresses and effective initiatives are needed, not only to avoid the increase of temperature, but to reduce it; this is why new approaches are developing, especially through strategies aiming at carbon neutrality in the long run, which means the ability and capacity to absorb eventual residual CO2 emissions.

The Agenda, which states 17 SDGs (Sustainable Development Goals), considers a few common issues, including also the environmental dimension, which have to be overcome by the international community as a whole. Explicitly, environmental actions are clearly stated in principles 7, 11, 12, 13, 14 and 15.

The 7th goal is "Ensure Affordable and Clean Energy Access", and it states that access to energy is essential for all; today, 13% of the global population still lacks access to modern electricity and 3 billion people rely on wood, coal, charcoal or animal waste for cooking and heating; slightly less than 1 billion people are living without electricity and 50% of them are found in Sub-Saharan Africa region alone. Fortunately, progresses have been made regarding the use of renewable electricity from water, solar and wind power and the ratio of energy used per unit of GDP is also declining.

However, energy is still the dominant contributor to climate change, accounting for around 60% of total global greenhouse gas emissions; thus, a good management of the energetic resources and structures is an essential element as it avoids the spread of climate change and its damaging effects such as GHGs emissions, air pollution and people's health. By 2030, the objective is to ensure universal energy access and enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, while promoting investment in energy infrastructure and clean energy technology.

The 11th goal is "Sustainable Cities and Communities", and it aims at maintaining cities in a way that continues to create jobs and prosperity without straining land and resources; indeed, current urban challenges include congestion, lack of funds to provide basic services, a shortage of adequate housing, declining infrastructure and rising air pollution within cities. The rapid growth of both people and urbanization have been felt a lot in the African continent, where a lot of people still lives in slums without even being able to fulfill their basic needs. Furthermore, world's cities occupy just

3% of the Earth's land, but they account for 60-80% of energy consumption and 75% of carbon emissions, not talking about the percentage of people that breathe unsafe and polluted air due to air pollution, causing 4.2 million deaths in 2016. By 2030, global community leaders aim at a substantial increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters. Moreover, technical assistance and financial aid should be provided to least developed countries, in which, efforts to ensure access to adequate, safe and affordable housing and basic services together with sustainable urbanization have to be made. Most important, by 2030 the number of deaths due to air pollution should be drastically reduced.

The 12th goal, "Sustainable Production and Consumption", is linked to climate change because it promotes resource and energy efficiency, sustainable infrastructure, access to basic services, green and decent jobs and a better quality of life for all peoples, especially the most fragile ones. The concern is that global population is growing at an unsustainable rate, as it will reach 9.6 billion people by 2050, which is the equivalent of almost three planets natural resources if the lifestyle remains the same as today. Water scarcity is the main driver to conflicts in dry zones such as all the Sahel area; in fact, less than 3% of the world's water is drinkable, of which 2.5% is frozen in the Antarctica, Arctic and glaciers. Humanity must therefore rely only on 0.5% for all of man's ecosystem's and fresh water needs; unfortunately, pollution in rivers and lakes is so high and fast that nature does not have the time to purify it, and as a consequence a rising number of people do not have access to fresh water. Furthermore, especially in isolated and rural areas, the infrastructure needed to delivery it is very expensive, and not affordable for many countries, such as some African regions. This is why the most important aim that this principle has is to achieve a sustainable management of natural resources, both water and food, by also increasing the awareness for people and companies to sustain much more sustainable patterns of consumption and production.

The 13th goal is explicitly called "Climate Change", and by 2030 the main achievements it poses are: **s**trengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries, but especially in the most affected ones; integrate climate change measures into national policies; improve education, awareness-raising and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning;

promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities.

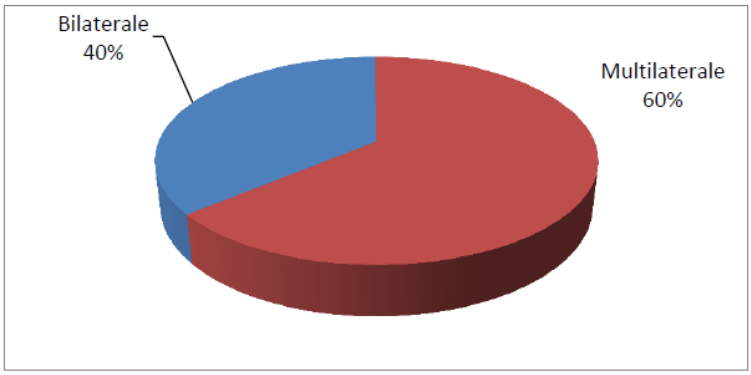
The 14th and the 15th goals refer respectively to protection of life below water and on land. Oceans and seas have to deal with overfishing, marine pollution and oceans acidification. On the other hand, land dangers regard mostly forests, desertification and loss of biodiversity. These last two principles that target environmental aspects focus on the protection and preservation of terrestrial ecosystems, without which humanity cannot live. Around 1.6 billion people depend on forests for their livelihood, and over three billion people depend on marine and coastal biodiversity; pollution is affecting both, and as damages proceed, more people have to struggle to sustain their lives in alternative ways. The main purposes which should be achieved through implemented policies include: by 2025, significantly reduce marine pollution of all kinds, in particular from land-based activities; by 2020, strengthening their resilience and take action for their restoration in order to achieve healthy and productive oceans; regulate destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible; increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology; by 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements; restore degraded forests and substantially increase reforestation; combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods; ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development; **m**obilize and raise financial resources from all sources to conserve biodiversity and ecosystems, forests; enhance global support for efforts to stop the traffic f protected species, also by increasing the capacity of local communities to pursue sustainable livelihood opportunities.

3.2 International environmental cooperation: Italian position

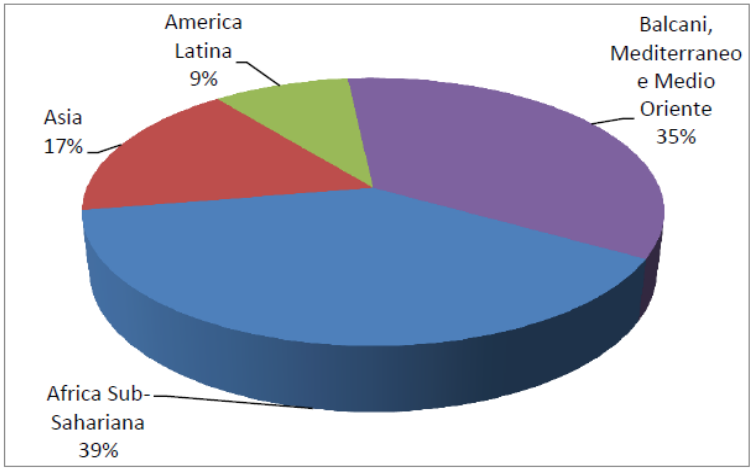
This thesis focuses on the Italian position in Africa regarding climate change initiatives. The structure and organization of these initiatives are very articulate, as a few ministerial bodies are involved, and each branch has its own lines, given by the government.
First of all, it has to be said that international cooperation is a key aspect to the fight of climate change: due to the range of the issue, effective solutions have to be implemented worldwide, with a common approach and common priorities.
There are two types of environmental cooperation: multilateral and bilateral, and Italy is involved in both. Multilateral cooperation comprises the intervention of many States, called also donor States, which, through the donation of financial resources, technology or other types of assets, use intermediaries such as the European Union, the United Nations and other international or regional fora to address such funds and implement environmental activities; in multilateral initiatives, international organizations have the resources to help developing (recipient) countries and set priorities and projects that should be developed. Among them the most important ones with which Italy has a partnership regarding climate change initiatives are: the European Union, World Bank, the G7-G20 group, all the bodies resulting from the Paris Agreement in 2015, OECD, UNEP, UNHABITAT, WWAP, IUCN, FAO, IFAD, CGIAR, UNDP, UNCCD, IOM, many African organizations, various development banks and private actors. Multilateral cooperation can also be defined as two donor States working together by addressing their efforts to the same recipient country.
On the other hand, bilateral cooperation refers to activities supported directly by one developed state in a developing country, region or continent, such as Africa, and it is usually connected to the foreign policy of the donor. With specificity to Italy, it has 3 bodies which are in charge of environmental initiatives: the MATTM, the DGCS and the AICS.
This work focuses on MATTM projects, as they are the ones closest related to adaptation and mitigation strategies to fight climate change.

