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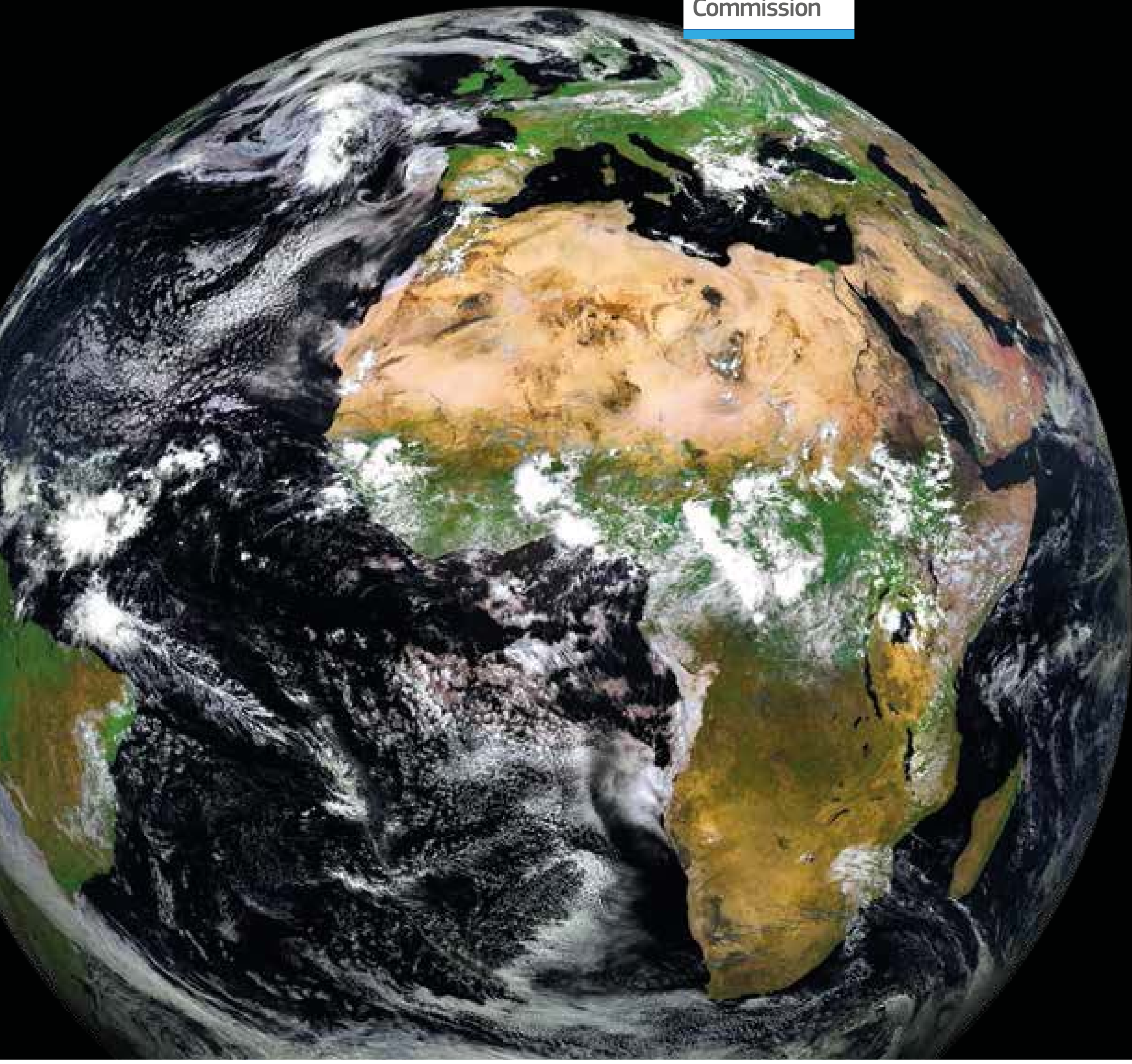

