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Société Générale Economic and Sector Studies

Africa and global warming: low contribution but high vulnerability

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Africa is a marginal contributor to global warming, accounting for less than 4% of total greenhouse gas emissions in 2020 (in line with its weight in global GDP, but significantly less than the 17% of the world's population that it represents). On the other hand, the region appears to be one of the most vulnerable to climate change, whether because of its intrinsic natural characteristics (water stress, desertification, etc.) or its own economic characteristics (high dependence of the continent on agricultural activities, low infrastructure development, still high level of poverty, etc.). In the coming years, global warming could have significant economic (loss of GDP) and human (displaced populations, famines, etc.) consequences, even though the region is still very dependent on its natural capital – whether renewable (forests, cultivated land and fisheries resources, for example) or non-renewable (such as minerals and fossil fuels).

Africa is a marginal contributor to global warming

A VERY LIMITED WEIGHT IN GLOBAL GREENHOUSE GAS EMISSIONS

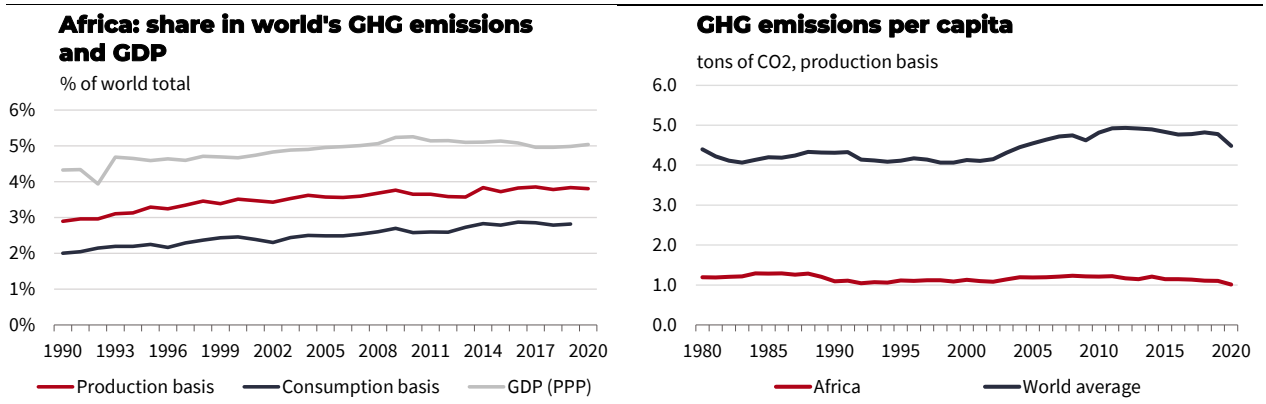
At present, Africa[1] is a "marginal" contributor to global warming. The most commonly used indicator in this perspective is greenhouse gas (GHG) emissions[2], evaluated on a "production basis"[3]: here, according to Global Carbon Project statistics, the continent accounted for 3.8% of global emissions in 2020 (about 1,325 million tons of CO_2 equivalent), i.e., less than Russia (~1,575 $MtCO_2$) or the four main countries of the Euro area (France, Germany, Italy, Spain; 1,425 $MtCO_2$). This ratio, which has changed only slightly over the long term (3.3% in 1971), is broadly in line

[1] *In this document, Africa is understood as the "continent", ie. including North Africa and Sub-Saharan Africa.*
[2] *Greenhouse gases (GHGs) are gaseous components that absorb infrared radiation emitted by the Earth's surface and thus contribute to the greenhouse effect. Carbon dioxide (CO_2) represents more than 80% of GHG emissions.*
[3] *Also called "territorial basis".*

with Africa's weight in the world economy: 5% of world GDP estimated in Purchasing Power Parity (PPP) in 2020 (according to the IMF).

The observation remains broadly the same if emissions are analysed on a "consumption basis" (i.e. tracking goods and services produced worldwide and attributing the corresponding GHG emissions to the country where the final consumption takes place). According to this metric, the weight of Africa is even more marginal, accounting for less than 3% of the world total (chart 1). This seems to reveal a development model (on average in the region) that is still too "extractive", i.e. based on the extraction of raw materials (oil, gas, minerals, etc.) that are then consumed in advanced markets, and which has not yet been able to create a class of local consumers.

