CHAPTER 4:

AN ASSESSMENT OF THE SITUATION IN NORTHERN, SOUTHERN, CENTRAL, EAST AND WEST AFRICA

UN environment programme

CLIMATE & CLEAN AIR COALITION TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

African Union

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CONTENTS

4.1 INTRODUCTION

This chapter considers the implications of the baseline and mitigation scenarios for the five main African subregions. The results presented build on the modelling approaches used for the whole continent to assess the potential to reduce emissions and impacts of air pollutants, SLCPs and GHGs, as described in Chapter 2 for the baseline, and in Chapter 3 for the SLCP and Agenda 2063 mitigation scenarios. This chapter starts with a situation assessment, describing the five subregions, their geography and populations, and considers their economic status before and after the Covid pandemic (Section 4.2). This is followed by a discussion of the role of regional cooperation across Africa, the make-up and mandates of the regional economic communities (RECs) and what regional agreements on air pollution and climate change issues have been forged (Section 4.3). The results of the modelling of emissions of air pollutants, SLCPs and GHGs at subregional levels are then presented (Section 4.4), followed by an assessment of air pollution and climate impacts at subregional levels (Section 4.5). Finally, summaries of the benefits estimated in this Assessment related to emission reductions in African subregions are discussed in Section 4.6.

4.2 SITUATION ASSESSMENT

MAIN MESSAGES

- The results of the Assessment are set in the context of the geography, populations and economic conditions in the five main Africa sub-regions: Northern, Southern, Central, East and West.
- Regional differences in climatic conditions and economic development implies a need for regionally contextualized action on integrated tackling of air pollution and climate change.
- Prior to the Covid pandemic, the economic situation in Africa was challenging amid the slowdown of the global economy, lingering effects from the collapse of commodity prices and protracted fragilities in some large countries. The economic situation varied across the subregions, with a robust economy in East Africa, an improving situation in Northern Africa, and growth in Southern, Central and West Africa being inadequate to meet increasing development challenges.
- Economic activity in Africa is recovering slowly from the effects of the pandemic, but economic recovery has been weaker than in other world regions.

4.2.1 GEOGRAPHY AND POPULATION

The continent of Africa contained approximately 1.34 billion people in 2020 (UN 2020a) and is estimated to have risen to more than 1.4 billion in 2022 (WPR 2022). This Assessment uses the United Nations' Geoscheme that divides the continent into five distinct subregions: Northern, Southern, Central, East and West Africa. The countries in each subregion are shown in Table 4.1 and are recognized by the AUC and UNEP and used in the modelling procedures of the assessment. These country groupings differ slightly to those of the RECs (see Table 4.3). Northern Africa is the largest of the subregions by land area, while Southern Africa is the smallest (WPR 2022).

Table 4.1 UN Subregional groupings in Africa used in this Assessment

SUBREGION	COUNTRIES
NORTHERN AFRICA	5 countries: Algeria, Egypt, Libya, Morocco, Tunisia
SOUTHERN AFRICA	14 countries: Angola, Botswana, Comoros, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Zambia, Zimbabwe
CENTRAL AFRICA	8 countries: Cameroon, Central Africa Republic, Chad, Congo, Democratic Republic of the Congo, Equatorial Guinea, Gabon, São Tomé and Principe
EAST AFRICA	11 countries: Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, South Sudan, Sudan, Tanzania, Uganda
WEST AFRICA	16 countries: Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo

NORTHERN AFRICA

The Sahara Desert covers much of Northern Africa, which is why the overwhelming majority of the subregion's roughly 246 million people live close to the Mediterranean or Atlantic coasts. Egypt is by far the most populous, with more than 102 million people living within its borders. Libya is the least populous country in the subregion and has a population of approximately 6.9 million (UN 2020a).

SOUTHERN AFRICA

It is estimated that 311 million people live in the 14 countries that make up the SADC (UN 2020a). Large urban agglomerations are present in South Africa and Angola.

CENTRAL AFRICA

Central Africa is home to an estimated 180 million people. The Democratic Republic of the Congo is the largest and most populous country in the subregion, while São Tomé and Principe the smallest and least populous, with more than 90 million people and just 219 000 respectively (UN 2020a).

EAST AFRICA

East Africa is the most populous of all the African subregions, with a total estimated population of 455 million. Almost a quarter of these people live in one country, Ethiopia, which has an estimated population of 115 million. In contrast, the Seychelles, an island country situated in the Indian Ocean, has the subregion's smallest population at 98 000 people (UN 2020a).

WEST AFRICA

The northern portion of West Africa consists of the Sahel, which is the semi-arid land that separates the Sahara Desert in the north from the savannas to the south. Half the countries of West Africa are situated in the Sahel, while the other half are located in the savanna region, close to the Atlantic Ocean. The total population of West Africa is an estimated at 402 million (UN 2019), about half of which live in Nigeria, 206 million people – it is the most populous country on the African continent and the seventh most populous country in the world. Nigeria also contains Africa's largest city, Lagos, which is home to approximately 9 million people (UN 2020a).

4.2.2 GROSS DOMESTIC PRODUCT BEFORE AND AFTER COVID

Prior to the Covid pandemic, the economic situation in Africa was challenging amid the slowdown of the global economy, lingering effects from the collapse of commodity prices and protracted fragilities in some large countries (UN 2022). The economic situation varied across the subregions, with a robust economy in East Africa, an improving situation in Northern Africa, and growth in Southern, Central and West Africa being inadequate to meet increasing development challenges (UN 2020b). Growth in GDP per person was almost stagnant at around 0.1–0.4 per cent in recent years (UN 2022) and in one estimate dropped from a projected increase of 0.7 per cent in 2020 to a -4.6 per cent decline (UN 2022). Economic activity in Africa is recovering slowly from the effects of the pandemic but remains fragile. Most African economies are witnessing rising output levels, when supported by a more favourable global context, but economic recovery has been weaker than in other world regions (UN 2022).

The effect of the pandemic on GDP was felt most in Southern Africa while the economic recovery was strongest in Northern Africa, where an estimated growth in 2021 was 11.7 per cent (AfDB 2022). Economic diversification in East Africa, mainly through sustained public spending on flagship infrastructure projects but also a result of closer trade ties in the subregion and strong agricultural performance, cushioned the subregion against the economic effects of the pandemic in 2020. Easing of pandemic restrictions in tourism-dependent economies was a key element of recovery in African countries (AfDB 2022).

4.3 REGIONAL COOPERATION

MAIN MESSAGES

- Regional cooperation plays an important role internationally in assisting countries to achieve the human health and environmental benefits of action on air pollution. For example, in Africa, regional cooperation has successfully motivated and facilitated the complete phase out of leaded fuel in vehicles in the 20 years between 2001 and 2021 and considerable progress towards achieving low-sulphur fuels in vehicle fleets across the continent.
- There are several regional agreements and declarations developed by African governments with support from UNEP, its partners and the Regional Economic Communities, which cover many of the issues described in this Assessment.

4.3.1 REGIONAL COOPERATION ON AIR POLLUTION ISSUES IN AFRICA

Regional cooperation plays an important role internationally in assisting countries achieve the human health and environmental benefits of action on air pollution. In Europe and North America there is the UNECE's Convention on Long-Range Transboundary Air Pollution (LRTAP), which has brought about considerable benefits from reducing S, N, PM and ground-level O_3 pollution since it was signed in 1979.

Progress has also been made in other parts of the world despite the absence of signed agreements, conventions and binding protocols. In Africa, regional cooperation has successfully motivated and facilitated the complete phase out of leaded fuel in vehicles in the 20 years between 2001 and 2021[1] and considerable progress towards achieving low-sulphur fuels (10–50ppm) in vehicle fleets across the continent. These achievements have been brought about by UN-backed alliances of governments, NGOs, businesses, academia and civil society. In the case of lead-free fuel, the process in Africa was initiated when the Dakar Declaration was agreed in June 2002 at a multi-stakeholder meeting attended by representatives of government, industry and civil society from 25 Sub-Saharan countries, as well as from international organizations. In the same year, the Partnership for Clean Fuels and Vehicles (PCFV), with its Secretariat hosted by UNEP, was set up at the World Summit on Sustainable Development with the aim of eliminating leaded petrol globally and providing support to countries and regional initiatives. At the time, 117 countries around the world were still using leaded petrol, 86 of which were being supported to phase it out. As a result of networking and assistance given by UNEP and partners to governments, in 2006 Sub-Saharan Africa eliminated the use of unleaded fuel and the last African country to switch was in July 2021.

Table 4.2 provides a summary of the Dakar Declaration and subsequent agreements and declarations developed by governments with support from UNEP, its partners and the RECs (Table 4.3). The agreements cover many of the issues described in this Assessment.

Table 4.2 Regional agreements on air pollution in Africa

DECLARATION/ RESOLUTIONS/ AGREEMENTS	REGION/ REGIONAL ECONOMIC COMMUNITIES	FOCUS	STATUS
DAKAR DECLARATION 2002	Sub-Saharan countries ECOWAS	Elimination of leaded fuel in Sub-Saharan Africa	Agreed by participants from 25 Sub-Saharan countries; including representatives of government, industry and civil society, as well as from international organizations Achieved in 2021
LUSAKA AGREEMENT 2008	SADC	Regional policy framework on air pollution outlining multilateral cooperation for action on air pollution from transport, industry, open burning, household air pollution, national environmental governance, public awareness, education, development and capacity building	Adopted by 14 SADC countries, representing governments, industry, NGOs, civil society, international organizations and academia
NAIROBI AGREEMENT 2008	EAC	Eastern Africa Regional Framework Agreement on Air Pollution to develop actionable targets to address air pollution in the following key areas: transport; industry and mining; energy; waste; vegetation fires; household air pollution; urban planning and management; and regional and national environmental governance	Signed by 7 countries
THE LIBREVILLE DECLARATION 2008	Continental	Health and environment in Africa with a policy statement that provides a cohesive and integrated framework to address human health and environment links on the continent	Signed by ministers of health and the environment from 52 African countries
ABIDJAN AGREEMENT 2009	ECOWAS and ECCAS	Actionable targets to address air pollution issues in the following key areas: transport; industry and mining; household pollution; waste disposal; bush fires; uncontrolled burning and deforestation; urban planning and management; and national and regional environmental governance	Signed by 13 countries

Source: Libreville Declaration: https://climhealthafrica.org/wp-content/uploads/2020/06/Libreville_30_10_Eng_Online.pdf; Lusaka Declaration (includes Dakar Declaration), Abidjan Agreement and Nairobi Agreement at: https://www.sei.org/projects-and-tools/projects/gap-forum/#international-cooperation

1. https://www.unep.org/news-and-stories/press-release/era-leaded-petrol-over-eliminating-major-threat-human-and-planetary

Each REC has developed individually as a grouping of African countries and they have differing roles and structures. Generally, the purpose of the RECs is to facilitate regional economic integration between members of their subregion and through the wider African Economic Community (AEC), which was established under the 1991 Abuja Treaty. The 1980 Lagos Plan of Action for the Development of Africa and the Abuja Treaty proposed the creation of RECs as the basis for wider African integration, with a view to regional and eventual continental integration. The RECs are increasingly involved in coordinating AU Member States' interests in wider areas such as peace and security, climate change, development and governance.

The RECs are closely integrated with the AU's work and serve as its building blocks. The relationship between the AU and the RECs is mandated by the Abuja Treaty and the AU's Constitutive Act and guided by the 2008 Protocol on Relations between the RECs and the AU; and the Memorandum of Understanding on Cooperation in the Area of Peace and Security between the AU, RECs and the Coordinating Mechanisms of the Regional Standby Brigades of Eastern and Northern Africa (AU 2022b).

The AU recognises eight RECs (Table 4.3). In addition, the Eastern Africa Standby Force Coordination Mechanism (EASFCOM) and North African Regional Capability (NARC) both have liaison offices at the AU.

