ISS | AFRICAN FUTURES

Climate

Carbon Emissions: Global Current Picture and Forecast

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Carbon Emissions: Global Current Picture and Forecast

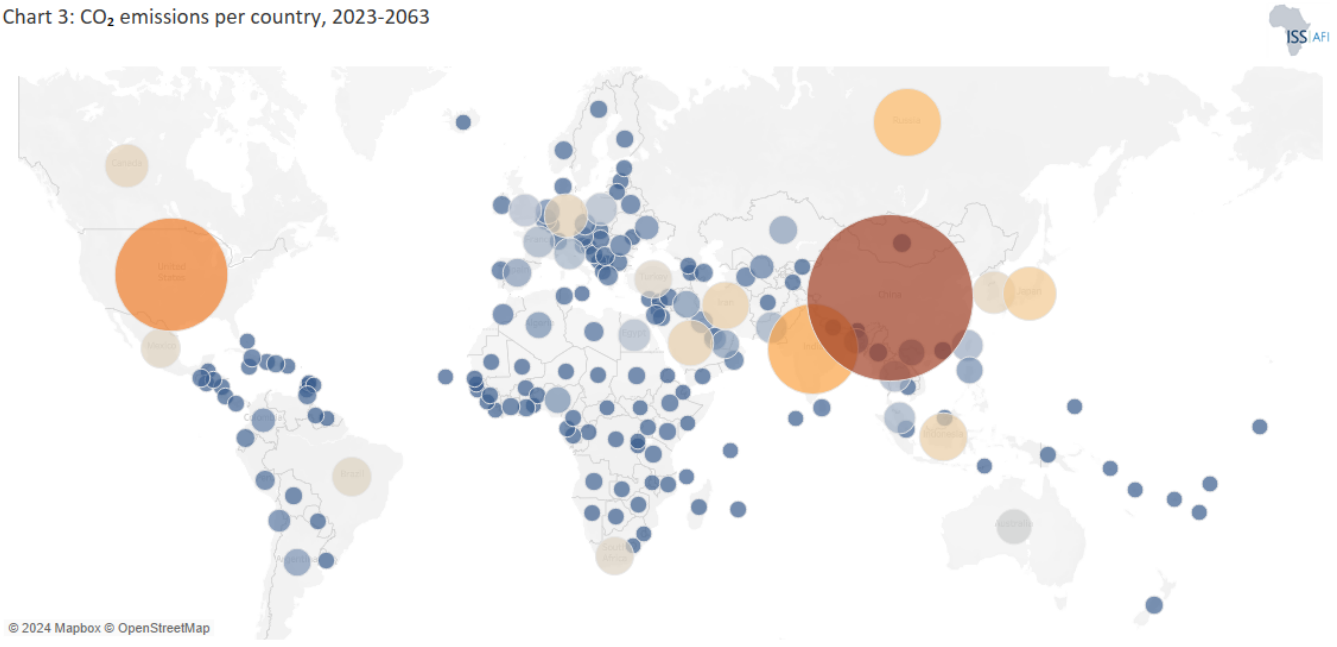
The substantial increase in CO_2 concentrations can primarily be attributed to the cumulative impact of human activities, including fossil fuel combustion, deforestation, land use changes, waste management, manufacturing processes, and land degradation. These activities are interconnected with the growing global population, marked by increased energy, food, and economic demands.

According to the Intergovernmental Panel on Climate Change (IPCC), around 86% of global carbon dioxide emissions in 2020 were due to fossil fuels and industry processes (70-75% directly from fossil fuel combustion and 10-15% from industrial processes). The number for 2021 is estimated at 89% and 87% in 2022. Deforestation and land-use changes contributed between 11% and 20% of global greenhouse emissions, but there is some overlap between these categories. Around 10% of carbon dioxide emissions are from agriculture, waste management, cement production and other industrial processes, with some overlap regarding carbon emissions from fossil fuels and cement production.

CO_2, constituting the most significant percentage of greenhouse gases in the atmosphere, is the leading driver of global warming and is consequential to alterations in climate patterns.

Chart 3 presents the progression of global carbon emissions from fossil fuels since 1960, with a forecast to 2063. In 2020, due to the significant economic slowdown caused by the COVID-19 pandemic, global emissions from energy combustion and industrial processes decreased by 5.8% compared to 2019. Then, as economic activities bounced back from the pandemic, emissions rebounded sharply. By 2023, CO_2 from fossil fuels has surged to over five times the levels observed in 1960, reaching 36.1 billion tons annually (the largest quantity ever recorded). The most significant contributors to these emissions are China, the USA, India, Russia, Japan, Indonesia, Iran, Germany, Saudi Arabia and South Korea. These top 10 global emitters collectively account for a substantial 69% of global fossil fuel emissions, 61% of the world's GDP and house 60% of the worldwide population.