Charts 1 and 2: a marginal contribution to global GHG emissions, and indicative of an "extractive" development model

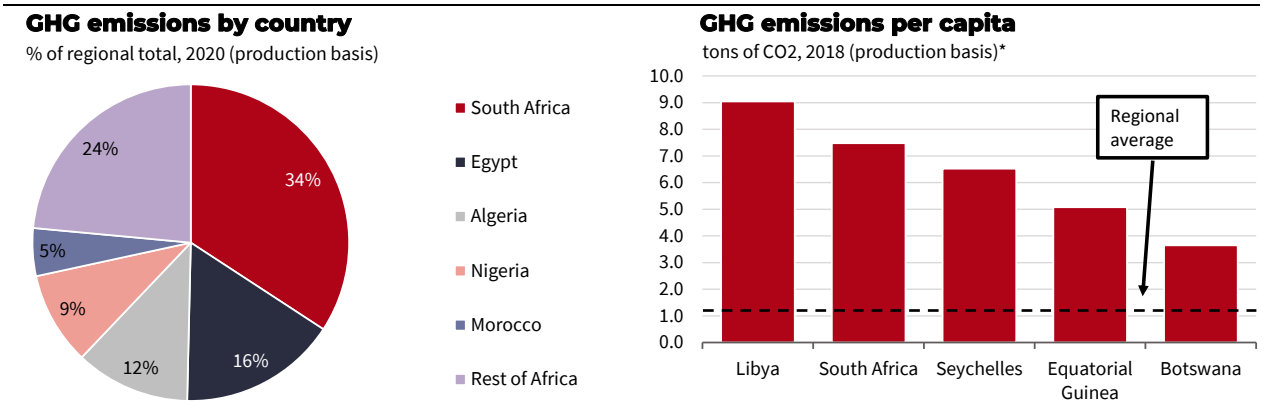


Source: SG Economic and Sector Studies, Global Carbon Project, IMF

This view is further reinforced if we consider GHG emissions per capita (chart 2). With a population of about 1.35 billion, Africa represents 17% of the world's population, for 3% to 4% of GHG emissions. On average in 2020, one inhabitant of the continent emitted 1 tCO_2, well below the world average of 4.5 or the per capita emission levels of advanced countries (whether they benefit from a "carbon frugal" model – like France, at 4.2 tCO_2 per inhabitant – or not – like the United States, at 13.7 tCO_2).

Within Africa, and not surprisingly, the most industrialized/wealthy countries contribute the most to regional emissions (chart 3): South Africa alone accounts for more than 1/3 of emissions, and the top 5 countries (adding Egypt, Algeria, Nigeria and Morocco) for more than 75% of total regional GHG emissions. As for the rest of the world, a view of per capita emissions, on the other hand, highlights (with the exception of South Africa) sparsely populated countries whose development model is "greedy" in terms of carbon: extraction of hydrocarbons or minerals (Libya, Equatorial Guinea, Botswana) or tourism (Seychelles).

Charts 3 and 4: unsurprisingly, the most industrialized/wealthy countries contribute the most to regional emissions



Source: SG Economic and Sector Studies, Global Carbon Project, IMF, World Bank.

**: for chart 4, 2018 data is used, as some countries do not have available data after this year.*

EMISSIONS HAVE MOVED IN LINE WITH DEMOGRAPHICS, WITH A DETERIORATING CARBON INTENSITY

The Kaya identity provides a simple way of decomposing CO_2 emissions and analysing changes over time, linking them to population growth, GDP per capita growth, the energy intensity of GDP and the CO_2 content energy production ("carbon intensity"):

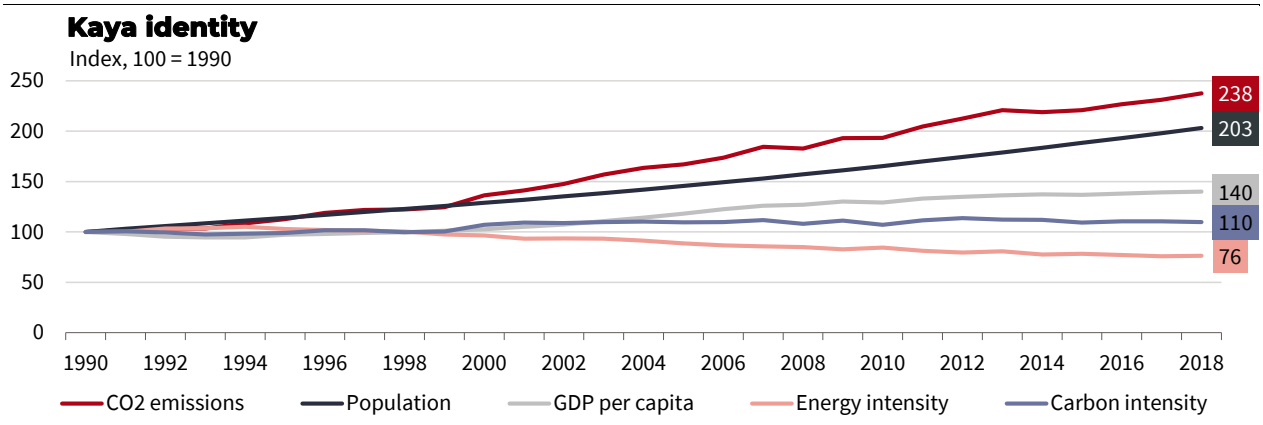
$$CO_2 = Population \times \frac{GDP}{Population} \times \frac{TOE}{GDP} \times \frac{CO_2}{TOE}$$

Where TOE = amount of energy expressed in tons of oil equivalent.

