



# Climate changes Causes, Manifestations, and Effects in Sahel

Diagram of the greenhouse effect (Source: ADEME, 2006)

## Summary

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## Synthesis

Published late 2013, the latest IPCC report demonstrates that the link between human activities and increasing temperatures observed since 1950 is *very likely*.

These activities are manifested by massive emissions of Greenhouse Gases (GHGs) in the atmosphere, including carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O).

Responsibilities are shared unequally between countries, but effects apply to everyone, especially African countries, particularly sub-Saharan ones.

Yet, the African continent as a whole represents only 3.4% of global GHGs emissions and the CILSS/ECOWAS countries all together less than 1% of global emissions.

At the global level, since the early 20<sup>th</sup> century, the temperature of the surface of the earth has increased by 0.8°C and sea levels rose from 19 cm. Each of the last three decades has been successively warmer than all previous decades since 1850!

At the level of sub-Saharan Africa, climate changes are also important and disrupt farming activities, backbone of the economy: increase in the frequency of hot days and nights, heat waves, rainfall anomalies (annual and monthly volumes, heavy rains, consecutive dry days, start and end of the rainy season, etc.), increase in extreme weather events, etc.

The example of the rainfall is striking: after experiencing an unprecedented drought in the world since the 1970s, West Africa has benefited from increased rainfall since the beginning of the 1990s, but with a strong inter-annual variability and more frequent episodes of heavy rains. The duration of the rainy season has decreased, while the frequency of flooding has increased.

The impacts of climate changes are perceived by the West African populations, but their causes are not well understood.

Informing these populations on climate changes, which will grow worse, is therefore an urgent challenge.

## Introduction

In 1987, the report from the World Commission on Environment and Development of the UNO, chaired by Gro Harlem Brundtland, highlights the risks posed by global changes, including climate changes.

The same year, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) call for the creation of an Inter-Governmental Panel of Experts on Climate Change (IPCC).

It is established in November 1988 with the mandate, among other things, to regularly compile available scientific information on the causes, manifestations and effects of climate changes.

The fifth IPCC report on climate changes was published recently. This note presents the latest results provided by the IPCC, as well as the results of the Agrhymet antenna of the CILSS, with a focus on the Sahel.



# 1. Causes

**CDIAC:** Carbon Dioxide Information Analysis Centre ([www.cdiac.ornl.gov](http://www.cdiac.ornl.gov))

**UNFCCC:** United Nations Framework Convention on Climate Change

**GHG:** Greenhouse Gas

**IPCC:** Inter-Governmental Panel of Experts on Climate Change

**LULUCF:** Land Use, Land Use Change, and Forestry

**ppb:** Part Per Billion

**ppm:** Part Per Million

**Sink:** Any process, activity or mechanism which removes a GHG, an aerosol or a precursor of a GHG from the atmosphere

The fifth IPCC report unequivocally shows an increase in atmospheric concentrations of carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O), which reached unprecedented levels since at least 800,000 years

## 1.1. GHG Emissions

Climate change is mainly due to the over-accumulation of GHGs in the atmosphere. These GHGs trap infrared radiation, which warms the earth's surface and cause climate changes in cascade.

The fifth IPCC report clearly demonstrates increased concentrations of carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O), which reached unprecedented levels in 800,000 years.

In 2012, according to the latest bulletin of the WMO, the respective concentrations of these GHGs were 393 ppm, 1,819 ppb, and ppb 325, and exceeded pre-industrial levels (before 1750), respectively, about 41%, 160% and 20%. More alarming, the rate of increase of atmospheric CO<sub>2</sub> between 2011 and 2012 is higher than the average over the last decade.

Other GHG, such as halogenated hydrocarbons (CFCs and HFCs) and sulfur hexafluoride (SF<sub>6</sub>) are also increasing.

According to the Global Carbon Project, CO<sub>2</sub> is mainly emitted from fossil fuels burning and cement production (in average: 8.6 ± 0.4 billion tons from 2003 to 2012), and land use change and deforestation (in average: 0.8 ± 0.5 billion tons from 2003 to 2012).

The first sector is steadily rising, while the second has declined steadily since 1990. The CO<sub>2</sub> emissions are offset by the oceanic and terrestrial sinks, which each accounted for an average of 2.6 billion tons over the period 2003-2012.

These emissions vary greatly from country to country. The website of the Global Carbon Atlas ([www.globalcarbonatlas.org](http://www.globalcarbonatlas.org)) used to represent the emissions per country calculated by the Carbon Dioxide Information Analysis Center (CDIAC). The top five emitters are China, USA, India, Russia, and Japan, which account on their own for 56.6% of CO<sub>2</sub> emissions (fossil fuels and cement only).

The African continent as a whole represents only 3.4% of global emissions and the countries of the CILSS/ECOWAS all together less than 1%.