Table 4.3 Regional Economic Communities recognized by the African Union. Source: AU (2022)

REC	PURPOSE	MEMBERS
ARAB MAGHREB UNION (UMA)	Established under the 1989 Marrakesh Treaty primarily to strengthen ties between the five member states; promote prosperity; defend national rights; and adopt common policies to promote the free movement of people, services, goods and capital within the region	5: Algeria, Libya, Mauritania, Morocco, Tunisia
COMMON MARKET FOR EASTERN AND SOUTHERN AFRICA (COMESA)	Established in 1993 by the COMESA Treaty, the primary purpose of which was the creation of a free trade region. Article 3 of the Treaty provides that the aims and objectives of COMESA are to attain sustainable growth and development of Member States; promote joint development in all fields of economic activity; cooperate in the creation of an enabling environment for foreign, cross-border and domestic investment; promote peace, security and stability among the Member States; and cooperate in strengthening relations between the COMESA and the rest of the world	19: Burundi, Comoros, Democratic Republc of the Congo, Djibouti, Egypt, Eritrea, Eswatini, Ethiopia, Kenya, Libya, Madagascar, Malawi, Mauritius, Rwanda, Seychelles, Sudan, Uganda, Zambia, Zimbabwe
COMMUNITY OF SAHEL-SAHARAN STATES (CEN-SAD)	Formed in 1998 with the primary objective of promoting the economic, cultural, political and social integration of its Member States	29: Benin, Burkina Faso, Cabo Verde, Central African Republic, Chad, Comoros, Côte d'Ivoire, Djibouti, Egypt, Eritrea, Gambia, Ghana, Guinea, Guinea Bissau, Kenya, Liberia, Libya, Mali, Mauritania, Morocco, Niger, Nigeria, São Tomé and Príncipe, Senegal, Sierra Leone, Somalia, Sudan, Togo, Tunisia
EAST AFRICAN COMMUNITY (EAC)	Initiated in 1999 as the regional intergovernmental organization of five East African countries. Article 5 of the Treaty for the Establishment of the East African Community states that the objectives of the community shall be "to develop policies and programmes aimed at widening and deepening cooperation among the Partner States in political, economic, social and cultural fields, research and technology, defence, security and legal and judicial affairs, for their mutual benefit"	7: Burundi, Democratic Republic of the Congo, Kenya, Rwanda, South Sudan, Tanzania, Uganda
ECONOMIC COMMUNITY OF CENTRAL AFRICAN STATES (ECCAS)	Formed in 1983 by the Treaty Establishing the Economic Community of Central African States. It has the primary objectives of promoting Member States' economic and social development, and improving people's living conditions	10: Angola, Burundi, Cameroon, Central African Republic, Chad, Congo, Democratic Republic of the Congo, Equatorial Guinea, Gabon, São Tomé and Príncipe
ECONOMIC COMMUNITY OF WEST AFRICAN STATES (ECOWAS)	Established by the ECOWAS Treaty in May 1975 with the primary objective of promoting economic integration in "all fields of economic activity, particularly industry, transport, telecommunications, energy, agriculture, natural resources, commerce, monetary and financial questions, social and cultural matters"	15: Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, Togo
INTERGOVERNMENTAL AUTHORITY ON DEVELOPMENT (IGAD)	Established in 1996 to represent the interests of states in the Eastern Africa region. Under Article 7 of the Agreement establishing IGAD, its aims and objectives include promoting joint development strategies; harmonizing Member States' policies; achieving regional food security; initiating the sustainable development of natural resources; promoting peace and stability in the subregion; and mobilizing resources for the implementation of programmes within the framework of subregional cooperation	8: Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, Sudan, Uganda
SOUTHERN AFRICAN DEVELOPMENT COMMUNITY (SADC)	Formed on 17 August 1992. Under Article 5 of the Treaty establishing SADC, amended in 2001, its objectives include promoting sustainable and equitable economic growth and development; promoting common political values and systems; consolidating democracy, peace, security and stability; achieving complementarity between national and regional strategies; maximizing productive employment and use of resources; achieving sustainable use of natural resources and effective protection of the environment; and combating HIV/AIDS and other diseases	15: Angola, Botswana, Democratic Republic of the Congo, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Tanzania, Zambia, Zimbabwe

4.4 RESULTS OF MODELLING EMISSIONS AT SUBREGIONAL LEVELS

MAIN MESSAGES

- There is significant overlap in the key mitigation measures that are most effective in reducing SLCP, air pollutants and GHG emissions between subregions, highlighting the applicability of the recommended priority measures to reduce SLCPs and achieve Agenda 2063 across different parts of the continent.
- At continental level, the emission results from this Assessment compare well with other international datasets, but at sub-regional level there are differences that underline the importance of countries and regions compiling their own estimates.
- The modelling shows the potential for substantial decarbonization in the transport, electricity generation and industrial sectors, the extent of which varies by subregion. Northern Africa has the potential to reduce CO_2 emissions by about 63 per cent, which is a 10 per cent greater reduction than the African average.
- The different levels of CO_2 emission reduction from the generation of electricity, ranging from 48 per cent in West Africa to 98 per cent in Central Africa, reflect the current generating mix and the varying potential for energy from renewable sources in each subregion.
- Emissions of CH_4 in Southern, Central, East and West Africa can be roughly halved using the recommended technical SLCP mitigation measures related to fugitive emissions from the energy sector and the waste and agricultural sectors, with the Agenda 2063 measures allowing further reductions in 2030 and 2063. In Northern Africa, methane emissions are dominated by the fugitive emissions from the energy sector and all subregions other than Northern Africa have contributions from charcoal.
- The agricultural sector is the dominant source of N_2O emissions in every African subregion with only Agenda 2063 measures related to reduced food waste and diets with less meat reducing emissions in 2063 relative to the baseline.
- The subregional results for BC are consistent with the results for the whole continent, which show that SLCP measures achieve most BC emissions reduction and the household sector dominates. There is a key difference in Northern Africa in which there are substantially fewer emissions from the household sector, as there is much less biomass burning than in Sub-Saharan Africa.
- The changes for $PM_{2.5}$ emissions have similar patterns to those of BC, as measures that reduce BC also reduce emissions of primary $PM_{2.5}$.
- For NOx and SOx emissions the major sources are similar to those of CO_2, i.e., electricity generation, industry and transport emissions that are reduced by SLCP measures but with additional benefits from implementing Agenda 2063 measures.
- As in the case of N_2O, NH_3 emissions are dominated by the agricultural sector across all the subregions, and the nitrogen content of feed for livestock and manure management are crucial for controlling emissions.

4.4.1 EMISSIONS REDUCTIONS ACHIEVABLE IN EACH SUBREGION

The modelling in this Assessment was conducted at a continental scale and the results for the key SLCPs, GHGs, and air pollutants are discussed in Section 3.3 for Africa as a whole. Here the results are presented at a subregional level for the five subregions modelled in this report (Table 4.1). At continental level, the emission results from this Assessment compare well with other international datasets (Table 3.8), and in this section they are compared with datasets available for the subregions.

There is significant overlap in the key mitigation measures that are most effective in reducing SLCP, air pollutant and GHG emissions between subregions, highlighting the applicability of the recommended priority measures to reduce SLCPs and achieve Agenda 2063 across different parts of the continent. There are also, however, regional differences in the relative importance of individual measures in reducing GHG, SLCP and air pollutant emissions. The following sections discuss the similarities with the continent-wide integrated air-pollution and climate change mitigation pathway outlined in Section 3 for each GHG, SLCP and air pollutant, as well as the key differences for each subregion.

4.4.1.1 CARBON DIOXIDE EMISSIONS

The emissions of CO_2 estimated by this Assessment in 2018, 2030 and 2063 in the baseline are mainly derived from the transport, electricity-generation and industrial sectors in most subregions with large increases by 2063 (Figure 4.1). The exception is Central Africa where agriculture, forestry and land use play a significant role in emissions across all scenarios.

For comparison with other datasets from other studies, the CO_2 emissions in Northern Africa by sector (Climatewatch 2021) have a similar sectoral breakdown to this Assessment. The emissions estimate for 2018 of just over a 1 000 million tonnes, is, however, approximately double the estimate of about 500 million tonnes shown for Northern Africa in this Assessment. The discrepancy underlines the importance of countries and regions compiling their own estimates. At a continental level, the CO_2 emission values compare well with the EDGAR dataset (Section 3.5.1, Table 3.8).

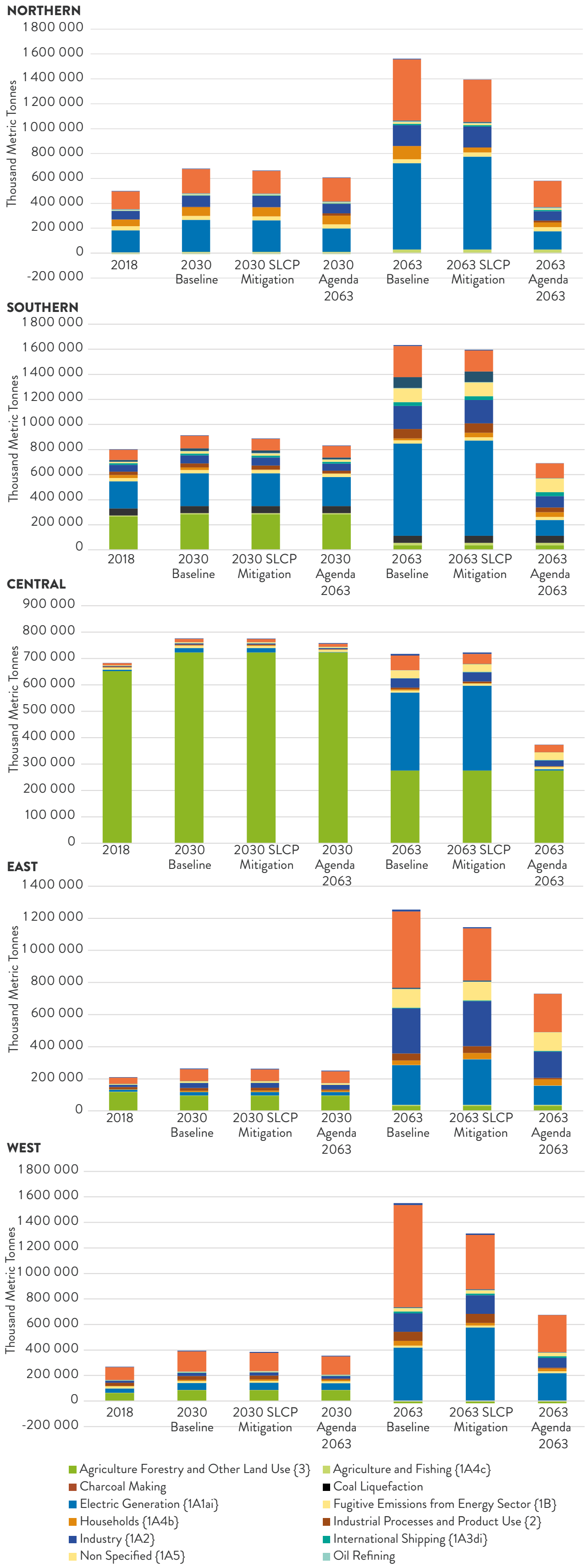


Figure 4.1 Carbon dioxide emissions calculated by sector in the baseline, short-lived climate pollutant mitigation and Agenda 2063 scenarios, African subregions, 2018, 2030 and 2063, thousand tonnes

The SLCP mitigation scenario shows a relatively small reduction in CO_2 emissions by 2030 and 2063 relative to the baseline (Figure 4.1) across all subregions, and there is an 8 per cent increase in CO_2 emissions from electricity generation relative to the baseline in the SLCP scenario. This is because of increased electricity demand due to shifts in the use of electric stoves for cooking in households and the introduction of EVs.

The largest mitigation potential is through the adoption of Agenda 2063 measures. Northern Africa, for example, has the potential to reduce CO_2 emissions by about 63 per cent, which is a 10 per cent greater reduction than the African average. The modelling shows the potential for substantial decarbonization in the transport, electricity generation and industrial sectors, the extent of which varies by subregion (Table 4.4).

Table 4.4 Reductions in carbon dioxide emissions in major sectors in the Agenda 2063 scenario relative to the baseline scenario value for 2063, per cent

SECTOR/ SUBREGION	NORTHERN (%)	SOUTHERN (%)	CENTRAL (%)	EAST (%)	WEST (%)
TRANSPORT	57	53	51	50	63
ELECTRICITY GENERATION	79	83	98	50	48
INDUSTRY	56	51	37	42	48
OVERALL	63	58	48	42	57

Under the Agenda 2063 scenario, Northern Africa has the potential to decarbonize electricity generation, reducing the sector's CO_2 emissions by 79 per cent relative to the baseline in 2063, reducing emissions from the transport sector by 57 per cent, and those from the industrial sector by 56 per cent. There is a similar result in Southern Africa, with a 58 per cent reduction overall and 83, 53 and 51 per cent reductions in emissions from electricity generation, transport and industry, respectively.

According to the SLCP scenario, by 2063 CO_2 emissions from electricity generation in Southern Africa will increase by 3 per cent relative to the baseline. Other sources of CO_2 in Southern Africa, for example, from the service sector, are almost completely eliminated in the Agenda 2063 scenario. In Central, East and West Africa there are relatively greater increases in emissions from carbon intensive industries than in Northern and Southern Africa up to 2063, reflecting the expected development in these subregions.