Expressed differently:

$$CO_2 = Pop. \times GDP\ per\ capita \times energy\ intensity \times carbon\ intensity$$

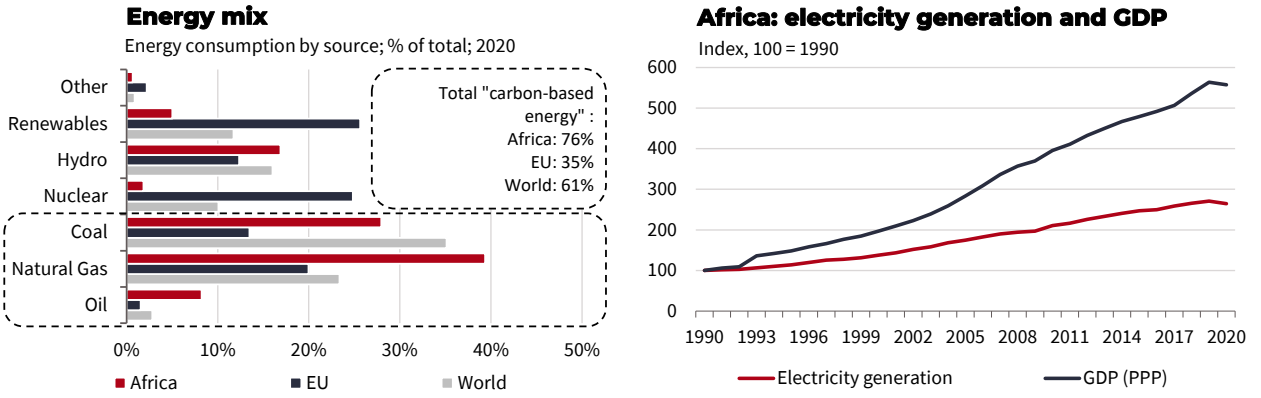
Chart 5: Africa has not yet benefited from an improvement in its "carbon intensity"



Source: SG Economic and Sector Studies, IEA

This identity (chart 5, based on data from the International Energy Agency – IEA) highlights that regional CO_2 emissions have evolved in line with the rapid growth of the African population (x2 since 1990) and, to a lesser extent, its level of wealth (+40% since 1990). On the other hand, and contrary to most other countries/regions, Africa has not yet recorded a real improvement in its carbon intensity, which seems to have reached a high plateau and stagnated since the early 2000s. This is mainly due to an energy mix that is among the least favourable in the world (chart 6): 76% of the energy consumed in Africa is produced via "carbon" solutions (ie. oil-, gas- or coal-fired power stations), compared to 35% on average for the European Union. Conversely, Africa's GDP is still not very energy-intensive (chart 7), which also reflects its own development problems: the predominance of subsistence-based agriculture, underdeveloped industrial – and particularly manufacturing – sectors, etc[4].

Charts 6 and 7: an unfavourable energy mix, even though Africa's GDP remains energy-efficient



Source: SG Economic and Sector Studies, British Petroleum, IMF.

… but would one of the regions most affected by global warming

THE EFFECTS OF GLOBAL WARMING ARE ALREADY BEING FELT

Although Africa is a marginal contributor to global warming, the continent is already facing its consequences. This vulnerability is due to both:

- Various intrinsic natural characteristics: for example, the continent faces significant levels of water stress (many countries remain dependent on neighbouring countries for their water supply[5] – chart 8) or desertification (the UN estimates that about 525 million people – over 40% of the regional population – live in drylands).

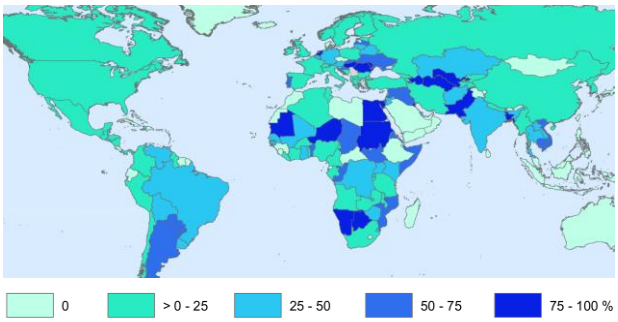
[4] These issues were explained more extensively in Risk&Opportunities #2 and #3, published in February 2019.
[5] 21 countries in Africa have a "dependency index" – an indicator calculated by the FAO, expressing the percentage of total renewable water resources coming from other countries – of over 33%.