Table 26: Italian funds repartition (funding channels, country, sector)

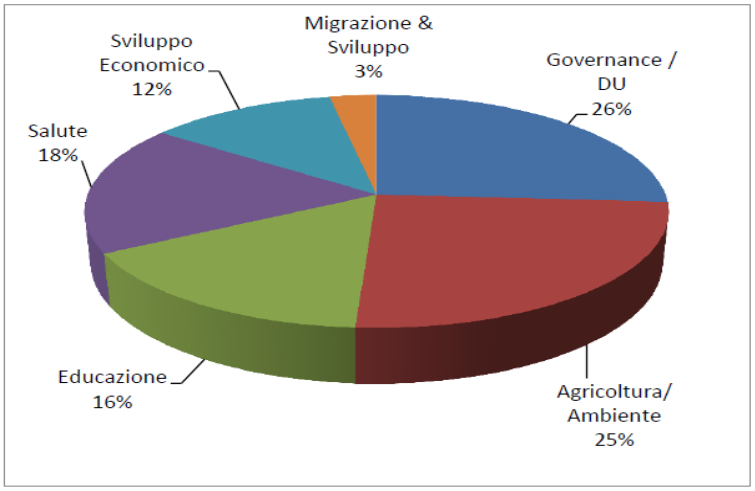
1)Funding channels (multilateral, bilateral)



2) Country



3)Sector (bilateral cooperation only)



Source: Ministerial Document, "Documento triennale di programmazione ed indirizzo 2016-2018"

DGCS AND AICS

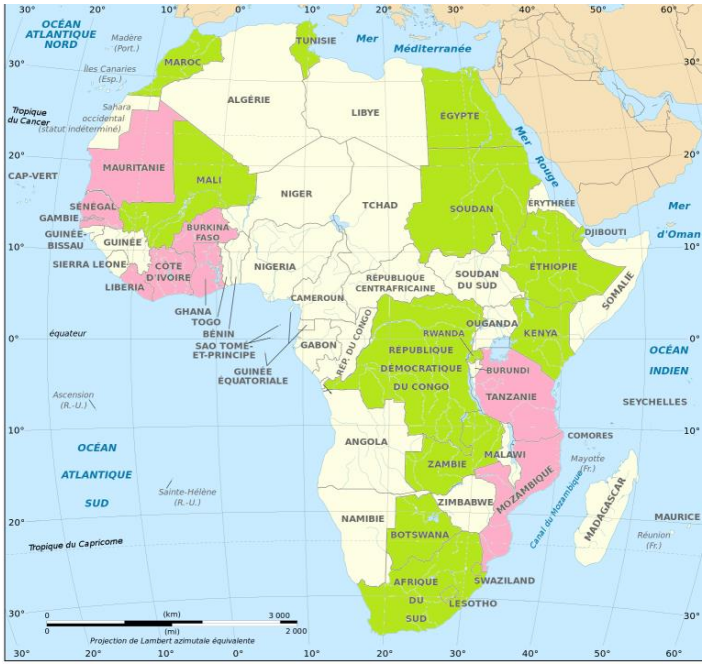
The DGCS (Direzione Generale per la Cooperazione allo Sviluppo), is a branch of the bigger Minister of Foreign Affairs (MAE), in which I did an internship focused on Italy-Africa relations, particularly regarding terrorism and environmental aspects. This body oversees every project related to international cooperation, with a special eye on Africa, with which Italy is establishing very good relations. With its recent development and its young generations, Africa can represent a big opportunity for the Italian country, which systematically proposes a lot of initiatives with everyday updated priorities; however, they focus mainly on the reduction of poverty and sustainable development, with the side effect of fighting also climate change.
The AICS (Agenzia Italiana per la Cooperazione allo Sviluppo) also, is a recent agency established with the reform 125/2014, which started its work on January 2016 with the aim of answering to an increasing need of sustainable worldwide development. It focuses on a more flexible and innovative approach, with tools adapting to an increasing changing scenario. Its tasks regard technical aspects such as formulation, management, financing and control of international initiatives; as stated before, this is an important part of the Italian foreign policy, as its implementation through the reform 125/2014 has been aimed at complying with the "2030 Agenda" proposed by the United Nations, addressing three main dimensions of sustainable development: economic, social and environmental. In particular, the work of the agency refers to urban air pollution, water pollution, deterioration of health environment, forest and soil degradation, loss of biodiversity and marine pollution. All these issues threaten not only human life and health, but also the base for development of future generations due to deterioration of environmental resources and poverty.
The overriding strategies of these two bodies include: humanitarian help as the first priority, especially regarding the enforcement of resilience in areas such as the Sahel region, Sudan, Horn of Africa and RCA; social engagement, which includes education, health and professional training, aimed at avoiding the development of intolerance and rising of extremisms; female empowerment; strategic fields such as agriculture, food security, environment and improvement of the private sector; displacement and migration, with innovative initiatives aimed at creating employment (Senegal) and special

attention to countries of origin of migratory flows; focus on least developed countries and strategic geographical areas such as sub-saharian Africa.

MATTM

MATTM (Ministero dell'Ambiente e della Tutela del Territorio e del Mare) does not have a clear division referring to the two previous bodies, however, due to government lines, it is the main institution that commits itself to the climate change cause, without the social and economic aspects.
Its activity abroad follows three main directions: decarbonization of the economies, efficient management of resources and coherence among funds and pursued sustainable objectives. In the next couple of years the Minister will prioritize the most vulnerable countries that are already experiencing global warming's impacts; this means that targets will be all the lowest income countries, which, due to less available technologies and structures, have minor capacity to contrast and cope with climate change.
The map below shows the States with which MATTM has environmental programs in place: the green ones represent the already signed agreements, while the pink ones constitute the ongoing negotiations.