According to the SLCP scenario, West Africa will have 38 per cent higher CO_2 emissions from electricity generation in 2063 compared to the baseline, mostly driven by an increase in EVs, with the transport sector showing a concurrent 47 per cent decrease in CO_2 emissions by 2063. Some reductions in the transport sector are thus offset by increased emissions from electricity generation, and the additional Agenda 2063 measures – efficiency improvements and the development of renewable energy sources – are required to achieve even larger reductions. In the Agenda 2063 scenario, West Africa shows the largest reduction in transport CO_2 emissions on the continent, 63 per cent in 2063 relative to the baseline (Table 4.4).

Central Africa is substantially different from the rest of the continent, with most CO_2 being emitted from AFOLU. The overall reduction of CO_2 emissions by 48 per cent would be much higher if AFOLU were excluded from the calculations, as there is no mitigation for forestry in the model and so the baseline level emissions remain.

The different levels of Agenda 2063 reductions in CO_2 emissions relative to the baseline scenario in the generation of electricity, ranging from 48 per cent in West Africa to 98 per cent in Central Africa (Table 4.4), reflect:

(a) the current generating mix, currently dominated by gas in Northern Africa and coal in Southern Africa, so there is more potential for reductions; and

(b) the varying potential for energy from renewable sources in each subregion, Central Africa, for example, could basically generate its entire electricity needs from hydro and other renewable sources (Figure 4.2).

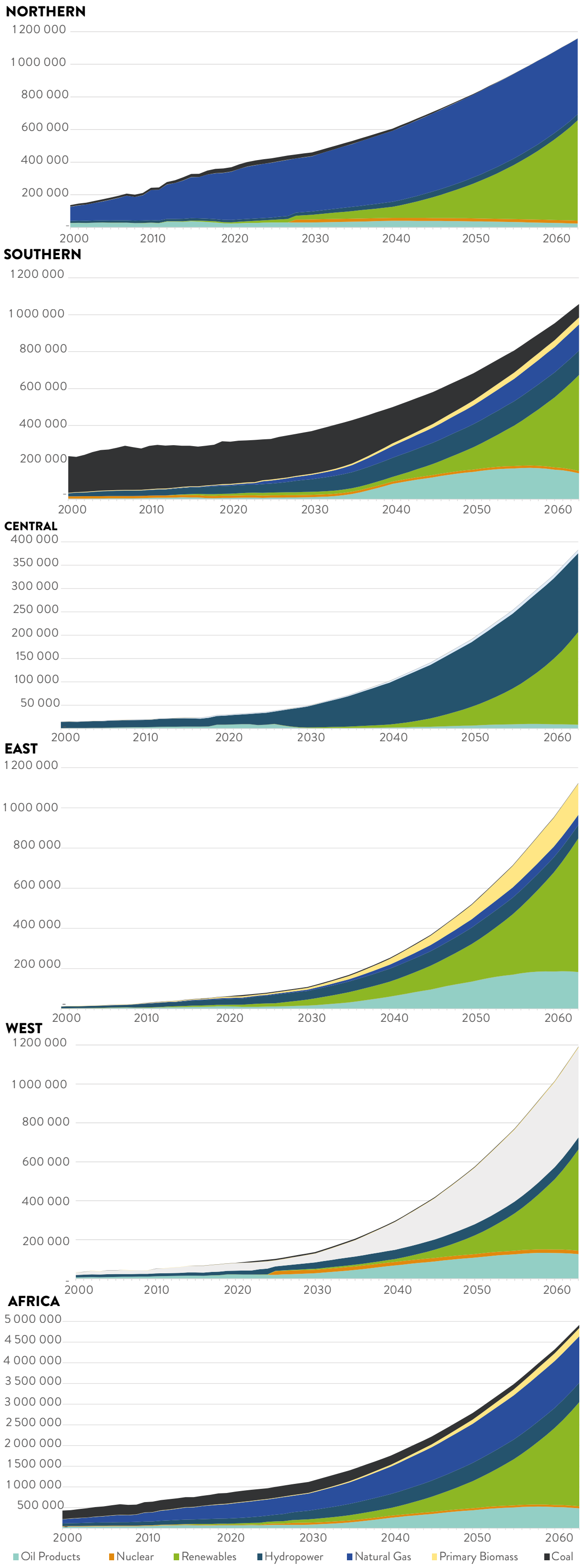


Figure 4.2. The current electricity generating mix and the varying potential for energy from renewable sources under the Agenda 2063 scenario, African subregions and all Africa, 2000–2063, terawatt[2] hours

2. 10^{12} watts/1 000 gigawatts

4.4.1.2 METHANE EMISSIONS

The emissions of CH_4 estimated by this Assessment for 2018, 2030 and 2063 in the baseline are dominated in most subregions by the agricultural sector with smaller contributions from the waste sector (Figure 4.3). In Northern Africa, methane emissions are dominated by the fugitive emissions from the energy sector and all subregions other than Northern Africa have contributions from charcoal. These emissions are reflected in the data from other studies for Northern Africa (Climatewatch 2021) and Southern Africa (SADC) from the EDGAR dataset, which also shows the large fraction of CH_4 emissions that come from livestock as a result of enteric fermentation. At the continental level, there is good agreement between the estimate of CH_4 emissions in this Assessment and in the most recent EDGAR database (Crippa *et al.* 2021a and b; Table 3.8 in Chapter 3).

Given the larger emissions from the energy and waste sectors in Northern Africa, the technical SLCP measures can potentially lead to large benefits. In this subregion, the adoption of all the SLCP measures would reduce in CH_4 emissions by 45 per cent, with fugitive CH_4 emissions from the energy sector halved, by 2030. Figure 4.3 shows that there is also potential to do more in the waste sector by 2030 with increased ambition. The Agenda 2063 measures have no effect by 2030 but by 2063 have additional benefits – a 73 per cent reduction under the Agenda 2063 scenario compared to 68 per cent under the SLCP one.

Emissions of CH_4 from charcoal making do not feature in Northern Africa, because of different mix residential fuel use, but are a feature in all other subregions, especially in Southern Africa, and grow to 2063 in the baseline scenario (Figure 4.3).

Figure 4.3 Methane emissions by sector in the baseline, short-lived climate pollutant mitigation and Agenda 2063 scenarios, African subregions, 2108, 2030 and 2063, thousand tonnes

In Southern Africa the largest reduction in CH_4 emissions will be in the fugitive emissions from the energy sector with SLCP mitigation measures driving a 96 per cent reduction by 2063 relative to the baseline emissions. The Agenda 2063 measures also produce 79 per cent and 68 per cent CH_4 emission reductions from the waste and agricultural sectors, respectively (Figure 4.3).

Central, East and West Africa are similar to Southern Africa in that emissions can be roughly halved using the recommended technical SLCP mitigation measures but the Agenda 2063 ones allow further reductions in 2030 and 2063.

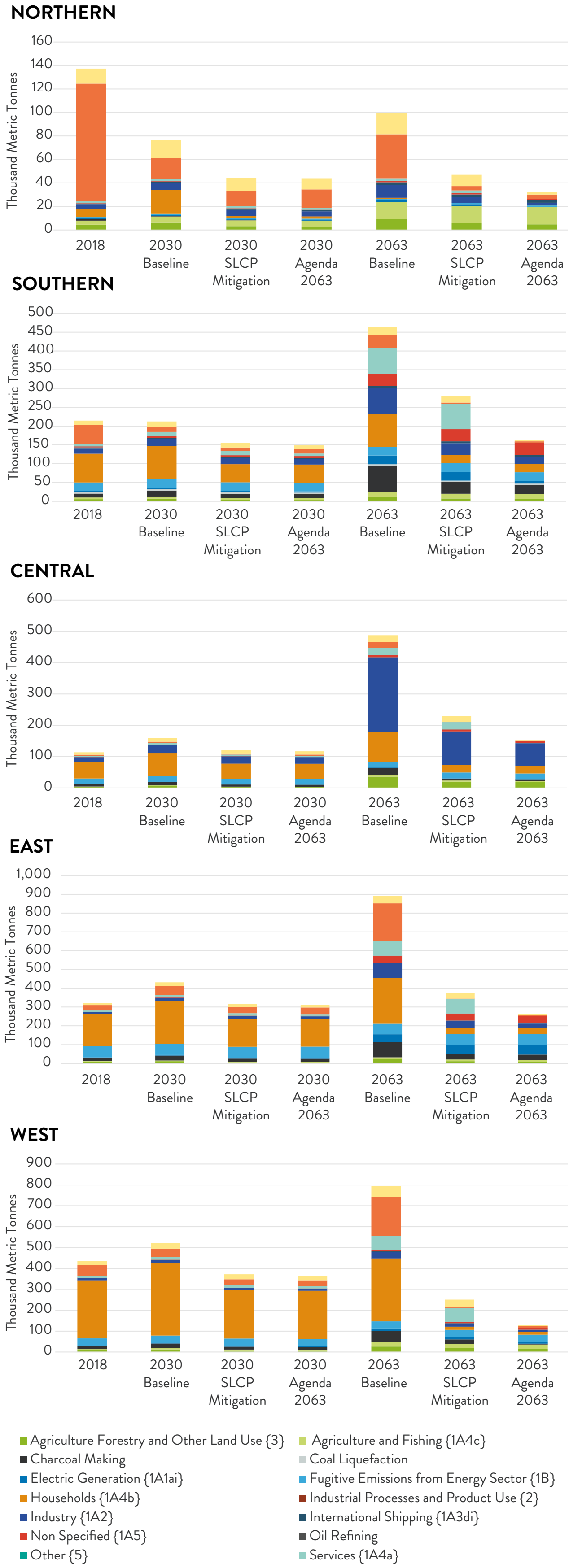
4.4.1.3 NITROUS OXIDE EMISSIONS

The agricultural sector is the dominant source of N_2O emissions in every African subregion (Figure 4.4), with only Agenda 2063 measures related to reduced food waste and diets with less meat reducing emissions in 2063 relative to the baseline. This is because emissions from the agricultural sector are largely driven by livestock production and the measure to reduce emissions from enteric fermentation with more digestible feed, involves animal feed with a higher N content. The SLCP measure on manure management goes some way to reducing N_2O emissions but to achieve larger reductions the more digestible feed would need to have lower N content. This effect is most pronounced in Central and East Africa.

The emissions estimate compared well with other studies, for example, the total N_2O emission in Northern Africa has been estimated at 49 million tonnes of CO_2e in 2018 (Climatewatch 2021), equivalent to approximately 0.16 million tonnes of N_2O, which compares to an estimate of 0.2 million tonnes of N_2O emissions for 2018 in this Assessment. At a continental level, there is good agreement between the estimates of N_2O emissions in this Assessment and in the EDGAR dataset (Crippa et al. 2021a and b; Table 3.8 in Chapter 3).

Figure 4.4 Nitrous oxide emissions by sector in the baseline and short-lived climate pollutant mitigation and Agenda 2063 scenarios, African subregions, 2018, 2030 and 2063, thousand tonnes

4.4.1.4 BLACK CARBON EMISSIONS



The subregional results are consistent with the results for the whole continent presented in Chapter 3, which show that SLCP measures achieve most BC emissions reductions and the household sector dominates. The baseline estimates for BC in 2018 in this Assessment compare well with those estimated for the same year by EDGAR (2018), although this Assessment's estimate for the Northern Africa subregion is twice that of EDGAR.

There is a key difference in Northern Africa in which there are substantially fewer emissions from the household sector, as there is much less biomass burning than in Sub-Saharan Africa, so that transport makes a larger contribution to the total (Figure 4.5, noting the lower values on the y axis in Northern Africa). Northern Africa shows a larger reduction in BC, 42 per cent, than for the whole of Africa, 28 per cent, by 2030, due to a faster transition to Euro VI vehicle standards and away from household biomass use.

There is a consistent story across the rest of Africa, in which the trends match those for the whole of Africa, with the SLCP technical measures dominating BC emissions reductions in 2030, but reductions from commercial and public services are only reduced with Agenda 2063 measures. The reduction in BC emissions is relatively greater in in West Africa, 63 per cent, compared to the whole of Africa, 57 per cent, as mitigation is more effective in the household and transport sectors in this subregion.

4.4.1.5 FINE PARTICULATE MATTER EMISSIONS

The changes for $PM_{2.5}$ emissions have similar patterns to those of BC (Figure 4.6), as measures that reduce BC also reduce emissions of primary $PM_{2.5}$. Compared to other datasets, such as the EDGAR (2018), this Assessment produces a larger estimate for $PM_{2.5}$ emissions in Northern Africa of around 400 000 tonnes in 2018 as opposed to EDGAR's 195 000 tonnes.