- Various economics characteristics: high dependence of the continent on agricultural activities, low development of infrastructure, (more simply) still high levels of poverty (chart 9), etc.

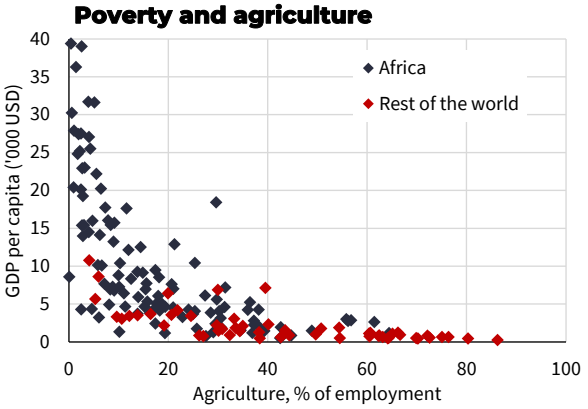
Charts 8 and 9: "natural" and economic factors explain Africa's high vulnerability to climate events

Dependency Index

% of total renewable water resources coming from abroad



Poverty and agriculture



Source: SG Economic and Sector Studies, World Bank, Food and Agriculture Organization of the United Nations.

Like other research organisations and institutions[6], Société Générale has developed its own *Sovereign Climate Vulnerability Index* (SCVI), which assesses the (relative) vulnerability of countries to two types of risk:

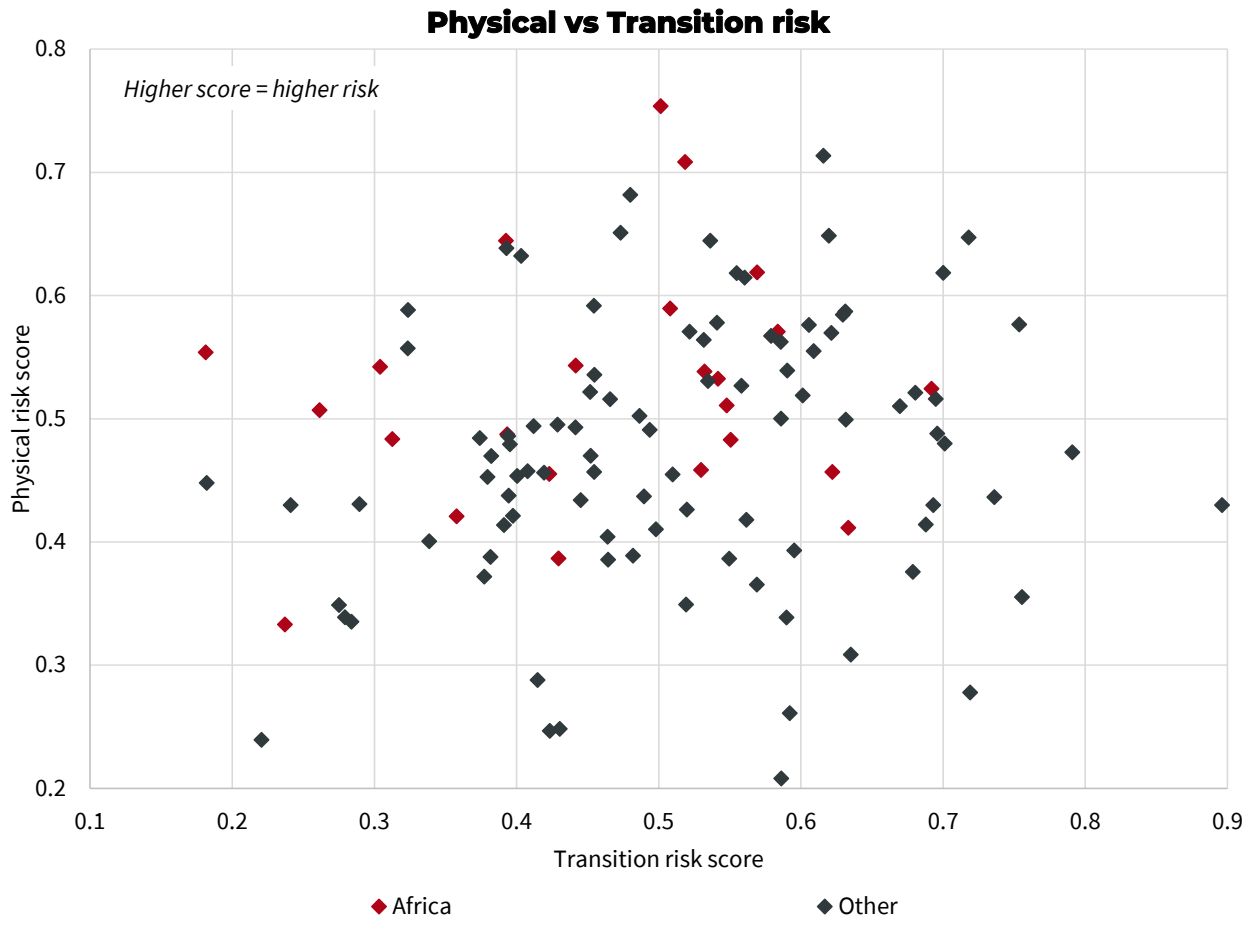
- Physical risks, which refer to the financial impact of climate change, be it more frequent extreme weather events (droughts, floods, storms, etc.) or more gradual changes (rising temperatures, sea level rise, etc.). For these types of risks and for a given country, our SCVI takes into account, for example, the percentage of water resources shared with other countries, or the percentage of the population living in areas where elevation is below 5 meters.
- Transition risks, which refer to the potential financial losses that may result (directly or indirectly) from the process of adjusting to a low-carbon and more environmentally sustainable economy. These adjustments can have a negative effect on the creditworthiness of a given country via two channels: of course the cost of transition to a less carbon-intensive economy (ie. the necessary investments), but also the opportunity cost of possible stranded assets (see below). For this type of risk and for a given country, our SCVI takes into account, for example, the dependence of energy imports, or the CO_2 intensity of the economy.