Table 27: MATTM collaborations in Africa



Source: Personal Elaboration based on MATTM data

Indeed, in Africa, Italy has a decennial partnership with Egypt, Tunisia and Morocco regarding the development of renewable energies, the spread of financial tools in order to boost the use of solar panels and the better management of water resources.
In Ghana, Ethiopia and Botswana the main priority is the control of deforestation; furthermore, special partnerships involving also the private sector are being developed, aimed at fighting forests degradation.
However, the common line of action regards the promotion of energy efficiency and renewable energy; also the multilateral cooperation in which Italy is involved prioritizes alternative energy as resilience to climate change. Through the World Bank's program "*Clean Energy Access Program Trust Fund* e *MENA Inclusive Green Growth Initiative"* and Development African Bank *"Africa Climate Change Fund* e *Africa Sustainable Energy Fund for Africa",* MATTM tries to contribute to this global cause, also developing a special partnership with UNDP, for the creation of the *"Africa Centre for climate and Sustainable Development and Agenda 2030".*

UNDP: AFRICA CENTRE FOR CLIMATE AND SUSTAINABLE DEVELOPMENT

The United Nations Development Program (UNDP) operates in about 170 countries and territories, with the aim of achieving the reduction of inequality and the eradication of poverty.
It is one of the largest United Nations agencies and it takes a leading role in the implementation of the Sustainable Development Goals**.**
In September 2017, Gian Luca Galletti, the Italian Minister of Environment, Land and Sea, together with Achim Steiner, the Administrator of UNDP, signed a special partnership agreement regarding the African Continent.
The Africa Centre for Climate and Sustainable Development has been then established, with the contribution of both UNDP and FAO. The centre will facilitate much-needed exchange of information and coordination to increase efficiencies and build synergies across Africa, develop and scale-up innovative solutions for sustainable development and implement the goals defined by the current international framework (Agenda 2030 and Paris Agreement).
As stated before, sustainable development in Africa is a main priority of Italy's foreign policy, together with other challenges ranging from security, migration and climate change. The focus will be on the Sahel region, Prime Minister Giuseppe Conte declared.

“Safeguarding out planet in terms of climate, environment and social cohesion can only be assured if we start from Africa,” announced Italy’s Environment Minister. Moreover, the UNDP Administrator asserted that the new center has been framed thanks to an Italian initiative at the meeting of G7 environment ministers in Bologna in 2017, and it offers a "practical foundation" for speeding up responses to the known challenges of the future. "We are entering a century when Africa's own development will increasingly determine the development of the world economy," he said.

The Center’s special interests regard climate, Climate-Smart Agriculture, access to water, clean energy generation and gender equality. It has already identified communication and support initiatives linked to accessing international funds, evaluating projects and enhancing the involvement of resources from the private sector in programs as core functions.

The Italian government has approved a trust fund for the structure, and one of its first tasks has been to support programs promoted by the United Nations Secretary General for sustainable development regarding the Sahel area.

3.3 Italian priorities

Italy commits itself not only at adaptation and mitigation strategies, but also at building resilience and management of new environmental risks in the weakest and most fragile countries, trying also to reinforce their social infrastructures and economy.

Moreover, knowledge and know how practices are very eradicated in Italy, and they usually play an important role in environmental projects together with technology transfers in the sectors of energy, industry and transports.

Also direct investments constitute an essential part in Italian climate initiatives, and government recently tried to improve also the involvement of private and profit actors in these processes, such as immigrant diasporas, financial actors and direct investors. This new approach resulted very effective, as the climate change concern, which does not respect boundaries, cannot be contained without the participation of every social component and group. Indeed, the contribution of the private sector is crucial for the success of the actions. Regarding the business sector as an example, on the one hand, companies are directly (production of fossil fuel and electricity) and indirectly (consumption of fossil fuels and electricity) responsible for GHGs emissions,

and in certain cases to a greater extent than countries. This is why they can play a huge role in mitigation.

This is the reason why Italy, in collaboration with "Cassa Depositi e Prestiti", is exploring new objectives and modern tools, introducing innovative elements that can be more incisive and help the fight against global warming in a concrete and real way. Following the example of the most responsible countries, Italy is shaping its environment-friendly policies in order to provide: mixed public-private funding tools; use of Italian technologies while implementing programs directly/indirectly aimed at mitigation, resilience and adaptation strategies; presentation of the most advanced Italian technologies in multilateral events focused on climate change, and most important, a particular attention to fragile ecosystems. With reference to the latter aspect, Italy (MATTM) is developing: energy-sector programs that aim at mitigation and transition to renewable energies also in rural areas; programs that aim at a sustainable modernization of urban areas; initiatives to recover soils and lands (especially in the Sahel region) through the reinforcement of familiar agriculture and reforestation; projects aiming at environmental conservation, such as water access, protection of oceans and seas, sustainable fishing.

Public funds aim at mixing both adaptation and mitigation strategies, this is why Italy is developing projects, especially in Africa, which cannot be actually labelled as only "mitigation" or "adaptation"; quite often they aim to achieve both, by not forgetting to take into consideration the peculiarities and needs of each country. About this aspect, the very innovative element is the role that the recipient African countries play in the decisional process. Indeed, is up to them to decide how to manage international funds and which projects are more urgent. The time in which developed countries could decide or impose the path of developing ones is over; hard and soft colonization are no longer acceptable. Africa has natural resources, is a market in expansion with mostly young people, and it is economically growing. It has been exploited for too long, and now, paradoxically, it has to cope with all the negative effects and impacts that this harsh exploitation caused. As a consequence, the least western countries owe to it is develop climate change effective strategies.

The reason why Italian cooperation prioritizes Africa is because, as not developed States, they are not able to cope by themselves to the destructive effects their territory is experiencing. Poor people are overexposed to natural disasters. It regards droughts, high temperatures, and most of all frequent,

low-intensity events, such as recurrent floods that affect many cities with insufficient drainage infrastructure. These events do not attract media interest and are poorly documented, but they have significant cumulative impacts, especially through their effects on health. Poorer countries also suffer from higher vulnerability , which is how much they lose when they are hit. When poor people are affected, the share of their wealth lost is two or three times that of the non-poor, largely because of the nature of the vulnerability of their assets and livelihoods. As the World Bank states, the majority of people in some countries of Africa still lives below the international poverty line (1.90$ per day), which means that they do not have enough to meet their most basic needs. They have less ability to cope and recover from climate change impacts, depending also on the support they receive. Coverage for poor people by social protection is often low. And after they are hit by a shock, poor people receive less post-disaster support than do non-poor people.

3.4 Mitigation

Mitigation constitutes one of the two challenges to reduce climate change impacts. It is needed to stabilize rising temperatures and avoid irreversible and catastrophic changes. However, to reach these goals, a big transformation of the energy system and a fast scale-up of mitigation action in all the sectors, leading to emission reductions as soon as possible, is needed. Effective results can be achieved by reducing both the sources of these gases, as the burning of fossil fuels for electricity, heat, transport, and enhancing the sinks that accumulate and store GHGs, such as the oceans, forests and soil. The goal of mitigation is to avoid significant human interference with the climate system, and stabilize the greenhouse gas levels in a timeframe sufficient to allow ecosystems to adapt naturally to climate change and encourage economic development to proceed in a sustainable manner.