Figure 4.5 Black carbon emissions by sector in the baseline and short-lived climate pollutant and Agenda 2063 scenarios, African subregions, 2018, 2030 and 2063, thousand tonnes

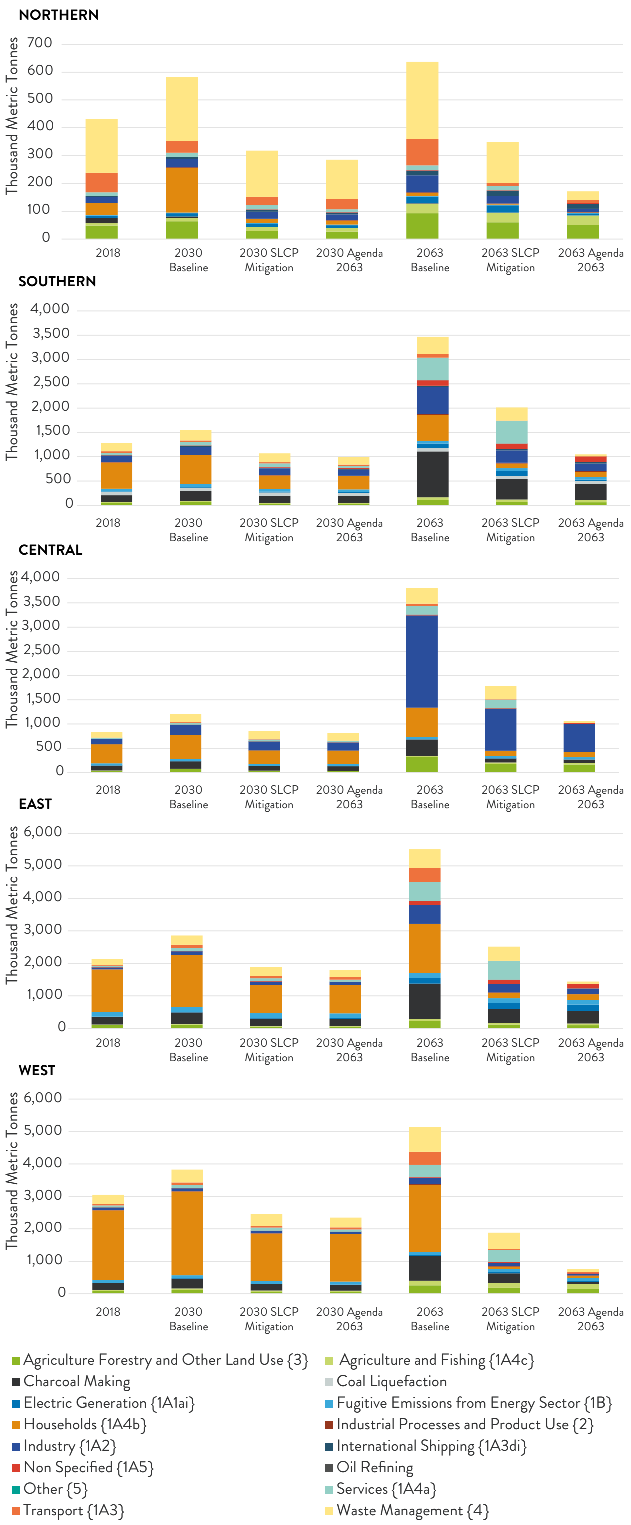


Figure 4.6 Fine particulate matter emissions by sector in baseline and short-lived climate pollutant mitigation and Agenda 2063 scenarios, African subregions, 2018, 2030 and 2063, thousand tonnes

4.4.1.6 NITROGEN OXIDES EMISSIONS

For NOx emissions (Figure 4.7) the major sources are similar to those of CO_2, i.e., electricity generation and transport emissions that are reduced by SLCP measures but with additional benefits from implementing Agenda 2063 measures. Emissions of NOx in the different subregions are similar, with industrial and shipping emissions being relatively more important in Southern Africa, and with East and West Africa being dominated by transport emissions. Central Africa has a greater mix of agricultural, industrial and transport emissions than the others.

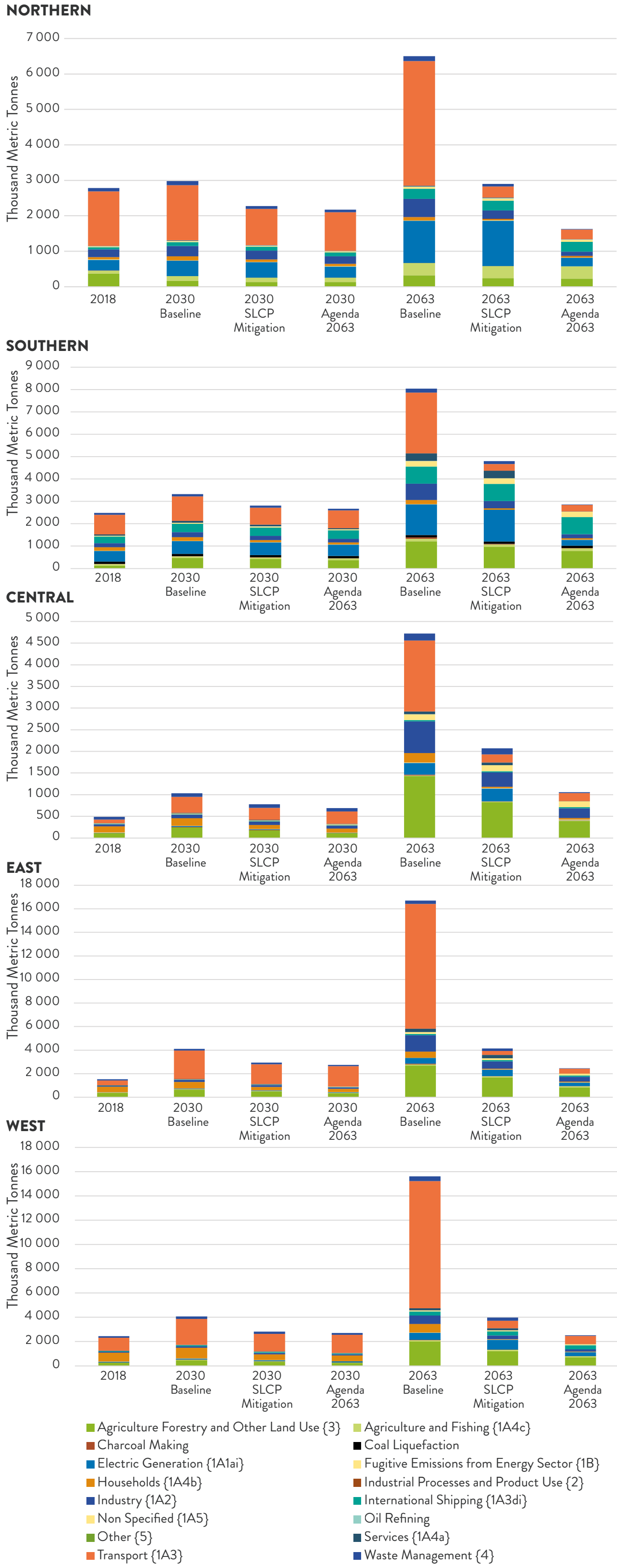


Figure 4.7 Nitrogen oxides emissions by sector in the baseline and short-lived climate pollutant mitigation and Agenda 2063 scenarios, African subregions, 2018, 2030 and 2063, thousand tonnes

4.4.1.7 SULPHUR DIOXIDE EMISSIONS

For SO_2 emissions (Figure 4.8), the major sources are similar to those of CO_2 and NOx, i.e., from electricity generation, industry and transport. These can be reduced to an extent by the SLCP mitigation measures and implementing Agenda 2063 measures will result in additional reductions.

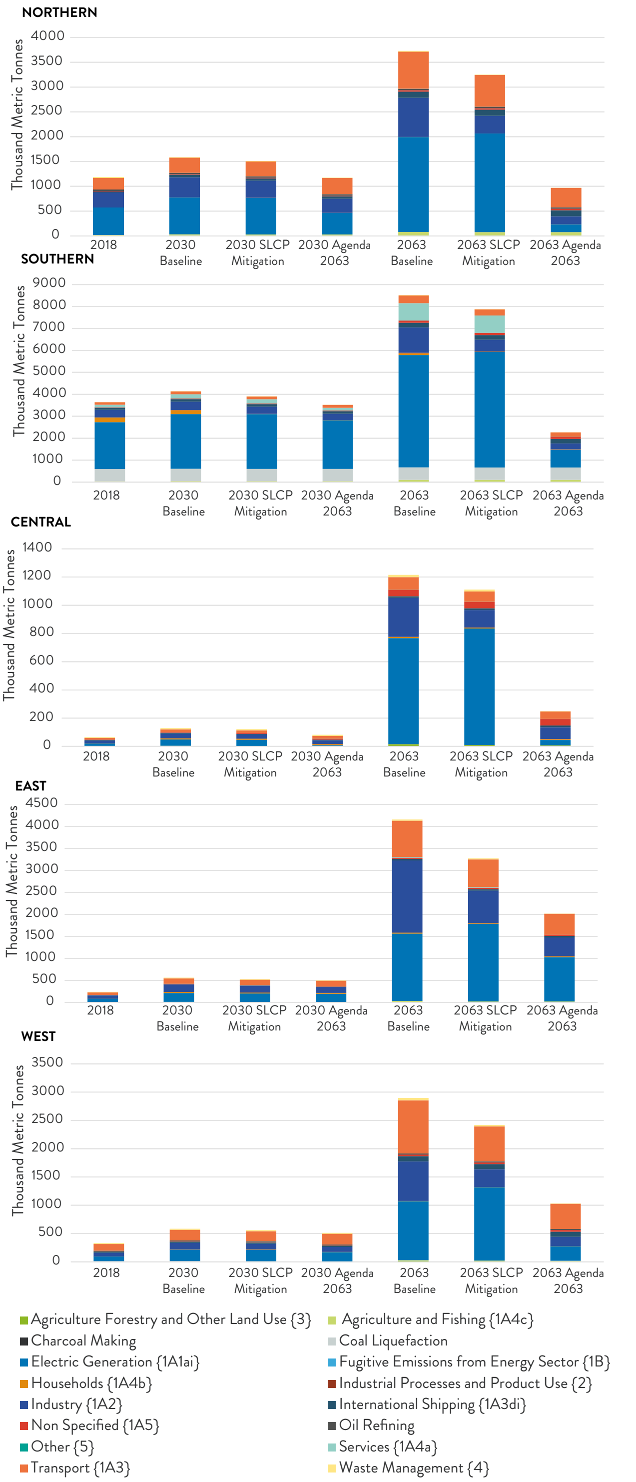


Figure 4.8 Sulphur dioxide emissions by sector in the baseline, and short-lived climate pollutant mitigation and Agenda 2063 scenarios, African subregions, 2018, 2030 and 2063, thousand tonnes

4.4.1.8 AMMONIA EMISSIONS

As in the case of N_2O, NH_3 emissions are dominated by the agricultural sector (Figure 4.9), and the N content of feed for livestock and manure management are crucial for controlling emissions. As for NOx and SO_2, NH_3 is an important precursor of secondary formation of $PM_{2.5}$, and their mitigation has consequently important health benefits, although removing the cooling effect that these particles, also known as nitrate, sulphate and ammonium aerosols, exert needs to be compensated for in mitigation strategies. There are also significant NH_3 emissions from the oil refining sectors in Northern and Southern Africa.