Our SCVI is built using publicly available and recognized data sources (World Bank, Food and Agriculture Organisation of the United Nations, etc.), and currently covers 114 countries representing 96% of global GDP and 88% of the world's population.

[6] *"ND-GAIN" index by the University of Notre-Dame (USA), "Climate Vulnerability Index" by Verisk Maplecroft, etc.*

In general (chart 10), our SCVI points to an overall high vulnerability to physical risks in Africa (compared to other countries in the world), but more limited transition risks (which seems logical, as most African economies are already "low-carbon" ones – see above).

Chart 10: overall, high physical risks but low transition risks



Source: SG Economic and Sector Studies

This diagnosis seems to be confirmed by similar indicators from other institutions, which tend to focus on the "physical risks" part:

- In the Notre-Dame Global Adaptation Initiative (ND-Gain) vulnerability sub-index, the 10 worst ranked countries are all in Sub-Saharan Africa[7];
- Verisk Maplecroft's Climate Vulnerability Index ranks 9 Sub-Saharan African countries among the 10 most vulnerable countries in the world[8].

This greater vulnerability is already reflected in the scale of climatic events in the region, whether in terms:

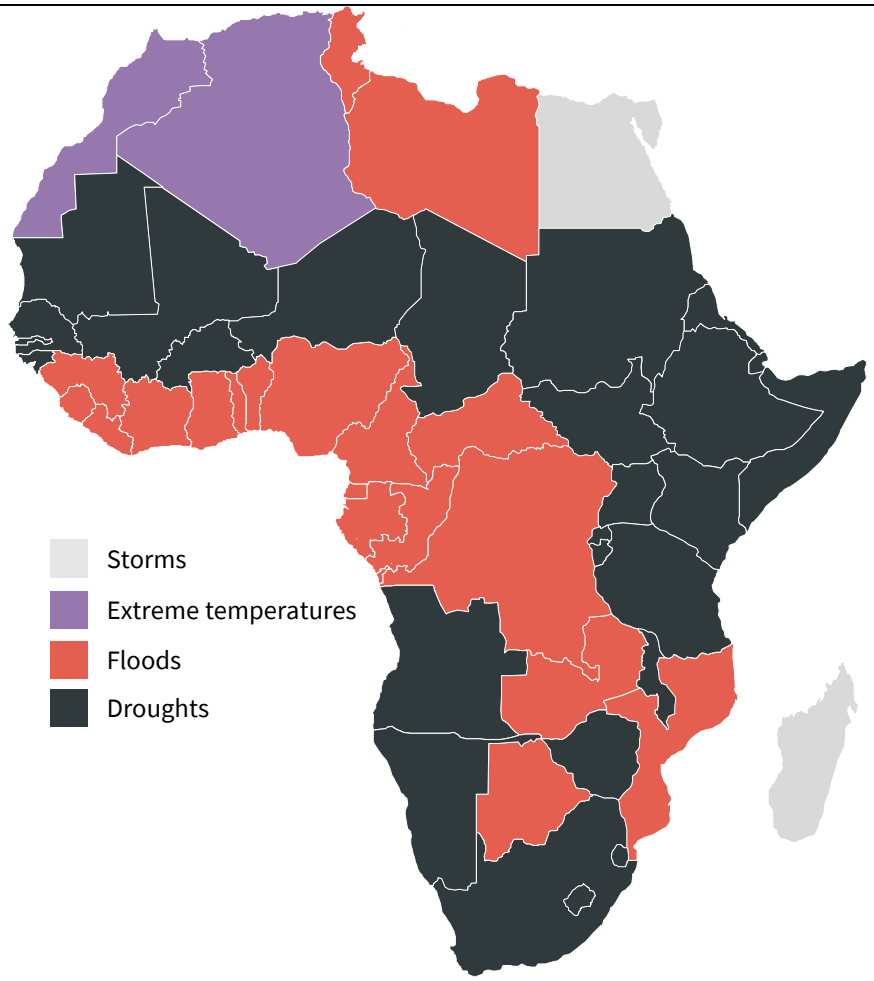
[7] *Niger, Somalia, Guinea-Bissau, Chad, Sudan, Liberia, Mali, Dem. Rep. of Congo, Eritrea, Uganda.*
[8] *Burundi, Central African Republic, Congo, De. Rep. of Congo, Guinea, Liberia, Sierra Leone, South Sudan.*