Chart 3: CO_2 emissions per country, 2023-2063



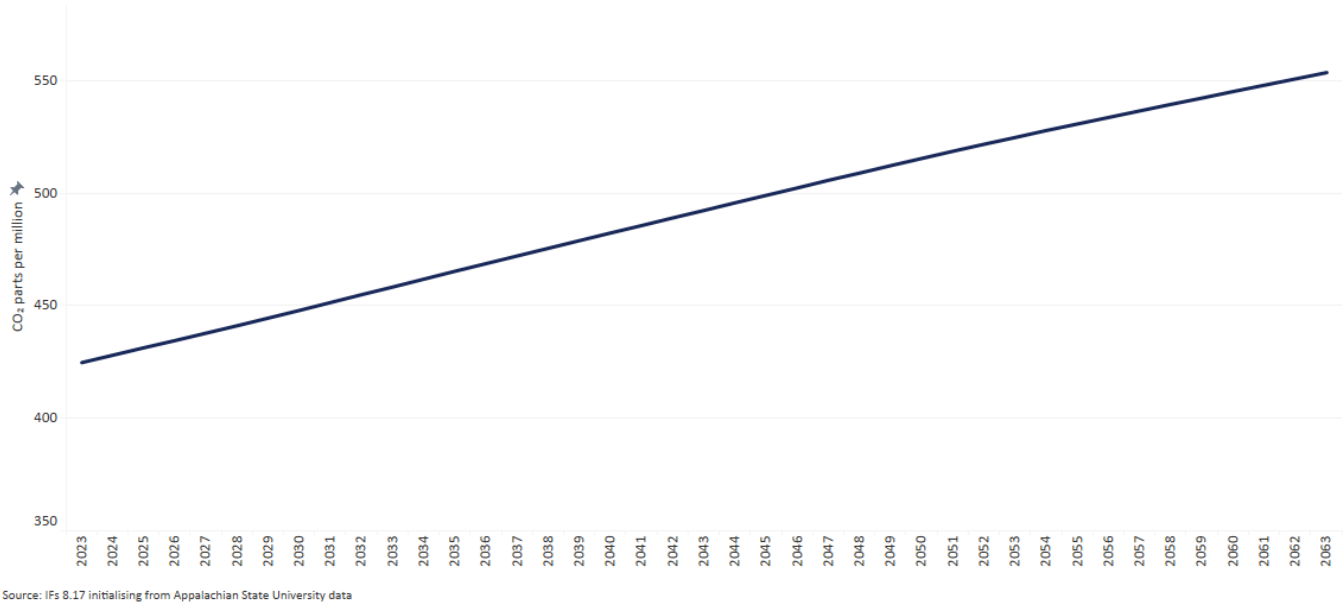
Source: IFs 8.17 initialising from Appalachian State University data

Although developed economies are slowly weaning off fossil fuels and moving towards more renewable energy sources (albeit with varying degrees of urgency), current mitigation actions and efforts must be revised. Without a solid collective response and given the lack of additional artificial and increasing natural carbon capturing and sequestration measures, atmospheric concentrations will accumulate, reaching 553 ppm by 2063 and over 600 ppm by the end of the century

(Chart 4). Such elevated atmospheric CO_2 levels pose a significant risk, intensifying global warming and placing the world on a trajectory that can see global temperatures rise by at least 3°C above pre-industrial levels by the end of the century. It will intensify the adverse impacts on ecosystems, weather patterns, and vulnerable communities.

Without additional carbon capturing and sequestration to get rid of these accumulated levels of carbon, 'the world has been locked into a path that will force us to focus on adaptation for survival'[1].

Chart 4: CO_2 concentration in atmosphere, 2023-2063



Source: IFs 8.17 initialising from Appalachian State University data

Economic progress and social development are intricately tied to energy use, transportation, and consumption. Achieving sustainable advancement becomes nearly impossible without acknowledging and mitigating the significant environmental impact associated with the cumulative effect of carbon emissions over time. It underscores the historical reliance of these countries on fossil fuels for their growth and development and the efforts that will be needed to decouple economic growth from carbon emissions.