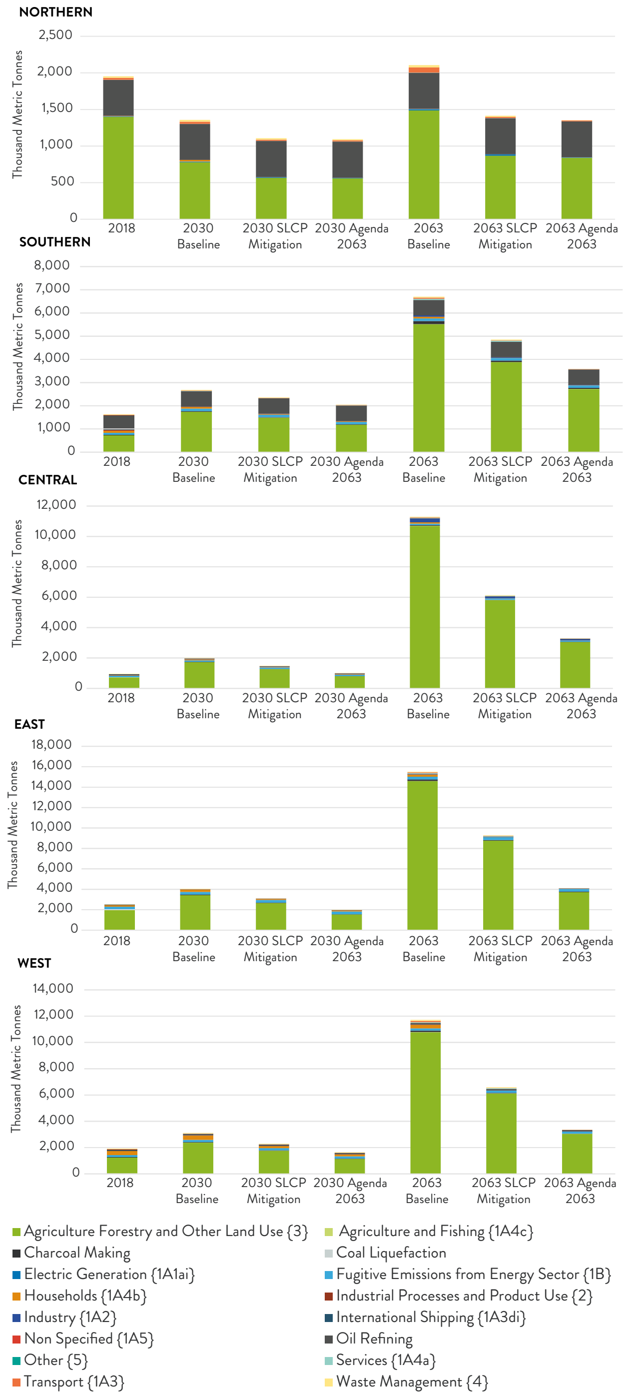


Figure 4.9 Ammonia emissions by sector in the baseline and short-lived climate pollutant mitigation and Agenda 2063 scenarios, African subregions, 2018, 2030 and 2063, thousand tonnes

4.5 ASSESSMENT OF AIR POLLUTION AND CLIMATE IMPACTS AT A SUBREGIONAL LEVEL

MAIN MESSAGES

- The warming projected in the baseline scenario to 2063, with year-round stronger warming across much of the northern and southern parts of the continent, i.e., the subtropics, will be dominated by emissions from the rest of the world, irrespective of changes in African emissions.
- A widespread reduction in warming across Northern and Central Africa is projected in the Agenda 2063 Scenario. Seasonally, the avoided warming is greatest during the local winter months in Northern (December–February) and Southern Africa (June–August).
- The Agenda 2063 emissions reductions strongly mitigate the baseline scenario's projected drying in Central, East and West Africa in June–August and in Southern Africa during January–March.
- The SLCP Scenario projects reduced mortality rates in all subregions by 2030 and by 2063 under the Agenda 2063 scenario, there are roughly 100 000, 45 000, 50 000, 100 000 and 130 000 fewer deaths per year in Northern, Southern, Central, East and West Africa respectively, relative to the baseline.
- Outdoor-air health benefits are particularly driven by emissions reductions in commercial sector activities, waste and agricultural residue burning, transport and industry, and emissions from biomass burning in the residential sector are also important to mitigate outdoor air pollution. The relative importance of each sector for mitigation of $PM_{2.5}$ emissions varies by subregion and integrated and coordinated approaches across sectors and scales are required to realise the full potential of the mitigation scenarios modelled in this Assessment.
- For household air pollution by 2063, the largest reduction in disease burden occurs in East and West Africa, with 57 per cent and 66 per cent reductions, respectively. In Central Africa, in which the implementation of clean cooking is projected to be less, the reduction in premature deaths drops to 36 per cent of the baseline in 2018.
- East Africa is the subregion to show yield gains under Agenda 2063 for all four crops modelled, ranging from about 6 per cent for rice to 10–12 per cent for maize, soy and wheat. By 2063, East and West Africa show significant gains for maize, rice and soy under both the SLCP mitigation and Agenda 2063 scenarios. Northern, Southern and Central Africa show a similar relatively small yield gain for maize under the Agenda 2063 scenario only, and soy shows yield gain in both scenarios by 2063 in Central Africa, and in Southern Africa under the Agenda 2063 scenario only.

4.5.1 CLIMATE

The climate modelling described in Chapter 3 shows that the warming projected in the baseline scenario to 2063, with year-round stronger warming across much of the northern and southern parts of the continent, i.e., the subtropics, will be dominated by emissions from the rest of the world, irrespective of changes in African emissions. Section 3.4.1 shows that at the subregional scale, there are statistically significant temperature responses to the Agenda 2063 scenario over Africa relative to the baseline by the 2050s. Specifically, there is a widespread reduction in warming across Northern and Central Africa. Seasonally, the avoided warming is greatest during the local winter months in Northern (December–February) and Southern Africa (June-August). For precipitation, the Agenda 2063 emissions reductions strongly mitigate the baseline scenario's projected drying in Central, East and West Africa in June–August and in Southern Africa during January–March. Sections 4.4 and 5.2.3 show that these climate benefits are particularly driven by emissions reductions in the electricity-generation, transport and industrial sectors for CO_2; the agricultural, especially related to enteric fermentation in livestock, waste and oil and gas sectors for CH_4; the agricultural sector for N_2O; and the residential, transport and industrial sectors for BC. Section 5.4 then describes how achieving these climate benefits depends on action across various sectors and at a variety of governance scales from the rural to the international.

4.5.2 PREMATURE DEATHS DUE TO OUTDOOR AIR POLLUTION

In the baseline scenario, estimates of mortality from $PM_{2.5}$ and O_3 outdoor pollution increase for all subregions throughout the modelling period, with East and West Africa experiencing particularly strong increases. By 2030, a reduction in premature mortality in all subregions can be seen under the SLCP scenario. The greatest benefits occur in Northern Africa with approximately 50 000 fewer deaths per year relative to the baseline as a result of reduced exposure to $PM_{2.5}$. The SLCP scenario delivers further reduced mortality rates in all subregions by 2063, but the greatest benefits are show in the Agenda 2063 scenario, under which there are roughly 100 000, 45 000, 50 000, 100 000 and 130 000 fewer deaths per year in Northern, Southern, Central, East and West Africa respectively, relative to the baseline.

Section 3.4.2 shows that the benefits of following the Agenda 2063 scenario provide a larger portion of the PM-related avoided mortalities. Table 4.5 shows the results of a recent study in which the cumulative avoided premature deaths under SSP scenarios are considerable in all subregions with East and West Africa showing the greatest benefits (Shindell *et al.* 2022).

Section 4.4 shows that these outdoor-air health benefits are particularly driven by emissions reductions in commercial sector activities, waste and agricultural residue burning, transport and industry, and emissions from biomass burning in the residential sector are also important to mitigate outdoor air pollution. As with achieving climate benefits, the relative importance of each sector for mitigation of $PM_{2.5}$ emissions varies by subregion and integrated and coordinated approaches across sectors and scales are required to realise the full potential of the mitigation scenarios modelled in this assessment (Section 5.4).

Table 4.5 Cumulative avoided premature deaths under SSP1_2.6 relative to SSP3_7.0, African subregions, 2020–2100. Source: Shindell *et al.* (2022).

SUBREGION	2020	2040	2050	2075	2100
NORTHERN	500 000	1 140 000	2 020 000	5 150 000	9 060 000
SOUTHERN	390 000	750 000	1 200 000	2 640 000	4 550 000
CENTRAL	300 000	630 000	1 120 000	2 820 000	4 900 000
EAST	890 000	1 870 000	3 140 000	7 630 000	12 810 000
WEST	880 000	1 930 000	3 450 000	9 390 000	17 170 000

Notes: Values are multi-model means across CMIP6 (Coupled Model Intercomparison Project's Phase 6) models, using Shared Socio-economic Pathways (SSPs):
SSP1_2.6: The effects of a worldwide transition to a sustainable development trajectory called SSP1 under a low warming scenario of roughly 2° C in 2100, *labelled* 2.6 for the radiative forcing reached in 2100.

SSP3: scenario under which development trajectories around the world are highly fragmented with many areas not transitioning to sustainable development. In the SSP3 scenario, emissions remain high and radiative forcing reaches 7.0 W/m² in 2100, leading to warming of around 3–4° C; hereafter SSP3_7.0. Under this scenario, investment in education declines and population growth in developing countries is projected to be large.

For details see Shindell *et al*. (2022).

4.5.3 PREMATURE DEATHS DUE TO HOUSEHOLD AIR POLLUTION

In the baseline scenario, by 2063 the largest levels of premature deaths attributable to household air pollution occur in East and West Africa and the smallest number are in Northern Africa, where the majority of households use gas for cooking. In Chapter 2 it was shown that, despite the increasing population across Africa projected in the baseline scenario, the gradual transition of households to cleaner fuels and a reduction in baseline mortality rates, especially for children, results in the number of premature deaths attributable to household air pollution being reduced by 40 per cent in 2063 relative to 2018 levels. Chapter 3 (Section 3.4.3) showed that the SLCP mitigation scenario, with steeper transitions to cleaner fuels, results in a substantially larger reduction in premature deaths compared to the baseline scenario, corresponding to a 12 per cent and 53 per cent reduction in 2030 and 2063, respectively. Furthermore, by 2063, the largest reduction in disease burden occurs in East and West Africa, with 57 per cent and 66 per cent reductions, respectively. In Central Africa, in which the implementation of clean cooking is projected to be less, the reduction in premature deaths drops to 36 per cent of the baseline in 2018 (Figure 4.10).

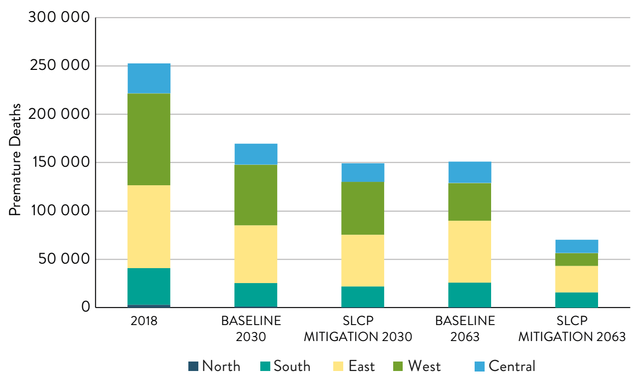


Figure 4.10 Premature deaths attributable to household air pollution from solid fuel combustion for baseline and short-lived climate pollutant mitigation scenarios disaggregated by African subregion, 2018 and 2030 and 2063.

Note: for clean cooking, the Agenda 2063 scenario only includes those measures already in the short-lived climate pollutant mitigation scenario, so the result is the same and not shown here (see Table 3.2).

4.5.4 BENEFITS FOR CROP YIELDS

In Section 3.4.4 the effects on crop yields of the SLCP mitigation and Agenda 2063 scenarios were discussed for the whole of Africa. The results for the four crops modelled at a continental scale showed a complicated picture, and as the impact on crop yields is a result of four different factors in combination – the response to temperature and precipitation and changes in concentrations of O_3 and CO_2 – further research is needed to disentangle the role of each factor. Maize shows the largest yield gains, followed by rice and soy, but with no clear gain for wheat. Figure 4.11 shows yield gains for the whole of Africa and in the five subregions (Table 4.1 details countries in each subregion).

As with the continental picture, wheat shows no clear trend in each of the subregions, apart from East Africa where there is approximately a 11 per cent yield gain by 2063 under the Agenda 2063 scenario. In fact, East Africa is the only subregion to show yield gains for all four crops, ranging from about 6 per cent for rice to 10–12 per cent for maize, soy and wheat. East and West Africa show significant gains for maize, rice and soy under both the SLCP mitigation and Agenda 2063 scenarios, with slightly larger yield gains for maize, 14–15 per cent, and soy, 12–14 per cent, in West Africa. North, Southern and Central Africa show a similar relatively small yield gain of 4 per cent for maize by 2063 under the Agenda 2063 scenario only. Soy shows a 6–8 per cent yield gain in both scenarios by 2063 in Central Africa, and an 8 per cent gain by 2063 in Southern Africa under the Agenda 2063 scenario only. As for the continental results, the subregional results also demonstrate the larger benefit associated with also implementing the behavioural-change related measures under the Agenda 2063 scenario. Reductions of concentrations of tropospheric O_3 that impact crop growth are driven by reductions in the emission of O_3 precursors CO, NOx, CH_4 and NMVOCs. Key to the emission reductions of CO and NMVOCs are the transport, electricity generation and residential sectors. The transport sector is particularly important for NOx emission reductions and agriculture for CH_4. Integrated and coordinated mitigation strategies across different pollutants, subregions and sectors are therefore required as discussed in Section 5.4.