The most efficient interventions include: a transition to a net zero emissions in all the most pollutant activities; a change in lifestyle; the modernization of buildings in order to make them more energy efficient; the adoption and spread of renewable energies such as solar, wind and hydropower; more sustainable cities and less pollutant transports such as electric vehicles and biofuels; more sustainable management and use of land and forests.

Examining each of these aspects, it can be stated that, if achieved, they can result in large co-benefits for human health and other societal goals.

Forests and land represent one of the major sources of GHGs emissions; however, at the same time, they can also be a part of the solution. First of all, they are closely linked with people; for instance, the Congo Basin forest is home to 24 million people, who rely on it for their livelihoods. Convert forests into arable land emits huge amounts of carbon dioxide, stopping the trees to retain and store it inside.

Even if emissions derived from forests degradation are on a declining trend, the ones resulting from agriculture are projected to grow by 2030, driven by the growth of population, especially in Africa. Through a good and sustainable management of lands and forests, along with the employment of climate-smart agriculture techniques, it could be possible to balance the need of the people with the environment.

Regarding energy efficiency, it can also have a lot of benefits if achieved; furthermore, it can cover a wide range of sectors: residential, building sector, transports and industry. People would have lower bills, industry would use better practices, technologies, save energy, reduce waste and save money. Most important, it would reduce emissions.

Another important player is renewable energy (solar, wind, geothermal, hydroelectric, tidal, biomass). By definition, they do not use fossil fuels, which means they generate 0 GHG emissions and pollute much less. Investments in this new kind of technology would also have additional benefits, such as a transition to a low-carbon economy, stimulation of employment and economic growth, better quality of life (health and pollution), and most important, especially in developing countries where a lack in energy services is still present, a strengthen in energy security.

Mitigation approaches in Africa must have a pro-poor orientation, leveraging developmental benefits through the participation of farmers and local communities in carbon offset systems (*IPCC, 2014*).

Be able to supply renewable energy resources, clean water and education in countries such as Africa means enabling local populations to better adapt to the effects of climate change and avoid leaving their homes. Mitigating climate change with these tools and methods will surely need a lot of time and progresses.

The on-going bilateral projects that Italy (MATTM) has in Africa are further described. Every initiative comprises the signature of a “Memorandum of Understanding” by both governments, with the relative amount of allocated

funds and the defined work plan. The official MoU also defines the establishment of an ad hoc Joint Committee, composed by scientific, research and technical expertise, which has the task to evaluate and provide the best solutions and practices for the needs of each country. It is important to state that, while some initiatives are clearly mitigation or adaptation-oriented, others do not have a sharp division between the two approaches; thus, the projects have been grouped with the criteria of final target: if the ultimate aim is to reduce emissions, they have been inserted in this paragraph; on the other hand, if they focus on coping with climate change effects, they have been be placed in the adaptation section.

BOTSWANA

Italian bilateral cooperation with Botswana started in Paris on December 2015, where MATTM and the Ministry of the Environment, Natural Resources Conservation and Tourism of the Republic of Botswana (MENT) signed the official MoU regarding climate change vulnerability.
MATTM agreed to co-finance the initiatives approved under the Memorandum with a maximum amount of 2 million €. The medium-term work plan, approved in April 2016, identified two main areas on intervention: promotion of renewable energy by strengthening the regulatory framework and launching bankable projects, and Smart Climate Agriculture, including integrated and sustainable water management, in partnership with FAO. Three projects have been approved by an established Joint Committee; among them, one is focused at reducing emissions, one at building resilience, while the last one on both mitigation and adaptation actions; the second and third project will be discussed in the next sections.
The first approved project is a "Technical Assistance program in supporting Botswana private sector and relevant institutions in renewable energy (RE) through the investment promotion and technology transfer". The initiative, implemented by UNIDO ITPO Italy (United Nations Development Industrial Organization-Investment and Technology Promotion in Italy), is aimed at identifying bankable projects to promote the development of renewable energies through know-how exchange and technology transfer. Consideration has been given to the participation of the public, private and non-profit sectors, together with universities, scientific and research bodies where considered appropriate. The activities include: improvement of climate data collection; management and forecasting through the enhancement mapping of renewable energy potential (Botswana could be very productive in solar, wind and biogas); develop community based mini-grids and macro-grids sourced

by renewables in isolated and rural zones; improve biogas utilization through the manure produced in livestock farms.

DEMOCRATIC REPUBLIC OF CONGO (DRC)

MATTM and the Ministry for the Environment, Nature Conservation and Sustainable Development of the Democratic Republic of Congo have signed, on November 17, 2016, the beginning of their partnership regarding the field of climate change mitigation and adaptation. The Italian Ministry for the Environment will co-finance the activities approved under the Memorandum with an amount of 2 million €, which can be integrated with additional funds.
The work plan has been approved on April 2017, in Milan, and the implementation of the project ideas has been proposed by the Democratic Republic of Congo. Currently there are four projects in place, and they all fall into the category of mitigation; the first one is " Decentralized networks of off-grid systems based on RE and energy efficiency measures", and it is promoting renewable energies and energy efficiency measures in the rural areas of the country that are not linked to the national electricity network. This initiative includes two stages: the first one includes the preparation and implementation of two pilot projects in the provinces of Kongo Central and Nord Ubangi, while the second step will focus on replicating the first one on a larger scale. The second project, "Bukavu Green Community as pioneers of an integral and sustainable development in Democratic Republic of Congo, also aims at spreading the use of RE, but also including social and economic advantages. Two demonstrative projects will be designed and implemented in Bukavu, at the "Center for Peace and youth aggregation" by the Sant'Egidio Community, and in Goma at the "School of Peace". The models will then be replicated in other locations of the country. The third plan of action, " Sustainable Energy Services for Rural DRC", aims at creating a sustainable model for providing clean, reliable and cost-effective electricity through a mini-grid and off-grid power plant, in a village of the Masisi region. The last one, "Reseau de Collecteurs de Dechets de Kinshasa", has the purpose of improving the management of waste in the municipality of Gombe.

DJIBOUTI

The MoU with Djibouti was signed on November 17th, 2016, at the UN Climate Conference in Marrakech (COP 22). The amount is equal to 3 million €, which can be integrated with additional funds.
The main areas of cooperation include: sustainable energy and energy efficiency, especially through: exploiting the renewable energy potential of the

country, identifying locations for installations, estimating the RE generation capacity, promoting small-scale and off-grid RE systems for rural electrification and implementing pilot projects in the residential, tertiary and industry sector; sustainable agro-pastoral practices, in order to enhance Djibouti's food security and reduce GHG emissions. To this end, technology transfer, sustainable agricultural, agroforestry and agro-pastoral practices and sharing of knowledge to the local agricultural producers will be implemented. The last area of cooperation is the smart management of water resources, and it will be achieved by optimizing their use in the agricultural sector and by reinforcing infrastructure in order to improve local access to water, together with side activities such as the reduction of water loss within the supply network and the introduction of innovative techniques for resource management.
The amount of the funds still has to be agreed, however, there are already two projects in place. The one which focuses on emissions reduction is "A Nearly Zero Emission Sustainable Building in the University of Djibuti". *It* defines the construction of a "model building" environmentally sustainable, with 0 emissions target, which should be replied as a best practice in other public buildings. The project will also play the role of incubator in the research of innovative and "green" materials and technologies.