Emissions from deforestation are mainly located in South America and Southeast Asia, and marginally in Africa.

## 1.2. Spatial Distribution

The distributions are highly uneven in space and vary from one GHG to the other, depending on the structure of the economies. Figure 1 shows the distribution of CO<sub>2</sub> emissions by country:

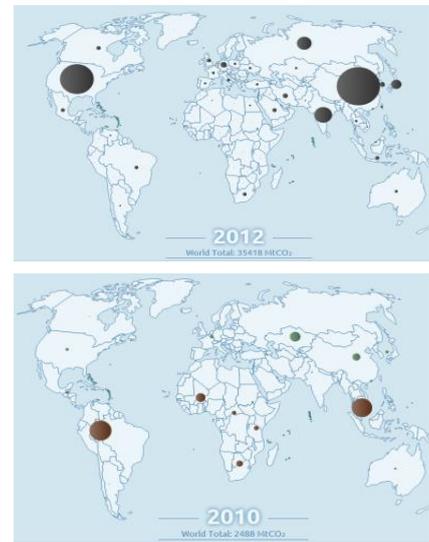


Figure 1 – Global GHG emissions: up for fossil fuels in 2012 and down for LULUCF in 2010 (Source: [www.globalcarbonatlas.org](http://www.globalcarbonatlas.org))

From the spatialised N<sub>2</sub>O emissions for 2000 (measured) and 2050 (forecasted), the significant increase of N<sub>2</sub>O emissions for Africa can be highlighted (IPCC, 2013):

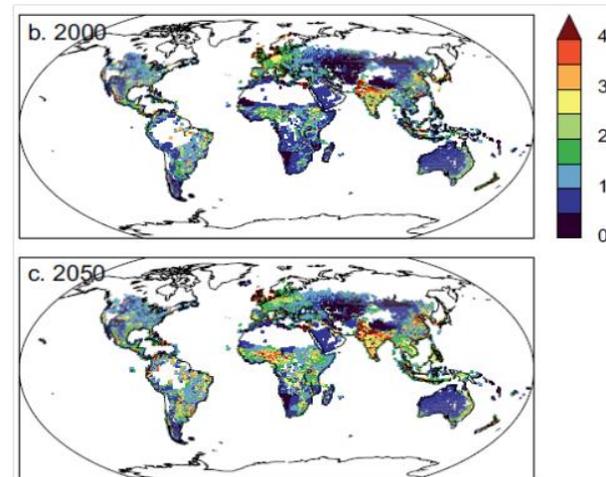


Figure 2 – Relative magnitude of spatialised N<sub>2</sub>O emissions (Source: figure 6.32 – IPCC Report, 2013)

CH<sub>4</sub> and N<sub>2</sub>O account for 75% of GHG emissions in West Africa, against 25% globally, as GHG emissions from the agriculture sector are proportionally more important (see Figures 3 and 4 below). Also, if the Land Use, Land Use Change, and Forestry (LULUCF) sector is a net sink worldwide, it is a net source for Africa. This result is detailed in the Soil Atlas for Africa (FAO, 2013).

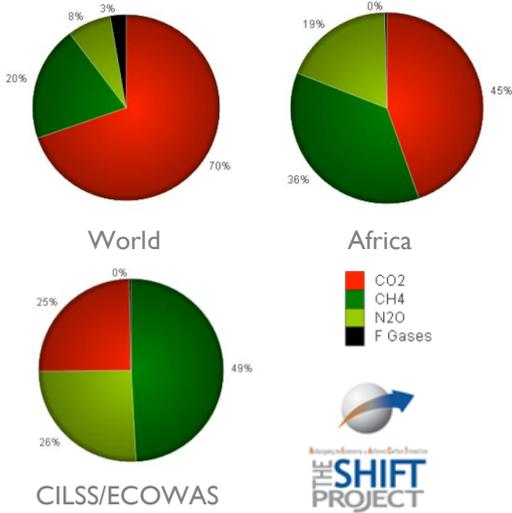


Figure 3 – GHG emissions per type of GHG, with a focus on Africa (Source: The Shift Project, 2010)

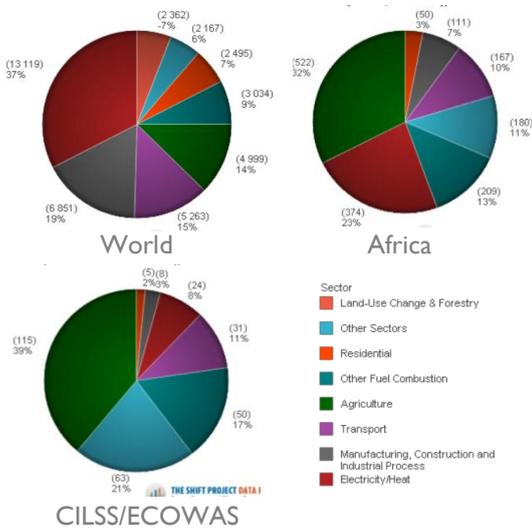


Figure 4 – GHG emissions per sector, with a focus on Africa (Source: The Shift Project, 2010)