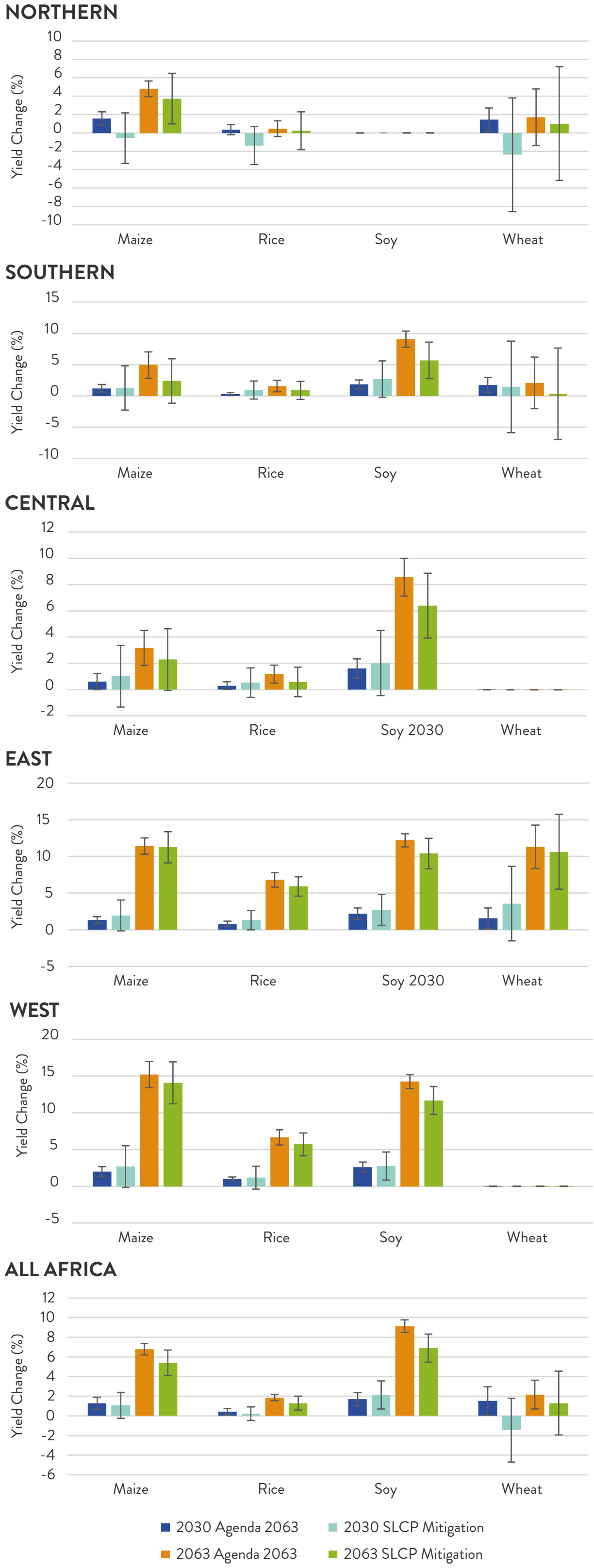


Figure 4.11 Simulated maize, rice, soy and wheat yield gains under the Agenda 2063 scenario by 2030 (blue) and 2063 (orange) and the short-lived climate pollutant mitigation scenario by 2030 (light blue) and 2063 (green) in response to changes in ozone, carbon dioxide, temperature and precipitation, African subregions and all of Africa, per cent relative to the baseline scenario

Note: Uncertainty bars reflect the variability in climate and O_3 across the five ensemble simulations completed for the baseline scenario and indicate when the modelled changes are statistically significant. There is additional uncertainty in the CO_2 concentration response to CO_2 emissions and in the crop impact-response functions that is not included here. As only one modelling run was carried out for the SLCP mitigation scenario, the error bars are large relative to the five model runs undertaken for the Agenda 2063 scenario, hence some of the changes in the SLCP mitigation scenario are not significant.
Source: GISS-E2.1-G simulations

4.6. BENEFITS RELATED TO EMISSIONS REDUCTIONS IN AFRICAN SUBREGIONS

MAIN MESSAGES

NORTHERN AFRICA

- Benefits of emission reductions estimated by the Assessment for Northern Africa include avoided warming, especially during the local winter months (December – February), some of the largest reductions in premature mortality from outdoor air pollution in Africa and crop yield gains for maize.
- It is estimated that the region has the largest potential in Africa for reducing CO_2 emissions and that it could be generating 50–60 per cent of its energy needs from renewable sources by 2063, with most of the remainder being provided by natural gas. In contrast to the other subregions, in which the agriculture sector dominates the CH_4 emissions, fugitive emissions from the energy sector dominate and SLCP mitigation measures in the energy and waste sectors could lead to large reductions, more than halving the CH_4 emissions by 2063.
- As much less solid fuel is burnt for cooking and heating than in Sub-Saharan Africa, transport is the dominant sector for BC emissions and the waste sector is the most significant in terms of $PM_{2.5}$ emissions.
- Intergovernmental cooperation has promoted improvements in air quality across the sub-region related to unleaded fuels and low-sulphur diesel and further progress could be achieved in the subregion by linking to the planning processes of the Arab Maghreb Union and follow up to the 2008 Libreville Declaration adopted by Ministers of Health and Environment.

SOUTHERN AFRICA

- Benefits of emission reductions estimated by the Assessment for Southern Africa include avoided warming during the local winter months (June to August) and drying in summer months (January to March), reductions in premature mortality from outdoor air pollution, approximate halving of disease burden due to household air pollution by 2063 via SLCP mitigation, and crop yield gains for rice, maize, and soy.
- CO_2 emissions can be more than halved by 2063 in the electricity generation (83 per cent), transport (53 per cent) and industry sectors (51 per cent).
- Under the Agenda 2063 scenario electricity generated from renewable sources accounts for approximately two thirds of the energy mix by 2063 but Southern Africa's reliance on fossil fuel can still be seen in the use of solid fuels, natural gas and oil products.
- Emissions of CH_4 from the agricultural, waste and charcoal-making sectors, as well as fugitive emissions from the energy sector, can be significantly reduced in the subregion, with fugitive emissions having the largest relative reduction in emissions.
- Substantial reductions in $PM_{2.5}$ can be achieved by 2063 with major contributions from household, waste, charcoal making and industrial emissions.
- Intergovernmental cooperation has promoted improvements in air quality across the subregion related to unleaded fuels and low-sulphur diesel and further progress could be achieved in the subregion by implementing agreements such as the 2008 Lusaka Agreement – (SADC) Regional Policy Framework on Air Pollution and the SADC Protocol on Regional Air Quality and Atmospheric Emissions.

CENTRAL AFRICA

- Benefits of emission reductions estimated by the Assessment for Central Africa include widespread reduction in warming, mitigation of drying of the climate in June–August, reductions in premature mortality from outdoor air pollution, a reduction in disease burden due to household pollution, and crop yield gains for rice, maize and soy.
- A reduction in CO_2 emissions (48 per cent) is achievable with a major contribution from the Agriculture, Forestry and Other Land Use (AFOLU) sector, with the electricity generation and industrial sectors becoming more important by 2063, reflecting the development status of this subregion. Agenda 2063 shows CO_2 emissions from electricity generation almost disappearing as there is a switch to renewable sources of generation.
- Methane emissions are dominated by the agricultural sector in both scenarios, with smaller contributions from fugitive emissions from industry, waste management and charcoal making.
- $PM_{2.5}$ emissions can be reduced by more than 60 per cent and BC emissions more than halved by the Agenda 2063 measures by 2063.
- Intergovernmental cooperation has promoted improvements in air quality across the subregion related to unleaded fuels and low-sulphur diesel and further progress could be achieved in the subregion by implementing initiatives such as the 2009 Abidjan West and Central Africa Regional Framework Agreement on Air Pollution and the Regional Climate Action Transparency Hub for Central Africa (ReCATH) was launched in 2022.

EAST AFRICA

- Benefits of emission reductions estimated by the Assessment for East Africa include mitigation of drying of the climate in June–August, reductions in premature mortality from outdoor air pollution, a 66 per cent reduction in disease burden due to household pollution, and crop yield gains for wheat, rice, maize, and soy.
- A reduction in CO_2 emissions (42 per cent) is achievable with a major contribution from the Agriculture, Forestry and Other Land Use (AFOLU) sector, with transport, industry and electricity generation becoming more dominant by 2063 as AFOLU transforms into more of a carbon sink.
- Substantial reductions in CH_4 emissions are achievable by 2063 through mitigation in the agriculture, waste and charcoal making sectors.
- $PM_{2.5}$ emissions can be reduced by more than 60 per cent and BC emissions more than halved by the Agenda 2063 measures by 2063, with large reductions possible in the household sector. The transport sector dominates NOx emissions and both mitigation scenarios are effective in reducing them substantially.
- Intergovernmental cooperation has promoted improvements in air quality across the subregion related to unleaded fuels and low-sulphur diesel and further progress could be achieved in the subregion by implementing initiatives such as Eastern African Regional Framework Agreement on Air Pollution, known as the 2008 Nairobi Agreement, and the Electronic Waste Management Framework and Management of Plastic and Plastic Waste Disposal.

WEST AFRICA

- Benefits of emission reductions estimated by the Assessment for West Africa include mitigation of drying of the climate in June–August, reductions in premature mortality from outdoor air pollution, a 57 per cent reduction in disease burden due to household pollution, and crop yield gains for rice, maize and soy.
- There is an overall 57 per cent reduction of CO_2 emissions in 2063, with the largest reduction from transport emissions on the continent (63 per cent) through the transition to electricity generation using more renewable sources to power electric vehicles.
- Substantial reductions in emissions of CH_4 can happen from agriculture, waste management and charcoal making, as well as fugitive emissions from the energy sector.
- Large $PM_{2.5}$ emission reductions are possible, dominated by the household sector but with contributions from other sectors including the charcoal making, waste management and transport.
- The transport sector is more important for BC and NOx emissions than for $PM_{2.5}$ emissions.
- Intergovernmental cooperation has promoted improvements in air quality across the subregion related to unleaded fuels and low-sulphur diesel and further progress could be achieved in the subregion by building on activities related to the Abidjan West and Central Africa Regional Framework Agreement on Air Pollution that was agreed in 2009 and the roadmap outlining priority areas by sector for 2019–2023 to further improve air quality in the West Africa subregion was developed by ECOWAS.

4.6.1 INTRODUCTION

In this section, elements of sections 4.3 to 4.5 are combined in terms of key regional processes (Section 4.3), the key emitting sectors in each subregion (Section 4.4) and impacts most relevant to each subregion (Section 4.5) to assess the opportunities for achieving air-quality and climate benefits related to development in the African subregions. Consideration of how to implement the measures at scale across the African continent is then provided in Chapter 5.

The following should be borne in mind when reading the sections below on the different subregions.

EMISSIONS

- The reduction of anthropogenic emissions will require different combinations of the 37 recommended measures in each subregion (see Chapter 3 and Table 5.1 for details of the 37 measures across transport, residential, energy, agriculture and waste management sectors).
- Natural sources of SCLPs and BC are not covered in this Assessment.

HUMAN HEALTH

- Air pollution is responsible for a greater health burden of in some subregions compared to others, and the subregions differ in the relative importance of household and outdoor air pollution (Sections 4.5.2 and 4.5.3).
- Reduced premature mortality is just one benefit of reducing air pollution and there are many others related to factors such as less illness and fewer work and school absences that have not been estimated in this Assessment, plus the health benefits of limiting climate change (Section 1.3). Socio-economic benefits are also not quantified here.

CLIMATE CHANGE

- Although all subregions can take action to mitigate climate effects, substantial mitigation action outside of Africa is required to protect the continent from the escalating impacts of climate change (Section 3.4.1).

CROPS AND ECOSYSTEMS

- This Assessment considers the impact of climate change – changes in temperature and precipitation patterns, CO_2 concentrations and tropospheric O_3 on the yields of four key crops – maize, rice, soy and wheat. The benefits of the package of measures recommended by this Assessment will also positively affect other crops and natural ecosystems but the extent of these has not been determined here.

KEY REGIONAL PROCESSES

- Key regional processes mentioned in the following sections, many of which were initiated decades ago, will benefit from alignment with the NDCs under the Paris Agreement (Sections 3.5.1 and 5.4.3) and national planning to achieve the SDGs (Section 3.5.2).

4.6.2 NORTHERN AFRICA

AIR QUALITY AND CLIMATE BENEFITS

The Assessment shows the following climate and air quality benefits.

- Widespread reduction in warming and seasonally avoided warming is greatest during the local winter months (December to February) under the Agenda 2063 scenario.
- Premature mortality from outdoor air pollution is reduced by approximately 50 000 avoided deaths per year under the SLCP scenario by 2030 relative to the baseline for $PM_{2.5}$, the largest reduction estimated for an Africa region by 2030, and reduced by about 100 000 per year under the Agenda 2063 scenario and about 80 000 per year under the SLCP mitigation Scenario by 2063, relative to the baseline.
- The Agenda 2063 scenario shows yield gains of about 4 per cent for maize, but a smaller and more uncertain benefit under the SLCP mitigation scenario, relative to the baseline.