EGYPT

Egypt is a country with which Italy has a ten-year cooperation experience, with more than 7 million € invested in water management, environmental education, safeguarding of marine areas and use of energy from renewable sources. Furthermore, in 2015 a renewal of the MoU was signed, with an amount of 4 million € invested in environmental pollution, environmental protection and sustainable development.
Three main projects have been completed: Med Desire (RE) , Improware (water protection) and Egysol (solar energy). Furthermore, Italy is currently co-financing other three projects (two mitigation initiatives and one both adaptation and mitigation). They focus on waste management (construction of burial cell for waste landfill) and reduction of transports emissions (pilot project which promotes the use of hybrid vehicles in selected areas). Moreover, Italy also cares about the promotion of capacity building activities, contributing with 580,000 €. Finally, besides the bilateral cooperation, MATTM also supports the project "Mediterranean Investment Facility", implemented by UNEP and with an Italian contribution equal to 2 million €,

regarding the improvement of renewable energies, in order to facilitate energy access to isolated populations.

ETHIOPIA

Italian Cooperation in Ethiopia started in 2016, and it developed in 2017 with the signature of a Contribution Agreement with the Global Green Growth Institute (GGGI), which has the task to support the counterpart in terms of technical assistance. In 2016, 2 million € have been allocated, with additional 100,000 € in 2017. The partnership wants to promote the strengthening and transferring of knowledge, forest management, sustainable agriculture, water resources management, GHG reduction activities and development of climate information and early warning system; following these guidelines, the Joint Committee has started 3 projects (plus 2 adaptation initiatives), which are further analyzed.
The first one regards the "Sustainable Water Supply System in Rural Areas of Somali and Afar Regional States ". It is going to provide a sustainable water collection in 22 villages located in the aforementioned areas; in particular, the existing diesel-working plants will be replaced with pumps powered by solar energy.
The second project involves also the participation of the World Bank Group, ("Action Plan for disseminating renewable energy technologies through private sector in Ethiopia: Mobilizing Climate Finance"), and targets the spread of : powered by renewable energy in the country's off-grid areas, with the involvement of the private sector.
The last approved initiative is called "Policy Responses to Climate Change: Sustainable Development And Energy Transition". It focuses on sustainable development and energy transition, with the aim of supporting Ethiopian administrators in achieving and monitoring their National Reduction Targets Emissions.

KENYA

Kenyan partnership is recent, as it stared in 2018. The maximum amount fixed for climate change projects is equal to 3 million €, with the identification of the key sectors such as the support for the implementation, monitoring and communication of National Reduction Targets (NDCs) in the renewable energy sector; the support for the development and implementation of policies, strategies and programs on renewable, in order to achieve the emission reduction target set by the Republic of Kenya; the promotion of RE deriving from thermal, solar, wind, hydro and biomass; the improvement of energy efficiency; technological development in the field of renewable for the

electrification of rural areas through small plants or off-grid systems. They will be pursued using joint planning activities, capacity building, training, technology transfer and technical assistance. The participation of the private sector will also be promoted, also in partnership with the public sector, and the involvement of non-governmental organizations, especially in the renewable sector.

LESOTHO

In 2016, the Italian Ministry for the Environment signed with the Ministry of Foreign Affairs of Lesotho, Mr. Tlohang Sekhamane, an Agreement providing 2 million € for climate finance. It focuses mainly on the energy sector (promotion and development of renewable energies), emissions counting: (development of a national system for measuring, reporting and verifying GHG emissions), and forestry (combat the deforestation and forest degradation, in synergy with the REDD+ mechanism).
The "Renewable energy potential maps for Lesotho project", approved in 2017, aims at producing renewable energy potential maps, in order to facilitate the Government in the planning and development of renewable energy exploitation and to achieve a concrete step towards attaining low-emission development pathway.
The assessment will cover different renewable sources such as hydro, wind and solar. The potential energy maps will be embedded in a GIS based tool containing further data suitable for the identification of appropriate sites, such as network grid, roads, rivers/basins, land cover, population distribution, etc. In addition, the project will promote capacity building and training. The project is in place with the contribution of the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA).

MALI

Italian bilateral cooperation with Mali started in Bonn on November 2017, where MATTM and the Ministry of the Environment and Sanitation of the Republic of Mali signed the official MoU regarding climate change vulnerability. Italy committed itself in financing adaptation and mitigation strategies with a maximum amount of 2 million €.
The several areas of cooperation include: the collection, analysis and dissemination of data related to the observation of climate change and the measurement of its impact on potentially vulnerable economic sectors; the promotion of renewable energy and energy efficiency; the promotion of

Climate-Smart Agriculture practices; sustainable forest management, including the reduction of deforestation and forest degradation and the enhancement of afforestation / reforestation; sustainable and integrated water management. At the moment, projects are under analysis, and specific case studies are being conducted in order to fill the actual and specific gaps which constitute an obstacle to the sustainable development of the society.

MOROCCO

Cooperation between Italy and Morocco has been promoted since 2002 in the framework of three Memorandum of Understanding, two concluded and one ongoing on climate change, energy efficiency and the implementation of the CDM (Clean Development Mechanism) under the Kyoto Protocol. Italy co-finances this cooperation with a contribution of 2 million €.
Currently, together with the *Agence Marocaine pour l'Efficacité Energétique (AMEE)*, MATTM is implementing a project which has the ambitious aim of promoting the energy efficiency of Casablanca Hospital, the largest in North Africa. The project will guarantee the installation, in the pediatrics department, of solar thermal systems, water heating and air cooling, through the supply of Italian technologies.
Four priority areas have been identified with the new agreement: spread of knowledge about climate change, adaptation and mitigation strategies; gove strength to the policy framework regarding the management of coastal areas; promote education on environment and sustainable development.

SOUTH AFRICA

MATTM and the Ministry for the Environment Land and Sea and the Department of Water and Sanitation of South Africa have signed in 2016 the beginning of their partnership regarding the field of climate change mitigation and adaptation. This document does not define a fixed amount of funds, as they will be decided based on each project proposed.
The Work Plan recognizes as main targets to be pursued: the coordination and improvement of adaptation and mitigation efforts; the importance of water resources and their good and sustainable management; the focus on water services, hygienic-sanitary technologies at rural level, especially in remote areas and where it is possible to strengthen the link between water, energy and food.
These objectives will be pursued through capacity building actions and pilot projects in various fields including: integrated water cycle management;

installation of pilot water treatment plants; improvement of sanitary conditions in some selected locations.

SUDAN

On November 17th, 2016, at COP 22, the governments of Italy and Sudan signed a treaty of cooperation in the field of climate change, defining a co-funding of 2 million €.
To this purpose, three main areas of cooperation have been identified: renewable energies, water management and sustainable urban waste collection. The decision-making body of the agreement, has currently approved the following projects (together with two adaptation ones).
"Policy responses to climate change: sustainable development and energy transition", which consists of training activities for 50 public officers, to be held in Khartoum, focused on integrated water management green cities, renewable energy and off-grid services.
The second one is "Solar pumps for sustainable livelihood", and it deals with a water supply system in 10 rural villages through the use of solar pumps.
The last one, "Water Harvesting" aims at improving traditional practices on collection and management of water resources, for irrigation and animal use, in the village of Elgihad, in the River Nile State.