The Current Path forecast suggests a slow and gradual increase in carbon emissions with a peak of 37.76 billion tons of carbon per annum in 2033, followed by a stabilisation period and eventual gradual decrease, aligning with various Nationally Determined Contributions (NDCs) and ongoing global initiatives to decarbonise economies. The plateauing is primarily driven by forecasted emission reductions from China, the US and Europe. Still, its eventual rate of decline will be principally affected by what happens with carbon emissions from Africa, given its current low levels of development, energy deficits, high rate of addiction to fossil fuels compared to other regions, and rapidly growing population.

China, the largest carbon emitter globally, is rapidly shifting from fossil fuels to renewables, evidenced by a significant increase in low-carbon electricity generation, especially from wind and solar sources. The substantial investments in low-carbon technologies, such as solar, electric vehicles, and batteries, reflect the nation's stance on domestic and international climate policies. While China's substantial reliance on coal for energy may keep emissions elevated in the coming decade, the surging investments in clean energy production and its NDC commitments will see the country emerge as a critical player in the global transition towards cleaner energy sources.

The United States, currently the world's second-largest greenhouse gas emitter, is experiencing a slower and delayed reduction in emissions. This is primarily attributed to the nation's heavy dependence on fossil fuels and the significant setbacks caused by the Trump administration, which withdrew from the Paris Agreement and dismantled key carbon

reduction policies like the Clean Power Plan. According to a study by the Rhodium Group, President Trump's actions are estimated to contribute to an additional 1.8 billion tons of $C0_2$ in the atmosphere by 2035. While the Biden administration has made notable strides in recommitting to the Paris Agreement and investing in renewable energy infrastructure (most prominently with the introduction of the Inflation Reduction Act in 2022. In looking to the future, the US appears to rely on unproven technological advancements in the petroleum and gas industry (such as green hydrogen power and carbon sequestration projects).

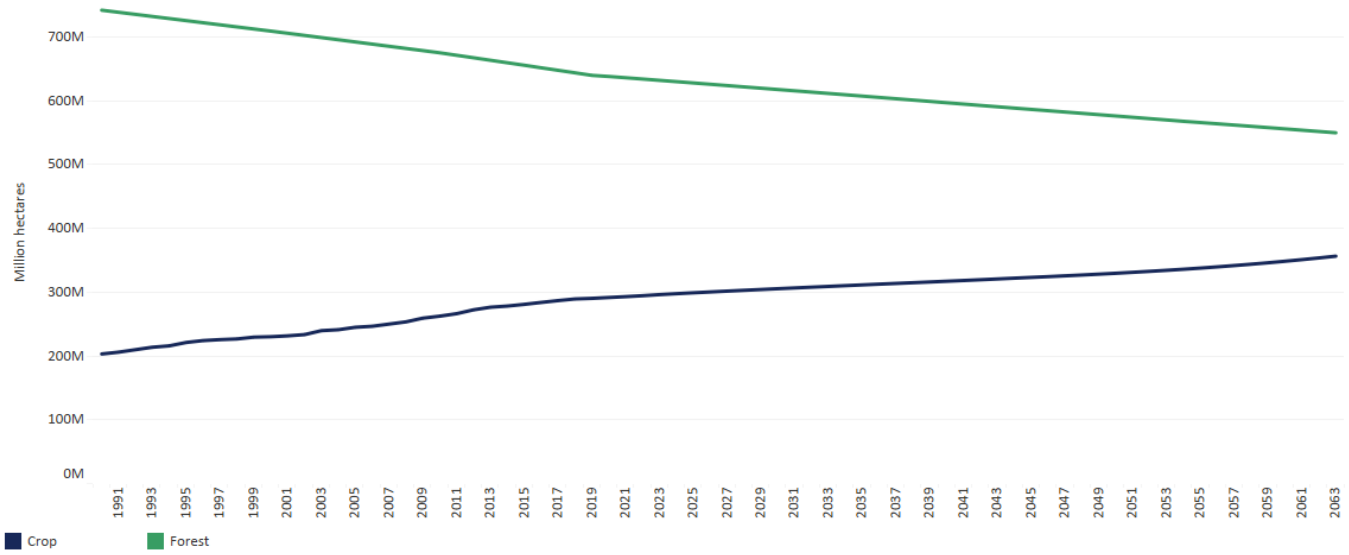
Compared with China, India, and the US, the EU27 group has the most comprehensive approach to combating climate change, including efforts to spur changes in consumer behaviour to cut emissions drastically. Other efforts include setting vehicle emission targets, defining requirements for building renovations, and adopting carbon pricing by expanding its market-driven emissions trading scheme at the heart of Europe's decarbonisation plan. The result, the European Green Deal, embeds emission targets within the EU27 industrial policy. In the process, the EU has now legally enshrined its commitment to reduce emissions by at least 55% by 2030 compared to 1990 levels and achieve net-zero emissions by 2050.[2] Among other measures, the EU has started phasing in a carbon border adjustment mechanism (EU CBAM) since May 2023.