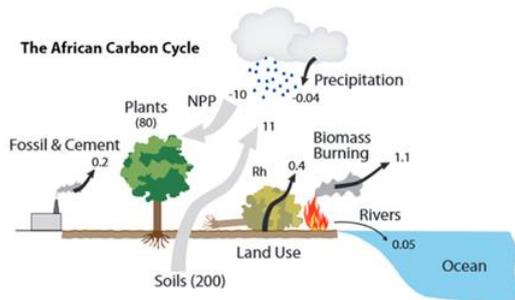


Figure 5 – The African Carbon Cycle (Source: The Shift Project, 2010)

## 2. Manifestations and Effects

### 2.1. At Global Level

At the global level, climate changes occur in the atmosphere, hydrosphere, biosphere, cryosphere, and geosphere.

Obviously, temperatures are often the main focus of public opinion, which more often refers to *global warming* instead of *climate changes*.

But other important changes also concern the water cycle (precipitation disturbances), cryosphere (melting of glaciers and polar ice cap in the North), and oceans (ocean acidification, alternations of El Niño and La Niña).

The United Nations Framework Convention on Climate Change (UNFCCC) defines "adverse effects of climate changes" as "changes in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare" (Article 1).

### Conclusions of the 5<sup>th</sup> IPCC Report (2013)

**"Warming of the climate system is unequivocal, and since the 1950s, many observed changes are unprecedented for decades or millennia. The atmosphere and ocean have warmed, the snow cover and ice cap has decreased, and sea levels have risen".**

From 1906 to 2012, the surface temperature of the earth has increased by 0.8°C.

The temperature of the earth's surface for each of the past three decades has been successively warmer than all previous decades since 1850.

The years 1983 to 2012 are probably the hottest period of 30 years the Northern Hemisphere has known since 1,400 years (medium level of confidence).

It is almost certain that the ocean surface (up to 700 m deep) has warmed between 1971 and 2010 and it has probably warmed between 1870 and 1971.

Over the past two decades, the mass of ice sheets of Greenland and Antarctica has decreased, glaciers in nearly all parts of the world have decreased, and Arctic sea ice and the spring snow cover of the Northern Hemisphere have continued to decline (high level of confidence).

Since the mid-nineteenth century, the rate of rise in mean sea level is higher than the average rate of the last two millennia (high level of confidence).

Between 1901 and 2010, the average sea level across the globe rose by 19 cm.

Desertification: "land degradation in arid, semi-arid, and dry sub-humid areas caused primarily by human activities and climatic variations" (United Nations Convention to Combat Desertification, 1996).

Desertification directly affects 250 million of people worldwide (UNCCD, 2013).

Each year, 10 million hectares of arable land are degraded in the world (UNCCD, 2013).

In Africa, 70 million hectares are now seriously affected by desertification (UNCCD, 2013).

La Niña: weather phenomenon produced by a thermal anomaly of the Pacific Ocean surface waters, it is characterized by an abnormally low temperature of these waters. El Nino has the opposite effects to those of La Niña. The correlation between these phenomena is low and their frequency is different. West Africa is marginally affected by these phenomena.

In 2010, the countries of the CILSS/ECOWAS represented less than 1% of global annual GHG emissions:

- World: 35,566 MtCO<sub>2e</sub>
- Africa: 1612 MtCO<sub>2e</sub>
- CILSS/ECOWAS: 296 MtCO<sub>2e</sub>

## Short bibliography

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GHG emissions per category: <http://www.tsp-data-portal.org/all-datasets>

WMO Bulletin: [http://www.wmo.int/pages/prog/arep/gaw/ghg/documents/GHG\\_Bulletin\\_No.9\\_fr.pdf](http://www.wmo.int/pages/prog/arep/gaw/ghg/documents/GHG_Bulletin_No.9_fr.pdf)

Soil Atlas of Africa (FAO, 2013)

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The IPCC's latest report says that "at the end of the twenty-first century, the increase in the surface temperature of the globe will probably be greater than 1.5°C compared to the period from 1850 to 1900".

All scenarios (except the said scenario RCP2.6) assume that "global warming will continue after 2100. This will continue to present an inter-annual to decadal variability and will not be uniform."

## 2.2. In West Africa

Rural populations in West Africa are well aware of the various impacts of climate change: these are perceived by 60% to 100% of the populations surveyed in some provinces of Burkina-Faso and Chad (SARR, 2014).

These rates reach up to 100% with regard to the increased temperatures and decreased precipitations (ibid). By cons, a tiny fraction of the population makes the link between these impacts and climate changes: 50% attribute it to natural phenomena and 47% to cultural and religious phenomena (ibid).