SWAZILAND

The Memorandum of Understanding signed by Italy and Swaziland is part of the United Nations Framework Convention on Climate Change (UNFCCC) and of the Paris Agreement, and it has been completed in 2017. The allocated funds have been estimated to be 2 million €, with a possibility of integration.
The Joint Committee identified the following four areas of intervention: environment, agriculture, water and energy.
On May 2018 it approved one mitigation-oriented project and one adaptation initiative.
The one challenging mitigation is a demonstration project about the improvement and development of green building practices ("Fossil fuel free and green building of the Raleigh Fitkin Memorial Hospital"). It will be implemented by UNDP Italy.

TUNISIA

The Italian Ministry for the Environment will co-finance activities approved under the Memorandum of Understanding with an amount not exceeding € 2 million.
In accordance with the Mid-Term Work Plan signed in 2017, the Parties will cooperate in various areas of common interest including: RE and a sustainable management of both the coastal zone and waste.

Cooperation among Italy and Tunisia has a long story, and has led to the implementation of various environmental initiatives, especially focused on water and renewables. The major successful programs include: PROSOL, which has stimulated the use of photovoltaic energy in the residential, industrial and tertiary sector, especially in the hotel circuit; MED DESIRE**,** which has supported the dissemination of energy efficiency and solar energy in different countries of the Mediterranean; IMPROWARE**,** which has focused on a more efficient use of water resources in Tunisia and in other Mediterranean countries. Italian bilateral activities are also supported by MEDREC (Mediterranean Renewable Energy Center), a Center established in 2004 in Tunis by the Italian Ministry for the Environment, for training, information dissemination, networking and development of pilot projects in the field of renewable energies around the Mediterranean basin.

3.5 Adaptation

The other major challenge is constituted by adaptation. Even if policies and efforts prove effective and in the right direction, some impacts and consequences of climate change will occur anyway; thus, strategies and actions not only aimed at reducing emissions, but also at adapting at its impacts are urgently needed.
Taking the African Continent into account, the major concerns it is already facing regard water stress, reduction of agricultural productivity, therefore food security, and diseases transmitted by vectors and water. Since 2007, the Contenent has gained experience in conceptualizing, planning, and beginning to implement and support adaptation activities, from local to national levels and across a growing range of sectors. However, most of the adaptation to climate variability and change is reactive in response to short-term motivations and it is occurring at household level, lacking support and resources from official institutions.

Anticipating adverse effects by taking appropriate measures, if planned well, can save a lot of money in the future, as it avoids to address them in recovering from occurred disasters. In Africa, early adaptation measures could include: development of drought-tolerant crops, building flood defenses, adapting buildings and infrastructures, choosing tree species and forests practices less vulnerable to extreme events. Furthermore, as stated above, vulnerability to climate change, especially for low-income people, is very high; the magnitude of impacts, their frequency and persistence have the ability to significantly reduce their potential for adaptation and increase uncertainty in their lives. Thus, healthy and resilient systems that can cope with natural hazards, shocks, and stressors are essential for achieving not only environmental benefits, but also solid foundation for economic and human development.

Climate resilience is a key component especially in weaker areas, where the majority of people rely on climate-sensitive natural resources and traditional agricultural practices for subsistence and livelihoods. The global community must continue mitigation efforts, but even if the world reaches the goal of the Paris Agreement and keep global warming below 1.5-2°C, at the same time the need for adaption efforts will still be needed. This exigency pushed 194 parties to the establishment of the *Least Developed Countries Fund (LDCF)* in 2001; managed by the GEF, it supports the world's most vulnerable countries in their efforts to adapt to the effects of climate change. It was designed to address the special needs of the Least Developed Countries under the UNFCCC. One of its most important tasks is the support for the countries implementation of their *National Adaptation Programs of Action (NAPAs)*. NAPAs are country-driven strategies that identify the most immediate needs of LDCs to adapt to climate change, reducing the vulnerability in the key sectors by financing on-the-ground adaptation activities.

The current situation it is likely to need support for adaptation in a wide variety of sectors; the important include: the protection and safeguard of coastal zones, as they are highly exposed to climate change, but at the same time they are often ill-equipped to adapt; roads, ports, infrastructures are also high sensitive to natural hazards; the spread of diseases which mostly affect urban poor, pregnant women, children and the elderly, traditional societies, subsistence farmers and coastal populations; overall systems, which have to learn to manage intense droughts and recurrent floods.

Adaptation in Africa is a priority to Italian government, this is why initiatives following this direction have been recently developed.

BOTSWANA

As explained in the previous paragraph, actions in Botswana are aimed at both adaptation and mitigation strategies. One project has been approved regarding the former, and it constitutes in supporting the Country's Early Warning System (EWS); *the initiative wants to str*engthen its EWS in order to provide real-time data for the prevention climate-related extreme weather events and their impacts. The project will also support Southern African Development Community (SADC) Region to manage floods through appropriated planning measures.

DJIBOUTI

In Djibouti, "Feasibility study for the realization of two boreholes in the localities of Adbouya and Bondara in the Tadjourah and Dikhil regions", is the focus of Italian cooperation. The objective of the project is increasing the resilience of local communities. Activities will be complementary to those carried out within the Adaptation Technologies in Fragile Ecosystems of Djibouti's Central Plains, funded by the Global Environment Facility-GEF and implemented by UNEP.

ETHIOPIA

Also in Ethiopia prominence has been given to the improvement of its EWS; applied to the local context, the importance of a reliable EWS is essential for reducing the incidence of drought, protecting the population at least to the extent that will not lack drinking water. This is why this initiative provides a complete package of training activities, in favor of the National Meteorology Agency, in order to improve the quality of weather forecasts and strengthen the reliability of the terrestrial monitoring network.
Another adaptation project in Ethiopia is about "Climate Smart Integrated Rural Development Project in the Pastoralist area of Ethiopia"; this program wants to protect the rural populations from climate change through an integrated approach to water management, agriculture and natural resources. Diversify and accurately select crop varieties could reduce food uncertainty; indeed, it will benefit 35,000 inhabitants.

RWANDA

Cooperation with Rwanda started with the signature of the Memorandum of Understanding on November 14, 2016. The amount defined in the Agreement is up to 2 million €, which can be integrated with additional funds if needed.

Furthermore, in 2018, the two governments also signed an Agreement with the Global Green Growth Institute (GGGI), which will give its support for the identification of project proposals to be approved.
As Italian Cooperation does not apply the "one fits all" principle, adaptation projects have been prioritized in Rwanda, as the country has been seriously confronted with increasing and more severe floods resulting from heavy rainfalls, especially in the north-western highlands, and periodic droughts in the eastern lowlands. An even more specific focus has been given to agriculture, as this increased variability in rainfall patterns have substantial impacts on rain-fed crops, which remain the main source of livelihood for the majority of the population. The Work Plan that has been approved identifies the following areas of interest: promotion of sustainable agricultural practices, integrated management of water resources and waste management.
In 2018 the Ruand Governement and GGGI proposed a program for the rehabilitation and remediation of some urban and periurban humid areas in Kigali, in the view of making the town more and more resilient. The project will involve the "Africa Center for Climate and Sustainable Development and Agenda 2030" promoted by the Italian Ministry for Environment at the 2017 G7 Environment.