Emerging economies are contributing an ever-growing percentage to the global total emissions. With a rapidly growing population and expanding industrial sector, India is set to increase its carbon emissions significantly in the coming decades. The country's heavy reliance on coal for energy production and its ambitious development goals present a considerable challenge in mitigating greenhouse gas emissions. Despite efforts to diversify its energy mix and promote renewable energy sources, coal continues to dominate India's energy sector due to its affordability and accessibility. India's industrial growth and urbanisation further contribute to rising emissions as manufacturing, construction, and transportation sectors expand to meet the demands of a growing population and economy. Moreover, the country's reliance on fossil fuels for transportation and household energy needs adds to its carbon footprint. As a result, India is projected to become the world's 2nd largest carbon emitter by mid-century, with Indonesia in 9th place. Indonesia's associated increased carbon emissions are driven by a growing population and significant land use changes, including deforestation of its rainforests. Saudi Arabia and Iran will remain in the top ten global emitters, with Nigeria joining the ranks as economies heavily reliant on their petroleum and gas industries and, in the case of the latter, its sizeable growing population. Pakistan is also likely to become a significant carbon emitter as an increasing population pressures land use, converting green vegetation into built-up urban areas.

While Chart 3 depicts carbon emissions from burning fossil fuels, the contribution from land use management practices (deforestation, agriculture, soil erosion, and land use management practices) is also essential. Second to energy, the agriculture sector (including forest and other land use management practices) is responsible for the second most carbon emissions. Land use change and management (e.g. clearing forests or grasslands for agricultural fields) can be enormous sources of greenhouse gas emissions. Still, undisturbed and flourishing land ecosystems also serve as significant carbon sinks. In addition to the substantial role of forests in carbon sequestration, grassy ecosystems (such as the savanna and grasslands) store a significant amount of carbon in the soil, primarily within their extensive root systems and decaying organic matter. Grasses account for over half of the soil carbon content across tropical savannas, highlighting the urgent need to avoid cultivating and tilling them.

Globally, agricultural land is expanding, with a growing global population and increasing food needs. In Africa, crop, grazing and urban land have been expanding unabatedly at the cost of forests and grasslands. In the last three decades, 100 million hectares of forest land have been cleared, making way for 66 million hectares of crop land[3]. The Current Path forecast (Chart 5) shows the declining forest land in Africa, shrinking from 632 million hectares in 2023 to an estimated 559 million hectares by 2063 — the result of a forecasted growth in urban, crop and grazing land. Cropland in Africa is forecasted to expand from 296 million hectares in 2023 to 356 million hectares while grazing land will grow from 881 million to 993 million hectares. As Africa's population expands and urbanises, subsequent urban land will almost double from 37 million hectares in 2023 to 81 million hectares in 2063 (See the theme on Agriculture).