KEY EMITTING SECTORS

Greenhouse gases and short-lived climate pollutants

This Assessment estimates that Northern Africa has the potential to reduce CO_2 emissions by about 63 per cent, which is a 10 per cent larger reduction than the African average. This is linked to the potential of the increased use of renewable sources of energy in Northern Africa, as modelled in this Assessment (Figure 4.2). The Agenda 2063 scenario projects that Northern Africa could be generating 50–60 per cent of its energy needs from renewable sources by 2063, with the majority of the remainder being provided by natural gas. In Northern Africa this significant potential for the decarbonization of electricity generation produces a 79 per cent reduction in CO_2 emissions relative to the baseline by 2063. This could be accompanied by a 57 per cent reduction in CO_2 emissions for the transport sector and a 56 per cent reduction in the industrial sector.

In contrast to the other subregions, in which the agriculture sector dominates the CH_4 emissions, in Northern Africa fugitive emissions from the energy sector dominate (Figure 4.3). Furthermore, given the greater emissions from the energy and waste sectors, the SLCP mitigation measures could lead to large reductions, more than halving the CH_4 emissions by 2063. As in all subregions, the agriculture sector in Northern Africa dominates N_2O emissions (Figure 4.4).

Air pollutants

A key difference in Northern Africa is that there are substantially fewer emissions of PM, including BC, from the household sector, as much less solid fuel is burnt for cooking and heating than in Sub-Saharan Africa. As a result, in 2018 transport is the dominant sector for BC emissions (Figure 4.5), and the waste sector is the most significant in terms of $PM_{2.5}$ emissions (Figure 4.6).

Key regional processes

Intergovernmental cooperation has promoted improvements in air quality across the subregion; for example, the Ministerial Resolution adopted at the Council of Arab Ministers Responsible for the Environment (CAMRE) at its 18th session, held in Algeria in 2006, which supported the goal of moving towards unleaded fuels and low-sulphur diesel as championed by the PCFV (Section 4.3). In 2009, UNEP and the Global Atmospheric Pollution Forum sponsored a Northern African subregional workshop on better air quality which recommended a series of activities to establish an intergovernmental network on air pollution for the subregion (APINA 2009a).

Further progress could be achieved in the subregion by linking to the planning processes of the UMA (Table 4.3) and follow up to the 2008 Libreville Declaration adopted by Ministers of Health and Environment (Table 4.2).

For most Northern African countries, the focus on transitioning to more sustainable energy systems has acquired importance since the subregion has a great potential for the increased use of energy from renewable sources, which could reduce dependence on imported fuels. Northern Africa has some of the most favourable locations for exploiting solar energy. All five countries have long-term targets for increasing renewable electricity capacity. By 2030, Morocco targets producing 10 GW from renewable sources, Libya 4.6 GW, and Tunisia 2.8 GW, while Algeria targets 15 GW and Egypt targets 54 GW by 2035 (IEA 2020).

4.6.3 SOUTHERN AFRICA

AIR QUALITY AND CLIMATE BENEFITS

The Assessment shows the following climate and air quality benefits.

- Seasonally avoided warming is greatest during the local winter months (May – August) under the Agenda 2063 scenario.
- Projected drying of the climate is strongly mitigated in January–March under the Agenda 2063 scenario.
- Premature mortality from outdoor air pollution reduced by approximately 12 000 deaths per year, relative to the baseline, due to $PM_{2.5}$ pollution under the SLCP mitigation scenario by 2030. It is further reduced by around 45 000 per year under the Agenda 2063 scenario and about 22 000 per year under the SLCP mitigation scenario by 2063, relative to the baseline.
- The disease burden due to household air pollution approximately halved by 2063 under the SLCP mitigation scenario.
- The Agenda 2063 scenario shows yield gains of about 1 per cent for rice, 4 per cent for maize and 8 per cent for soy relative to the baseline, but smaller and more uncertain benefits under SLCP mitigation scenario.

KEY EMITTING SECTORS

Greenhouse gases and short-lived climate pollutants

Under the Agenda 2063 scenario, there is a 58 per cent reduction in CO_2 emissions overall and 83 per cent, 53 per cent and 51 per cent reductions in the electricity generation, transport and industry sectors respectively (Table 4.4). Under the SLCP mitigation scenario, there is a 3 per cent increase in CO_2 emissions relative to the baseline, for electricity generation by 2063. Under the Agenda 2063 scenario electricity generated from renewable sources accounts for approximately two thirds of the energy mix with renewables by 2063 (Figure 4.2), but Southern Africa's reliance on fossil fuel can still be seen in the use of solid fuels, natural gas and oil products. Carbon dioxide emissions from services are almost completely eliminated in the Agenda 2063 scenario.

Emissions of CH_4 from the agricultural, waste and charcoal-making sectors, as well as fugitive emissions from the energy sector, are significant in the subregion, with fugitive emissions having the largest relative reduction in CH_4 emissions – the SLCP mitigation scenario shows a 96 per cent reduction by 2063, relative to the baseline (Section 4.4.2; Figure 4.3). The agricultural sector also dominates N_2O emissions (Figure 4.4).

Air pollutants

By 2030, the household sector is the key contributor to $PM_{2.5}$ emissions in Southern Africa in the baseline scenario, followed by waste, charcoal making and industry (Figure 4.6). By 2063, the charcoal making dominates, followed by the industrial, services, household and waste sectors. Considerable reductions are seen in all sectors under the two scenarios by 2063, with the Agenda 2063 scenario showing the largest reductions in $PM_{2.5}$ emissions – around 70 per cent compared to the baseline. There are similar changes for BC emissions (Figure 4.5). For NOx, industrial and shipping are relatively important in Southern Africa, with the transport sector dominating the emissions (Figure 4.7).

Key regional processes

The Air Pollution Information Network for Africa (APINA) was developed in Southern Africa in 1998, as a response to increasing air pollution issues. Air-pollution policy processes within the SADC subregion were then influenced by APINA and its partners, helping to facilitate the Lusaka Agreement – (SADC) Regional Policy Framework on Air Pollution in 2008 (APINA 2008). The development of an SADC Protocol on Regional Air Quality and Atmospheric Emissions was also initiated. Most recently, SADC agreed a regional framework for the harmonization of low-sulphur fuels and vehicle-emission standards in 2019.

The SADC has included the SDGs in its planning and policies and adopted the SADC Green Economy Strategy and Action Plan for Sustainable Development. .

4.6.4 CENTRAL AFRICA

AIR QUALITY AND CLIMATE BENEFITS

The Assessment shows the following climate and air quality benefits.

- Widespread reduction in warming under Agenda 2063 scenario.
- The projected drying of the climate is strongly mitigated in June–August under Agenda 2063 Scenario.
- Premature mortality from outdoor air pollution reduced by approximately 8 000 per year relative

to the baseline for $PM_{2.5}$ pollution under the SLCP mitigation scenario by 2030. Furthermore, it is reduced by around 50 000 per year under the Agenda 2063 scenario and about 35 000 per year under the SLCP mitigation scenario by 2063, relative to the baseline.

- A 36 per cent reduction in disease burden due to household pollution by 2063 is expected under the SLCP mitigation scenario.
- Under the Agenda 2063 scenario, there are yield gains of about 1 per cent for rice, 3 per cent for maize, 8 per cent for soy, relative to the baseline, but smaller and more uncertain benefits under SLCP mitigation scenario.

KEY EMITTING SECTORS

Greenhouse gases and short-lived climate pollutants

Under the Agenda 2063 scenario, there is a 48 per cent reduction in CO_2 emissions overall relative to the baseline in 2063. As a source of emissions, AFOLU plays a major role across all scenarios to 2030 and by 2063, with the electricity generation and industrial sectors becoming more important by 2063. Agenda 2063 shows CO_2 emissions from electricity generation almost disappearing as there is a switch to renewable sources of generation. There are relatively large increases in carbon-intensive industries out to 2063, reflecting the development status of this subregion.

Methane emissions are dominated by the agricultural sector in both scenarios, with smaller contributions from fugitive emissions from industry, waste management and charcoal making. The SLCP mitigation scenario shows significant reductions in CH_4 emissions but much larger reductions are possible under the Agenda 2063 scenario which shows a more than 80 per cent fall in overall CH_4 emissions by 2063 (Figure 4.3). The agricultural sector also dominates N_2O emissions, as in other subregions (Figure 4.4). The Agenda 2063 scenario goes some way to reducing these emissions but to achieve larger reductions more digestible feed would need to have a lower N content.

Air pollutants

In the baseline, $PM_{2.5}$ emissions out to 2030 are dominated by the household sector but by 2063 industry becomes dominant, with smaller contributions from households, the waste sector, charcoal making, services and agriculture. Under the Agenda 2063 scenario, $PM_{2.5}$ emissions can be reduced by more than 60 per cent (Figure 4.6). In Central Africa, there is a large contribution of BC emissions from industry, which is more than halved by the Agenda 2063 measures by 2063, compared to the baseline (Figure 4.5).

Key regional processes

In 2009, APINA helped to facilitate the West and Central Africa Subregional Workshop on Better Air Quality in Abidjan, Côte d'Ivoire, which resulted in the Abidjan West and Central Africa Regional Framework Agreement on Air Pollution (Table 4.3). This agreement was revisited by nine countries from the West Africa subregion in 2018 to discuss progress towards its implementation. In 2022 the Regional Climate Action Transparency Hub for Central Africa (ReCATH) was launched, which marks a milestone in regional climate cooperation. The Hub will establish a centre and a network for the subregion to support countries' ongoing efforts to address climate challenges by building strong frameworks with sound data to plan, implement and track effective climate policies and action (ICAT 2022).

4.6.5 EAST AFRICA

AIR QUALITY AND CLIMATE BENEFITS

The Assessment shows the following climate and air quality benefits.

- The projected drying of the climate strongly mitigated in June–August under the Agenda 2063 scenario.
- Premature mortality from outdoor air pollution is reduced by approximately 25 000 per year relative to the baseline for $PM_{2.5}$ pollution under the SLCP mitigation scenario by 2030. Furthermore, it is reduced by around 100 000 per year under Agenda 2063 scenario and about 80 000 per year under the SLCP mitigation scenario by 2063, relative to the baseline.
- The SLCP mitigation scenario shows a 66 per cent reduction in disease burden due to household pollution in 2063.
- Under the Agenda 2063 scenario, there are yield gains of about 6 per cent for rice and 10–12 per cent for maize, soy and wheat, relative to the baseline, but smaller and more uncertain improvements under SLCP scenario.

KEY EMITTING SECTORS

Greenhouse gases and short-lived climate pollutants

Under the Agenda 2063 scenario. there is a 42 per cent reduction in CO_2 emissions overall in 2063, relative to the baseline. In 2018, these emissions are dominated by AFOLU, which is a net emitter of CO_2 in East Africa. This situation changes by 2063 as transport, industry and electricity generation become dominant and AFOLU transforms into more of a carbon sink.

Methane emissions are also dominated by agriculture with contributions from waste management and charcoal making that persist to 2063 in the baseline. The SLCP mitigation scenario shows substantial reductions overall CH_4 emissions by 2063, while the Agenda 2063 scenario reduces emissions in 2063 to the 2030 baseline level (Figure 4.3). The agricultural sector dominates N_2O emissions. (Figure 4.4); the Agenda 2063 scenario goes some way to reducing these but to achieve larger reductions, more digestible feed would need to have a lower N content.

Air pollutants

The households sector dominates $PM_{2.5}$ emissions in 2018 and out to 2063 in the baseline, with smaller contributions from the charcoal making, waste management, transport and industrial sectors. The SLCP mitigation scenario reduces these emissions by about a third relative to the baseline in 2030 and by over half in 2063. The Agenda 2063 scenario shows a more than 60 per cent reduction compared to the baseline (Figure 4.6). Black carbon and $PM_{2.5}$ emissions have a similar distribution across the sectors but transport sector is the most prominent for BC than for $PM_{2.5}$ emissions, especially by 2063. The SLCP mitigation scenario reduces BC emissions in 2063 by more than half and the Agenda 2063 scenario by about two thirds (Figure 4.5). The transport sector dominates NOx emissions and both mitigation scenarios are effective in reducing them, with SLCP mitigation measures reducing them by about 75 per cent and Agenda 2063 by almost 90 per cent in 2063 (Figure 4.7).

Key regional processes

At a multi-stakeholder policy dialogue in Nairobi, Kenya in 2008, all partner states of the EAC (Table 4.3) adopted the Eastern African Regional Framework Agreement on Air Pollution, known as the 2008 Nairobi Agreement. Subsequently, the states have agreed to develop actionable targets to address air pollution in the following key areas: transport, industry and mining, energy, waste management, vegetation fires, indoor air pollution, and urban planning and management. The EAC is also working on the development and harmonization of standards and regulations on pollution control and waste management, while the EAC Secretariat is working on the implementation of the provisions of the Nairobi Agreement and developing the EAC Electronic Waste Management Framework and Management of Plastic and Plastic Waste Disposal (EAC 2022).

4.6.6 WEST AFRICA

AIR QUALITY AND CLIMATE BENEFITS

The Assessment shows the following climate and air quality benefits.