SUDAN

The ongoing adaptation programs in Sudan aim mostly at strengthening its meteorological data acquisition. The two projects provide a complete package of training activities and expansion of land observation network, in favor of the SMA (Sudan Meteorological Authority) in order to strengthen the hydro-meteorological network and of climate service and radar instruments.

SWAZILAND

Strengthen Swaziland early warning system and climate services are the most pressing matters regarding adaptation. The projects aim to strengthen the Swazi meteorological EWS in order to provide real-time data for the prevention of climate-related extreme weather events and their impacts, which are likely to be considerable, especially on the agricultural and water sector. The project will be implemented by UNDP (United Nation Development Program).

3.6 Additional projects

This section has been created to describe the programs that Italy is developing in Africa which combine both mitigation and adaptation approaches. These type of projects mainly include spread of knowledge and capacity building activities, however, also more detailed actions have been implemented in two States: Botswana and Egypt.
In Botswana, actions have been taken in the civil sector, more specifically actions aimed at greening MENT buildings, by providing for devices for energy production and water saving (up to 80% and 50% respectively). The installed air conditioning systems will be HFC- free, in compliance with Kigali amendment to the Montreal Protocol.
In Egypt, the project is called "Protected Areas Management and Renewable Energy"; it is going to provide sustainable infrastructures in Wadi Degla protected area.
The funds of the Italian Cooperation have been allocated by country, not by type of project, this is why not every project has the import of funds.

3.7 African Position

In order to join international efforts to reduce climate change, all African countries signed the Paris Agreement. In particular, through their nationally determined contributions (NDCs), they committed to contribute to the global effort to mitigate greenhouse gas emissions with the aim to constrain global temperature increases to 'well below 2°C' and to pursue efforts to limit warming to '1.5°C above pre-industrial levels'. The target of limiting global warming to 1.5°C above preindustrial levels is useful for conveying the urgency of the situation.
However, the outcome of how Africa will deal with climate change, now and in the future, is mostly determined by the funding it receives from the international community; its ability to mitigate and adapt relies heavily on international contributions. Indeed, the major limit it experiences is the lack of financial, technological and technical resources to fight climate change, even if it represents one of the most affected areas.
In the Article 4.4 of UNFCCC "The developed country Parties and other developed country Parties shall also assist the developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse effects". This means that the gap between developed and least developed countries is globally recognized and accepted, together with the result that the latter do not have the possibility to rely just

on their capacities; in fact, as climate change is a transnational issue, a joint approach has been defined as the best solution for all.

In this regard, the Global Environment Facility (GEF) and the Green Climate Fund (GCF) are the Operating Entities of the Financial Mechanism of the Convention, they establish and decide the allocation of resources and instruments in LDCs, to support them coping with the financial costs that impacts cause.

However, the access to international funding remains challenging at every stage of the funding process for countries with technical, institutional and human capacity gaps. The first challenge lies in developing national adaptation and resilience-building plans and strategies in line with countries' development priorities, including necessary stakeholders consultation processes at national and sub-national level.

Furthermore, capacity constrained countries have difficulties to formulate costed, bankable, result-oriented projects and programs derived from strategies and plans. Moreover, those countries also face difficulties in meeting internationally agreed fiduciary, financial management standards, and internationally agreed environmental and social safeguards and therefore might not get their national entities accredited and granted direct access. Thus, it remains a very complex mechanism which not always results effective, with the negative implications of climate change affecting the most vulnerable and less responsible populations. Fortunately, steps in the right direction in order to facilitate administrative and structural problems are being made, however, time is running out and if the international community does not adopt an homogeneous line everyone will experience the outcomes of what we have done in the past.

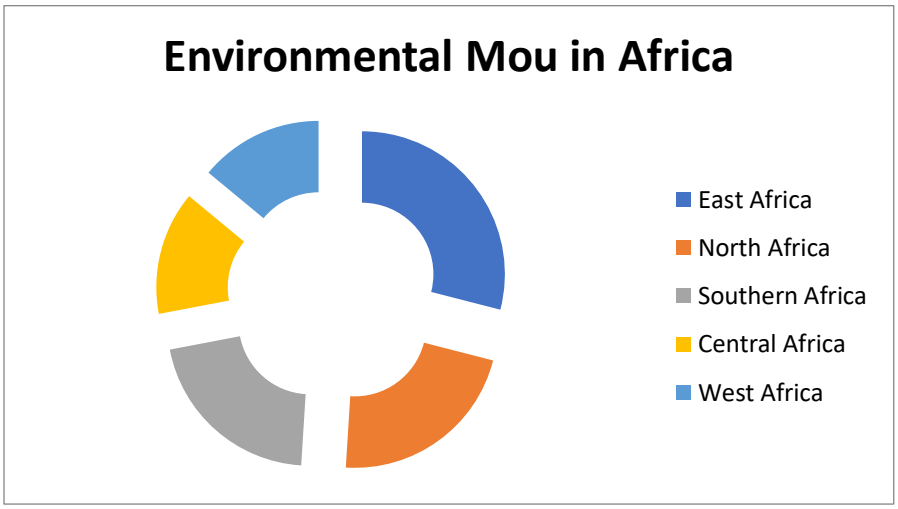
CONCLUSIONS

During the course of this discussion, various aspects regarding climate change have been exposed and subsequently analyzed. After having considered the process of global warming, from its discovery to its current implications, present International Agreements and their commitments have been overviewed. The reduction of emissions and the transition to a more sustainable economy are the pillars to achieve concrete results. Subsequently, the topic has been contextualized analyzing anthropogenic emissions by source, sector and country, as they constitute the main driver of the changes that are affecting terrestrial atmosphere and ecosystems. This chapter has been developed with the aim of clarify and give all the indispensable information to understand the range and seriousness of the apocalypse that is happening and worsening day by day. In the final part of this work, developing countries with a special focus on Africa have been under analysis, with their impossibility to manage on their own climate change seriousness. Therefore, developed countries engaged themselves to put in place strategies aimed at both reducing GHGs emissions and adapting with new tools and technologies. The report also finds that Italian development cooperation is well placed to address complex and unpredictable local events, with its long story of valid knowledge, technical expertise and advanced technologies.

The innovative Italian framework applied to help Africa has some common elements, without forgetting to take into account the peculiarities of each Country. A broad and general approach to build community resilience, based on gender equality and promotion of human rights, is combined with specific support to important weaknesses, such as water scarcity, energy access and food security. Forests, agriculture, renewable energies and sustainable development are the protagonists in this new scenario, also while promoting disaster risk reduction in fragile and conflictual contexts.

Italy has a partnership with 15 African States, and with each of them it has signed a Memorandum of Understanding and developed a Work Plan to implement actual strategies, each of them proposed by the recipient country. Furthermore, it has Agreements under negotiation with: Burkina Faso, Ivory Coast, Gambia, Ghana, Liberia, Mauritania, Mozambique, Senegal, Tanzania, and Zambia.