- Of occurrence: accounting for 20% of the world's land surface, the continent recorded 21% of the severe climatic events (storms, extreme temperatures, floods, droughts, etc.) in 2020 according to the United Nations[9]. This proportion has also tended to increase: Africa accounted for "only" 10% of global climatic events recorded between 1989 and 1998, and around 15% between 1999 and 2019. Floods and droughts remain the disasters affecting the continent the most (chart 11).
- Of consequence: accounting for 17% of world's total, African populations accounted for 26% of the 98 million people affected by natural disasters in 2020[10]. Here too, the "weight" of Africa has gradually increased: 4% of the total number of people affected between 1989 and 1998, 6% between 1999 and 2008 and 10% between 2009 and 2019.

Finally, in both cases, it is likely that the weight of Africa is underestimated, the continent probably having the least developed logistical capabilities / statistical apparatuses to detect, identify and assess climate disasters.

[9] CRED & UNDRR; "2020: The Non-COVID Year in Disasters"; Brussels: CRED; 2021.
[10] Two droughts in 2020 – in Niger and in Burkina Faso – have alone affected 3.7 and 2.9 million people, respectively.

Chart 11: type of climate event affecting populations the most, by country (2000-2019)



Source: SG Economic and Sector Studies, CRED

This greater economic vulnerability of Africa, "for an equal climate event", also seems to be confirmed by a recent study by the IMF focused on Sub-Saharan Africa[11]. According to this study (carried out on monthly data between 2013 and 2017), a rise in temperatures of 0.5°C (compared to the average over 30 years) would reduce activity by 1%, twice the average impact at the world level.

... AND WHICH COULD INCREASE IN THE YEARS TO COME

Africa's vulnerability to climate change is expected to continue to have significant macroeconomic consequences over the coming decades. Several works – dissimilar, by nature[12] – have been carried out to estimate the expected changes in continental

[11] *IMF; "Adapting to Climate Change in Sub-Saharan Africa"; Washington, DC; 2020.*
[12] *There are several reasons for this: current limitations of statistical apparatuses in Africa, discrepancies between the econometric models chosen, differences between the perimeters studied (Africa or Sub-Saharan Africa, temperature scenarios, etc.), reference points used, etc.*

GDP (or GDP per capita) in the medium term, according to different scenarios of increases in average global temperature.

As a reminder, global warming scenarios are most often expressed in terms of the expected increase in the average global temperature (AGT) by 2100, compared to pre-industrial levels (average 1850-1900). Thus, a "1.5°C scenario" assumes an increase in the AGT of 1.5°C compared to pre-industrial levels, knowing that the current AGT is already more than 1°C higher than pre-industrial levels.

Schematically, it is estimated that:

- *A "4.5°C scenario" (generally called "hot house") corresponds to a scenario where the AGT would continue to progress on its current trend, and therefore where climate policies would remain broadly similar to those currently in place;*
- *A "3°C scenario" corresponds to a scenario where global climate policies would be improved to be in line with the national commitments made at COP21 (rise in the AGT of 3.2°C) or COP26 (rise of 2.7°C);*
- *A "1.5°C scenario" corresponds to a scenario where global climate policies would be further strengthened, for example through the implementation of a "Net zero emissions" carbon strategy by 2050 by all countries (including China, for example).*

Our own simulations (carried out on NiGEM) suggest that by 2050, African GDP would be about 2% higher in a 3°C scenario compared to a 4.5°C scenario, and 6% higher in a scenario 1.5°C compared to a 3°C scenario. These orders of magnitude appear in line with several other studies carried out recently:

- A World Bank study[13] indicates that compared to a "0°C scenario" (only theoretical and de facto "unrealistic"), the loss of potential GDP for Sub-Saharan Africa by 2100 would be 3.8 % in a 1.5°C scenario and 8.6% in a 3°C scenario. Thus, based on these figures, the loss of potential GDP between the 3°C and 1.5°C scenarios would be around 5% by 2100.
- The simulations carried out by the NGFS (Network for Greening the Financial System)[14] for the whole of Africa point to an overall comparable impact, with a loss of potential GDP of 3.5% by 2050 between a 3°C scenario and a 1.5°C scenario.