Much remains to be done in terms of information, education, and communication to the general public with regard to climate changes in West Africa, especially as extreme weather events and climate-related slow-onset events are already observed and should only get worse in the future.

Agriculture, the basis of sub-Saharan economy is disrupted by these climate changes: increase in the frequency of hot days and nights, heat waves, rainfall anomalies (annual and monthly volumes, heavy rains, consecutive dry days, start and end of the rainy season, etc.), increase in extreme weather events, etc.

If we consider the rains for example, the facts are striking. Since the end of the 1970s, the drought in West Africa is the most severe and longest in the world in the 21<sup>st</sup> century - IPCC, 2007 (see Figure 6):

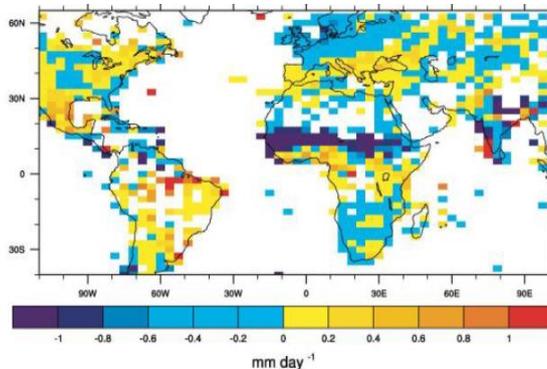


Figure 6 – Changes in terms of July-August rainfalls, 1967-98 VS 1948-66 (Source: Univ. East Anglia - IPCC, 2007)

Rainfall has certainly increased from the 1990s, but its variability also increased (see Figure 7), as the frequency of heavy rains (see Figure 8):

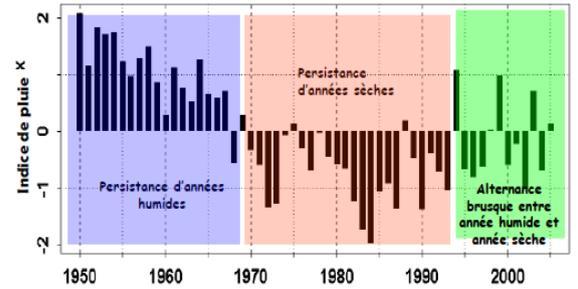


Figure 7 - Evolution of the rain index in Sahel from 1950 to 2005 (Source: Agrhymet, 2010)

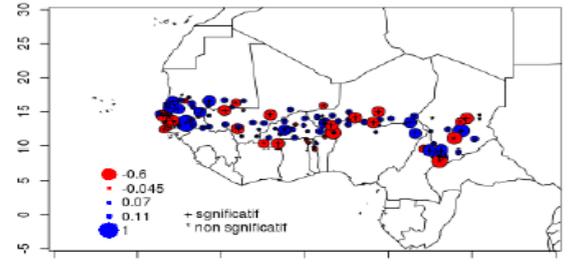


Figure 8 - 1990-2010 evolution of heavy rains (stacking 3 days maximum rainfall) (Source: Agrhymet, 2013)

Moreover, the duration of the rainy season has decreased since the 1950s, thus reducing the cropping season (see Figure 9):

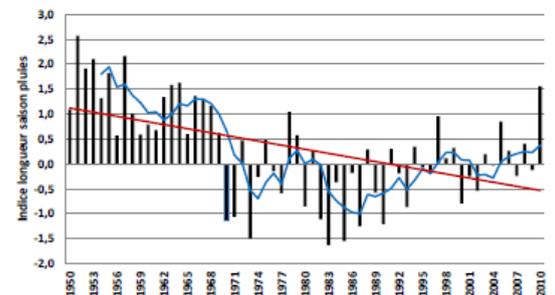


Figure 9 - 1950-2010 evolution of the index of length of the rainy season in Sudan and-Sahel (Source: Agrhymet, 2013)

Finally, floods, whose occurrence is most likely related to climate changes according to the IPCC, are frequent, and should be more frequent and intense (see Figure 10):

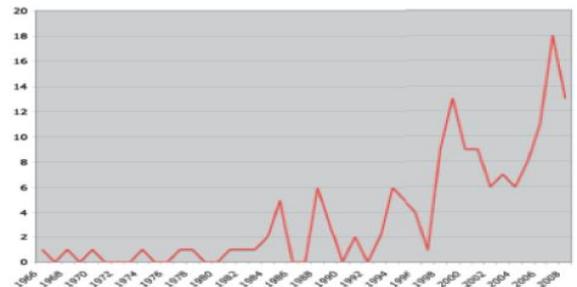


Figure 10 - Evolution 1966-2008 of the number of floods in Africa (Source: International Federation of Red Cross, 2008)