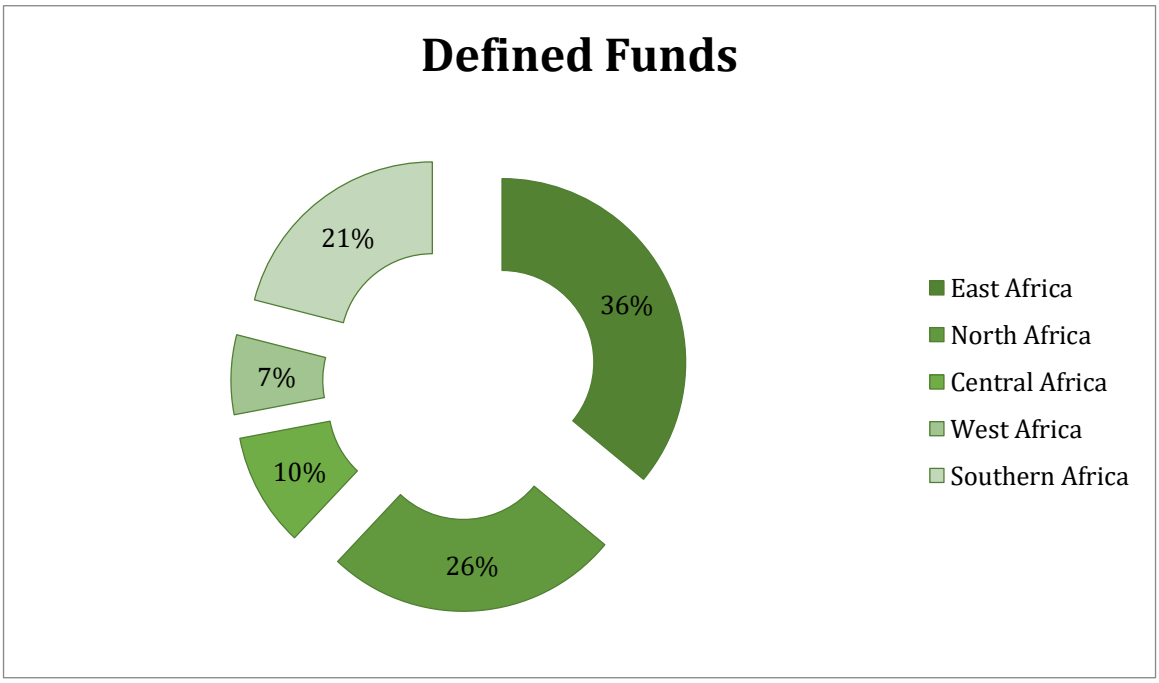
Table 28: Geographical Repartition

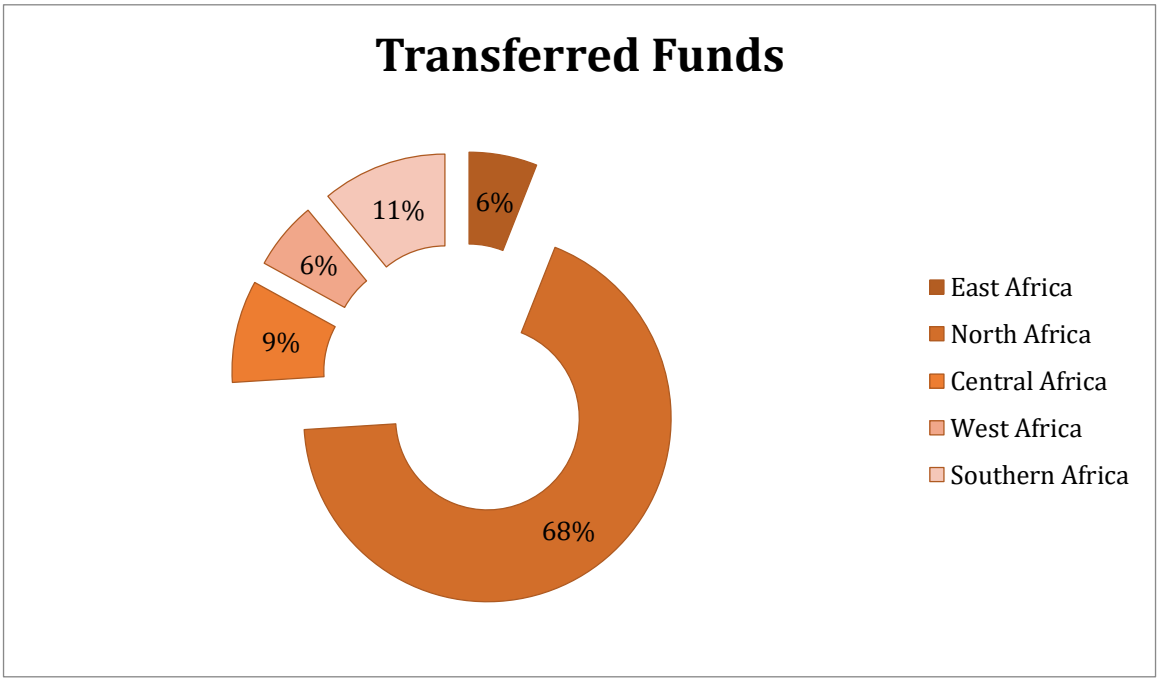


Source: Personal elaboration based on ministerial data (MAE), 2018

The graph shows the repartition as follows: North Africa 22%, Southern Africa 21%, Central Africa 14%, West Africa 14%, East Africa 29%.
In the next two graphs the total amount of both defined and transferred Italian funds is showed. The difference between the two categories is that defined funds are the ones agreed in the official document, with an eventual opportunity of integration with additional pools. On the other hand, the transferred ones just refer to the amounts already granted and transferred to implement specific initiatives.
The first table represents the defined funds, according to regions, percentages and amounts. In North Africa 11.267.466 € have been agreed; East Africa registers 15,265,853 €; West Africa 3,052,257 €; Central Africa 4,344,000; lastly, Southern Africa with 9,175,252 €.
The second table shows the actual transferred financial tools, out of the ones defined in the Agreements as the maximum amount available: North Africa 1,646,837 €; East Africa 142,893 €; West Africa 140,300 €; Central Africa 222,000 €; Southern Africa 280,500 €.
It has to be noted that the transfer of funds is linked to the ratification and adoption of specific projects, which have to be decided by both governments on recipient's initiative, and in some cases other international bodies have a say in the final decision.

Table 29 and 30: Defined and Transferred Funds





Source: Personal Elaboration based on ministerial data (MAE), 2018

Dividing the transferred funds by country, the classification is as follows: East Africa (Djibouti 20,000 €; Kenya, no transferred funds yet; Ethiopia 84,973 €; Sudan 37,920 €;), Southern Africa (Botswana 99,750 €; Lesotho 180,750 €; Swaziland no transferred funds yet;), North Africa (Egypt 658,423 €; Morocco 788,414 €; Tunisia 200,000 €;), West Africa (Mali 140.300 €), Central Africa (DRC 172,000 €; Rwanda 50,000 €;).

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