[13] *WorldBank; "Africa's Pulse, No. 24" (October); Washington, DC; 2021.*
[14] *A network of 83 central banks and supervisors, which purpose is to help strengthening the global response required to meet the goals of the Paris agreement and to enhance the role of the financial system to manage risks and to mobilize capital for green and low-carbon investments in the broader context of environmentally sustainable development.*

Regardless of the studies carried out and/or the models used, these 3 estimates focus on transition risks, omitting the assessment of potential "direct" physical risks. Several factors explain this loss of potential GDP in the event of a continued rise in global temperatures: impact on agricultural activities obviously (decline in crop yields, reduction in the productivity of agricultural labour), but also impact on human capital (increase in mortality, deterioration of health and education conditions, etc.), on levels of political stability (a multiplication of climate events and the drop in agricultural yields being among the possible causes of political crises) , or on the already high levels of economic inequality in Africa (the poorest populations often being the first to be affected by climate change).

These estimates of macro-economic impacts are likely to be "on the lower range"

TRANSITION RISK IS POTENTIALLY UNDERESTIMATED, DUE TO THE DIFFICULTY OF CORRECTLY VALUING STRANDED ASSETS

The orders of magnitude stated above may seem relatively modest, but i) should not be underestimated in terms of their impact on the development of the continent and its inhabitants, and ii) should be seen as "minimum" estimates.

On the one hand, even focusing on transition risks, a loss of "a few points of GDP by 2050" is already very detrimental for a continent whose current growth rates (around 3.5% / 4 % per year, on regional average) are insufficient to ensure a real economic catch-up with the more advanced economies[15], or more simply to significantly and sustainably reduce still high poverty rates[16].

In addition, an important part of the assessment of the macroeconomic consequences relating to transition risks is the proper valuation of opportunity costs linked to possible "stranded assets" (or "unrecoverable assets"). Indeed, the expected evolution of national / global climate standards could lead to unforeseen write-downs or conversions to liabilities of certain assets. More specifically, it is generally expected that policies to reduce carbon emissions will reduce the value of fossil resources (oil, gas, coal, etc.), *de facto* reducing investments in this sector. In addition, countries or companies could themselves limit the use of these resources to meet their climate commitments. The proper valuation of "stranded assets" is – understandably – particularly difficult, reinforcing the possibility that aforementioned estimates are on the lower range. For example, a study in Nature[17]

[15] These issues were also explained more extensively in Risk&Opportunities #2 and #3, published in February 2019.
[16] For example, in sub-Saharan Africa, the percentage of the population living on less than USD 1.9 a day "only" fell from 55% in 1990 to 40% in 2018, then increased sharply due to the Covid-19 crisis.
[17] McGlade & Ekins; "The geographical distribution of fossil fuels unused when limiting global warming to 2 °C"; Nature (2015).

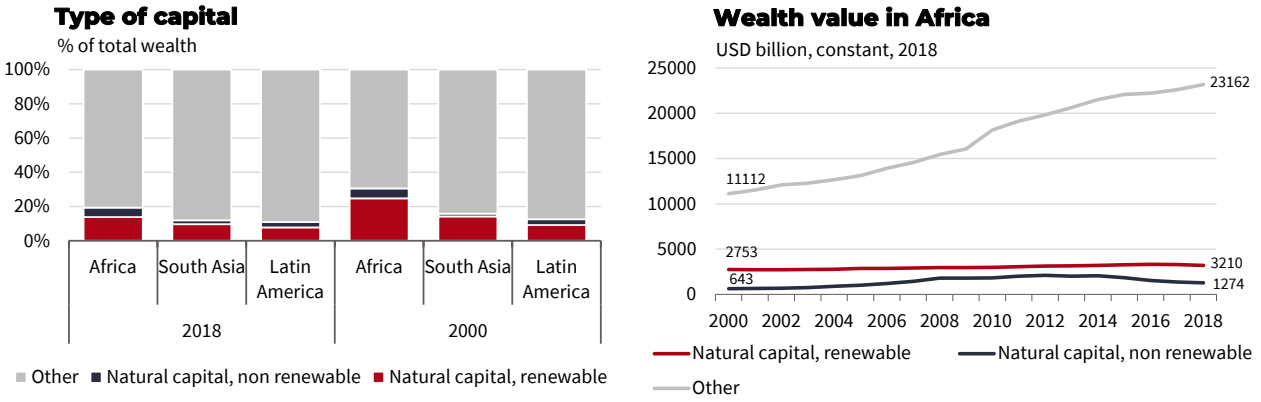
estimates that to meet the commitments made during the COP21 (increase in the AGT limited to 2°C by 2100), Africa would have to "give up" (ie. not use) 90% of its known coal reserves, 34% of its natural gas reserves and 26% of its oil reserves. This “shortfall” would be highly detrimental for a continent that is still very (too) reliant on the extraction and export of its raw materials for its development (see above). For example, in 2020, fossil resources exports accounted for almost 30% of Africa's total exports.