- Under the Agenda 2063 scenario, the projected drying of the climate strongly is mitigated in June–August.
- By 2030, premature mortality from outdoor air pollution is reduced by approximately 30 000 per year relative to the baseline for $PM_{2.5}$ pollution under the SLCP mitigation scenario. Furthermore, by 2063 it is reduced by around 130 000 per year under Agenda 2063 scenario and about 100 000 per year under the SLCP mitigation scenario, relative to the baseline.
- The SLCP mitigation scenario shows a 57 per cent reduction in the disease burden due to household pollution by 2063.
- Under the Agenda 2063 scenario, there are yield gains of about 6 per cent for rice, 14 per cent for soy and 15 per cent for maize, relative to the baseline, but smaller and more uncertain improvements under SLCP mitigation scenario.

KEY EMITTING SECTORS

Greenhouse gases and short-lived climate pollutants

In 2018, CO_2 emissions in West Africa are dominated by the transport, industrial and electricity generation, with transport being the main emitting sector. West Africa shows the largest reduction in transport CO_2 emissions on the continent, 63 per cent in 2063 under the Agenda 2063 scenario relative to the baseline, through the transition to electricity generation using more renewable sources to power electric vehicles. For CO_2, under the Agenda 2063 scenario there is an overall 57 per cent reduction of emissions relative to the baseline in 2063.

The projections for CH_4 are similar to those for Southern Africa, where emissions of CH_4 from agriculture, waste management and charcoal making, as well as fugitive emissions from the energy sector, are important in the subregion. The Agenda 2063 scenario shows an almost complete reduction in CH_4 emissions in 2063 relative to the baseline (Figure 4.3). The agriculture sector dominates N_2O emissions (Figure 4.4).

Air pollutants

The projections for $PM_{2.5}$ emissions in West Africa are very similar to those of East Africa, with household emissions dominating and both mitigation scenarios achieving large reductions in emissions, especially by 2063 under the Agenda 2063 scenario. The transport sector is more important for BC and NOx emissions than for $PM_{2.5}$ emissions (Figures 4.5–4.7).

Key regional processes

As discussed in Section 4.6.4, the Abidjan West and Central Africa Regional Framework Agreement on Air Pollution was agreed in 2009 (APINA 2009b) and since then ECOWAS has followed up with a review of progress in 2018 and stated that it "*supports countries in the subregion to tackle air pollution, a major health challenge*" (UNEP 2018). At the 2018 workshop, participants were updated on the progress made on the implementation of the Abidjan Agreement and gaps and constraints to implementation of the Agreement were identified. A roadmap outlining priority areas by sector for 2019–2023 to further improve air quality in the West Africa subregion was developed.

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ABBREVIATIONS AND ACRONYMS

AC	air conditioner
ACCP	African Clean Cities Platform
ADHD	attention deficit/hyperactivity disorder
AEC	African Economic Community
AERONET	Aerosol Robotic Network
AfDB	African Development Bank
AfCFTA	African Continental Free Trade Area
AFOLU	agriculture, forestry and other land use
AFR100	African Forest Landscape Restoration Initiative
AGNES	African Group of Negotiators Expert Support
AMCEN	African Ministerial Conference on the Environment
AMCOMET	African Ministerial Conference on Meteorology
AMCOW	African Ministers' Council on Water
AMMA	African Monsoon Multidisciplinary Analysis
APINA	Air Pollution Information Network for Africa
AOD	aerosol optical depth
ARBE	Department of Agriculture, Rural Development, Blue Economy, and Sustainable Environment (of the African Union)
ARSO	African Regional Organization for Standardisation
ART	acute respiratory-tract infection
ASAP	A Systems Approach to Air Pollution
ASD	autism spectrum disorder
AU	African Union
AUC	African Union Commission
AUDA-NEPAD	African Union Development Agency
AWD	alternate wetting and drying
BC	black carbon
BSC	Barcelona Supercomputing Center
BSFL	black soldier fly larvae
C	carbon
°C	degrees Celsius
CAADP	Comprehensive Africa Agricultural Development Programme
CAMRE	Council of Arab Ministers Responsible for the Environment
CAMS	Copernicus Atmosphere Monitoring Service
CAN	Climat Action Network
CAR	Central African Republic
CArE-Cities	Clean Air Engineering projects – Clean Air Engineering for Cities
CArE-Homes	Clean Air Engineering projects – Clean Air Engineering for Homes
CCAC	Climate and Clean Air Coalition
CCAK	Clean Cooking Association of Kenya
CCS	carbon capture and storage
CEDS	Community Emissions Data System
CIESIN	Center for International Earth Science Information Network
CH_4	methane

CI	confidence interval
CMIP	Coupled Model Intercomparison Project
CMIP6	Sixth Coupled Model Intercomparison Project
CO	carbon monoxide
CO_2	carbon dioxide
CO_2-eq	carbon dioxide equivalent
COMESA	Common Market for Eastern and Southern Africa
COP	Conference of the Parties
COPD	chronic obstructive pulmonary disease
CRS	Common Reporting Standard
CSIR	Council for Scientific and Industrial Research
CSO	civil society organization
CSP	concentrated solar power
3D	three dimensional
DALY	disability-adjusted life years
DCHS	Drakenstein Child Health Study, Western Cape, South Africa
DICCIWA	Dynamics-aerosol-chemistry-cloud interactions in West Africa
DPSIR	drivers, pressures, state, impacts and responses
DRC	Democratic Republic of the Congo
EAC	East African Community
EASFCOM	Eastern Africa Standby Force Coordination Mechanism
ECCAS	Economic Community of Central African States
ECMWF	European Centre for Medium Range Weather Forecasting
ECOWAS	Economic Community for West African States
EDGAR	Emissions Database for Global Atmospheric Research
EEA	European Environment Agency
e.g.	exempli gratia (for example)
EIP	Eco-Industrial Park
EMEP	European Monitoring and Evaluation Programme
ERGP	Economic Recovery and Growth Plan
ETSAP	Energy Technology Systems Analysis Program
EV	electric vehicle
FAO	Food and Agricultural Organization of the United Nations
FDI	Foreign Direct Investment
FEER	Fire Energetics and Emissions Research
F-gas	fluorinated gas
FINN	Fire INventory from NCAR
FRM	Federal Reference Method
GBD	global burden and disease
GCF	Green Climate Fund
GCM	global circulation model
GDL	Global Data Labs
GDP	gross domestic product
GEDAP	Ghana Energy Development and Access Project
GEF	Global Environmental Facility
GEO	geostationary Earth orbit

GEOS	Goddard Earth Observing System
GFED	Global Fire Emissions Database
GFAS	Global Fire Assimilation System
GHAir	Ghana Urban Air Quality Project
GHG	greenhouse gas
GISS	Goddard Institute for Space Studies
GMAO	Global Modeling and Assimilation Office
GMP	Global Methane Pledge
GPI	genuine progress indicators
GPPDB	Global Power Plants Database
GPW	Gridded Population of the World
GRAP	Green Recovery Action Plan (of the African Union)
GSAT	global surface air temperature
GW	gigawatt (109 watts)
GWh	gigawatt hours
GWP	Gridded Population of the World
HFC	hydrofluorocarbon
H_2O	water
hPa	hectopascal
IBC	Integrated Benefits Calculator
IBD	inflammatory bowel disease
IBS	irritable bowel syndrome
ICAO	International Civil Aviation Organisation
ICCT	International Council on Clean Transportation
ICE	internal combustion engine
ICLEI	Local Governments for Sustainability
i.e.	id est (that is)
IEA	International Energy Agency
IGAD	Intergovernmental Authority on Development
ICLEI	Local Governments for Sustainability
IGO	intergovernmental organizations
ILO	International Labour Organization
IMF	International Monetary Fund
IMO	International Maritime Organization
INDAAF	International Network to study Deposition and Atmospheric
IP	Industrial Park chemistry in Africa
IPCC	Intergovernmental Panel on Climate Change
IPPU	industrial processes and product use
IQ	intelligence quotient
IRENA	International Renewable Energy Agency
IWRM	integrated watershed resource management
JICA	Japan International Cooperation Agency
kg	kilogram
KJWA	Koronivia Joint Work on Agriculture
km	kilometre

LEAP	Low Emissions Analysis Platform
LEAP-IBC	Low Emission Analysis Platform – Integrated Benefits Calculator
LED	light-emitting diode
LGV	Ligne à Grande Vitesse Maroc
LMIC	lower middle-income country
LPG	liquified petroleum gas
LRTAP	Convention on Long-Range Transboundary Air Pollution
LRTI	lower respiratory-tract infection
LULUCF	land use, land-use change and forestry
µg	microgram
m	metre
m^2	square metre
m^3	cubic metre
mm	millimetre
MAFLD	metabolic dysfunction-associated fatty liver disease
MDB	multilateral development bank
MEA	multilateral environmental agreement
MEPS	minimum energy-performance standards
MODIS	moderate resolution imaging spectroradiometer
MOPITT	Measurement of Pollution in the Troposphere
MSMEs	micro, small and medium-sized enterprises
MVOC	microbial volatile organic compound
MSW	municipal solid waste
MVA	Manufacturing Value Added
MW	megawatt (106 watts)
N	nitrogen
NAIPS	National Agricultural Investment Plans
NARC	North African Regional Capability
NASA	National Aeronautics and Space Administration
NCAR	US National Center for Atmospheric Research
NCD	non-communicable disease
NDC	Nationally Determined Contributions (to the Paris Agreement)
NEPAD	New Partnership for Africa's Development
NGO	non-governmental organization
NH3	ammonia
NH4	ammonium
NIR	New Industrial Revolution
NMT	non-motorised transport
NMVOC	non-methane volatile organic compound
NO	nitric oxide
N_2O	nitrous oxide
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NREL	National Renewable Energy Laboratory
NSB	national standards body
O_x	containing oxygen

O_3	ozone
OC	organic carbon
ODA	overseas development assistance
OECD	Organisation for Economic Co-operation and Development
OICA	International Organisation of Motor Vehicle Manufacturers (Organisation internationale des constructeurs automobiles)
OMI	ozone (O3) monitoring instrument
PCFV	Partnership for Clean Fuels and Vehicles
PIDA	Programme for Infrastructure Development in Africa
PIQ	performance intelligence quotient
PM	particulate matter
PM_1	very fine particulate matter (with a diameter of less than 1 micron)
$PM_{2.5}$	fine particulate matter (with a diameter of less than 2.5 microns)
PM_{10}	large particulate matter (with a diameter of 10 microns or less)
POLCA	Pollution de Capitales Africaines
ppb	parts per billion
ppbv	parts per billion by volume
ppm	parts per million
PPP	purchasing power parity
PREFIA	Air Quality Prediction and Forecasting Improvement for Africa
PV	photovoltaic
QFED	Quick Fire Emissions Dataset
R-COOL	Rwanda Cooling Initiative
REC	Regional Economic Community
ReCATH	Regional Climate Action Transparency Hub for Central Africa
RFA	regional framework agreements
RLP	Rural LPG Promotion Programme
3Rs	reuse, reduce and recycle
S	sulphur
SAAQIS	South African Air Quality Information System
SADC	Southern African Development Community
SDG	Sustainable Development Goal
SEI	Stockholm Environment Institute
SEZ	Special Economic Zone
SLCF	short-lived climate forcer
SLCP	short-lived climate pollutant
SNAP	Supporting National Action and Planning on Short-Lived Climate Pollutants
SNAQ	Sensor Network for Air Quality
SO_2	sulphur dioxide
SSP	shared socioeconomic pathway
TAREA	Tanzania Renewable Energy Association
TROPOMI	Tropospheric Monitoring Instrument
TSP	total suspended particulates
TW	terawatt (1012 watts)
TWh	terawatt hour
U4E	United for Efficiency

UHI	urban heat island
UIC	International Union of Railways (Union internationale des chemins de fer)
UMA	Arab Maghreb Union (Union du Maghreb Arabe)
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UN DESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEA	United Nations Environment Assembly
UNECA	United Nations Economic Commission for Africa
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNEP ROA	United Nations Environment Programme Regional Office for Africa
UNFCCC	United Nations Framework Convention on Climate Change
UN-Habitat	United Nations Human Settlement Programme
UNIDO	United Nations Industrial Development Organization
UN WPP	UN World Population Prospects
US	United States of America
VAT	value-added tax
VNR	Voluntary National Review
VOC	volatile organic compound
W	watt
WAGP	West African Gas Pipeline
WAPP	West African Power Pool
WDI	World Development Indicators
WEC	World Energy Council
WEPP	World Electric Power Plants Database
WEO	World Economic Outlook
WHA	World Health Assembly
WHO	World Health Organization
WMO	World Meteorological Organization
WRF	Weather and Research Forecasting


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