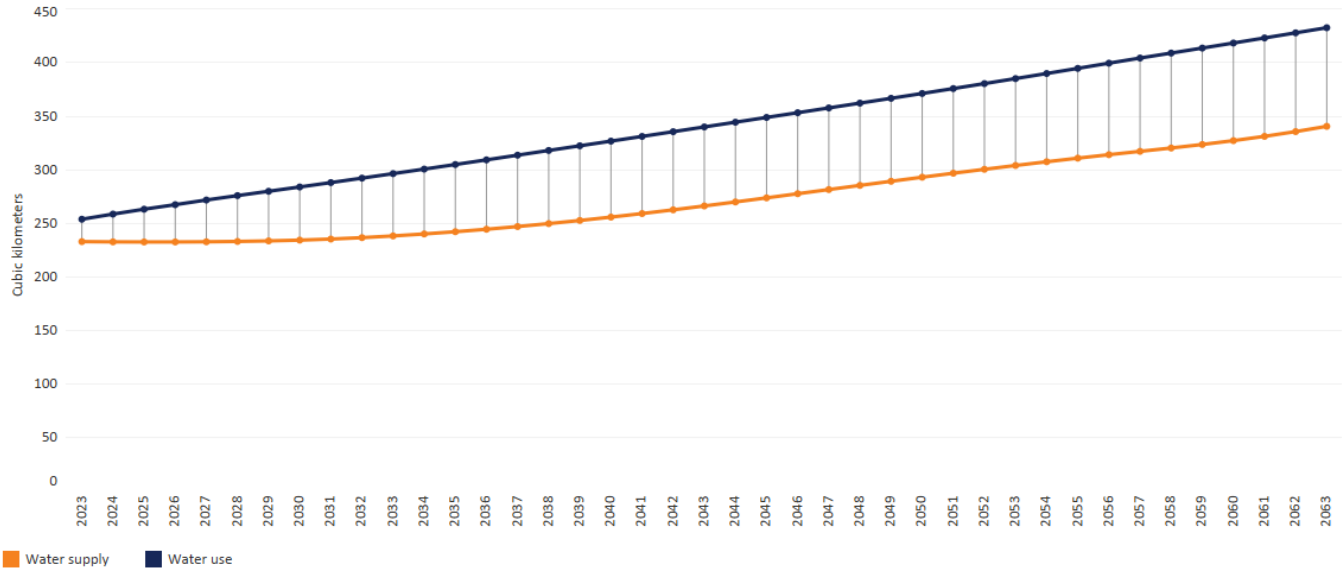
Chart 5: Crop and forest land use in Africa, 1990-2063



Source: IFs 8.17 initialising from FAOSTAT data

Another concerning trend is the increased annual water use resulting from a rapidly growing African population and improved agricultural land and food production. The Current Path forecast is that annual water use will increase from 254 cubic kilometers in 2023 to 433 cubic kilometers by 2063, posing a significant challenge to the sustainability of water resources in Africa (Chart 6). A growing population and intensified agricultural practices will lead to overexploitation of water resources, resulting in several interconnected challenges, such as water scarcity, competition for limited water supplies, environmental degradation, and potential conflicts over water access. This worrisome projection underscores the urgent need for comprehensive water governance, cooperation and management strategies to address the growing demands of population expansion and intensified agricultural activities. The IPCC's 6AR further emphasises the critical importance of sustainable water practices, highlighting the potential implications of climate change on water resources and the need for adaptive measures to ensure resilience in the face of evolving environmental conditions such as droughts. Every African country needs proactive, climate-smart and science-based policies to mitigate the adverse effects of increased water use on ecosystems and communities. Promoting for example, water conservation measures such as rainwater harvesting and drip irrigation or investing in ecosystem restoration can significantly enhance resilience to climate change and mitigate water scarcity impacts.

Chart 6: Water use vs supply, 2023-2063



Source: IFs 8.17 initialising from FAO aquastat

Endnotes

1. Prof Barend Erasmus 23/11/2023 internal briefing on Climate tipping points.
2. M Khan, L Hook, V Mallet and K Manson, New US climate strategy opens up old faultlines with Europe, Financial Times, 23 April 2021; note that the IFs forecasting system measures/forecasts carbon emissions, not CO_2 equivalent emissions.
3. Extracted from IFs database. Original source: Food and Agriculture Organization of the United Nations (FAO), FAOSTAT on-line statistical service (FAO, Rome, 1998--99), faostats.fao.org

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Cite this research

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About the authors

Ms Alize le Roux joined the AFI in May 2021 as a senior researcher. Before joining the ISS, she worked as a principal geo-informatics researcher at the CSIR, supporting various local and national policy- and decision-makers with long-term planning support. Alize has 14 years of experience in spatial data analysis, disaster risk reduction and urban and regional modelling. She has a master's degree in geographical sciences from the University of Utrecht, specialising in multi-hazard risk assessments and spatial decision support systems.

Dr Jakkie Cilliers is the ISS's founder and former executive director. He currently serves as chair of the ISS Board of Trustees and head of the African Futures and Innovation (AFI) programme at the Pretoria oce of the Institute. His 2017 best-seller Fate of the Nation addresses South Africa's futures from political, economic and social perspectives. His three most recent books, Africa First! Igniting a Growth Revolution (March 2020), The Future of Africa: Challenges and Opportunities (April 2021), and Africa Tomorrow: Pathways to Prosperity (June 2022) take a rigorous look at the continent as a whole.

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