If we consider an even wider scope of study than that of “stranded assets”, Africa moreover remains particularly dependent on its “natural capital”. This theme has been developed by a World Bank project[18] which seeks to overcome criticism of the use of Gross Domestic Product (GDP) as the sole measure of a country's wealth, by aiming to measure for each country i) the economic value of its renewable (e.g. forests, cropland, fisheries, etc.) and non-renewable (e.g. minerals and fossil fuels) natural capital, ii) its human capital (a person's lifetime income), iii) its produced capital (buildings, infrastructure, etc.), and iv) its net foreign assets.

This study tends to show that, in addition to the problem of "stranded assets", Africa is on average more dependent on its natural capital than most other emerging regions, with the exception of the Middle East (driven by the value of its fossil resources). Thus, natural capital accounted for nearly 20% of total capital in Africa, compared to only 11% to 12% in South Asia or Latin America (chart 12). In addition, renewable natural capital (ie the value of ecosystems) alone represents 6% of total capital, the highest level in the world. As noted earlier, this greater dependence makes the region more vulnerable to global warming. In this respect, it is interesting to note that since 2000 Africa has recorded very weak growth in the value of its renewable natural capital: +17%, compared to +43% in Latin America, or +83% in South Asia. South (chart 13). Although it is difficult to be exhaustive as to the reasons explaining this quasi-stagnation, it is likely that it is explained at least partially by the combination of i) global warming (for example: desertification which reduces the value of the "stock” of arable land – the main sub-component of renewable natural capital, the value of which has fallen by nearly 10% since 2000); and ii) difficulties for local authorities to protect (or better enhance) their ecosystems (for example: fall of nearly 50% since 2000 in the value of fish resources, partly explained by the practice of overfishing).

[18] *WorldBank; “Changing Wealth of Nations 2021: Managing Assets for the Future”; Washington, DC; 2021.*

Charts 12 and 13: a (proportionally) greater "natural capital" in Africa, which already seems to be suffering from global warming



Source: SG Economic and Sector Studies, World Bank, Food and Agriculture Organization of the United Nations.

ESTIMATES THAT DO NOT (OR LITTLE) TAKE INTO ACCOUNT PHYSICAL RISKS, OR POSSIBLE INTERNATIONAL REPERCUSSIONS

Finally, as indicated previously, the various estimates mentioned above do not (or little) take into account physical risks, which by nature are even more difficult to model and assess. Nevertheless, these risks are often those with the most "direct" and "significant" impacts, whether on the human (deaths, displaced populations, famines, rise of extreme poverty, etc.) or economic (destruction of infrastructure, etc.) level, particularly when they affect the most vulnerable populations.

In addition, whether physical risks or transition risks are concerned, the macro-economic impacts of climate change on the region – if they will primarily concern Africa – could ultimately have international repercussions. In this respect, the example of "environmental migrations"[19] is interesting: if it is always difficult to quantify the extent of environmental migrations (due to the multiple factors linked to these movements, the methodological difficulties associated with them and the lack of standards for data collection), a World Bank[20] report indicates that by 2050, they could concern 86 million people in Sub-Saharan Africa (4.2% of the total population) and 19 million people in North Africa (9% of the total population) in the most pessimistic scenario[21]. Although this report specifies that these climatic migrations will remain mostly internal (i.e. without crossing borders), it is likely that global warming and the associated events (direct: extreme temperatures, floods, droughts, etc. – or indirect: political instability, inequalities, etc.) also push people

[19] *A definition of what "climatic migrations" are can be found here: https://www.migrationdataportal.org/themes/environmental_migration_and_statistics.*
[20] *WorldBank; "Groundswell Part 2: Acting on Internal Climate Migration"; Washington, DC; 2021.*
[21] *Respectively 17 and 2.9 million in the most optimistic scenario.*

to flee regions that have become almost uninhabitable to regions that are both benefitting from milder climates and richer.

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