Science for the Africa-EU Partnership

Building knowledge for sustainable development

Joint Research Centre

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Contact information
JRC-Africa@ec.europa.eu

Alan Belward, Aude Neuville (editors)
via E. Fermi, 2749 – 21020 Ispra (VA) - Italy

JRC Science Hub
https://ec.europa.eu/jrc

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Science for the Africa-EU Partnership - Building knowledge for sustainable development
People, planet, prosperity and peace are four priorities shared by Africa and Europe, and areas where opportunities for beneficial cooperation abound. Over the past three decades, the European Commission's Joint Research Centre (JRC) has worked with many organisations and institutions across Africa. This report and its accompanying interactive online service 'Africa StoryMaps' present the key findings from this collaboration, and set out options the decision-making, research and education communities may consider.The report focuses on the African dimension of the partnership. It explores the opportunities and challenges arising from the fact that Africa has over twice the population of the European Union (EU), is the world's most youthful continent, has an economy that is growing faster than that of the EU, is almost seven times larger geographically, yet is vulnerable to diverse internal and external stresses.

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Building knowledge for sustainable development

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Executive Summary

Science for the Africa-EU Partnership

Building knowledge for sustainable development

People, planet, prosperity and peace are four priorities shared by Africa and Europe, and areas where opportunities for beneficial cooperation abound. Over the past three decades, the European Commission's Joint Research Centre (JRC) has worked with many organisations and institutions across Africa.

This report and its accompanying interactive online service 'Africa-StoryMaps' present the key findings from this collaboration, and set out options the decision-making, research and education communities may consider.

The report focuses on the African dimension of the partnership. It explores the opportunities and challenges arising from the fact that Africa has over twice the population of the European Union (EU), is the world's most youthful continent, has an economy that is growing faster than that of the EU, is almost seven times larger geographically, yet is vulnerable to diverse internal and external stresses.

People, Planet, Prosperity and Peace; win-win options

Africa is changing: economic, social and infrastructural advances, natural capital management, climate change and energy choices are among the opportunities and challenges facing African decision-makers. Alternative pathways to development are always open. Sharing African and European experience can help identify sustainable options, and facilitate access to them.

Development issues and sectoral policies are often interlinked, as are components of the human, natural, physical and economic worlds. Interdisciplinary thinking and cross-sectoral approaches to planning and decision-making are thus indispensable, but not often followed. Integrated approaches that bring together knowledge and the capacity to deal with interdependencies are required.

Many key sustainable development variables have strong location and time dimensions which can be linked using geographic information and knowledge-management systems. These must operate at local and national scales (to account for the enormous variability within and between nation states), as well as regional and pan-continental levels (to address transboundary issues and provide context for global initiatives such as the Rio Conventions and the 2030 Agenda for Sustainable Development). Integrated systems including up-to-date geospatial and multi-sectoral information can document past and current situations, provide a basis for developing forecasts and scenarios, guide choices, and support strategic planning. They contribute to transparency and can facilitate cross-sectoral dialogue and underpin governance systems.

For example, efficient urban planning and better roads improve market access, facilitate trade, reduce agricultural waste, boost productivity, provide jobs and reduce accidents. But new roads and towns threaten natural capital and bring new challenges in terms of energy demands, water needs and the sealing of productive, fertile soils. Interlinked geographic information and knowledge-management systems can help determine where the balance between outcomes rests.

Water availability can vary enormously with geographic location and over time. This variation should be accounted for in any country, yet transboundary aspects can also be critical. Accurate information over time is needed to prevent conflicts and promote stability, to plan urban, industrial and irrigation supply, to address food security, nutrition and public health issues, to orient agricultural choices and livestock and wildlife management, to regulate seasonal grazing schemes, to cope with seasonal rainfall anomalies, and to enable the monitoring of possible outbreaks of disease.

Good governance, integrated planning, monitoring and sustainable development go hand in hand. Information gathering, including from satellites, plays a crucial role. Aligning African Union (AU) and EU space policies can lead to improved data sharing, infrastructure development and security. Jointly building up pertinent knowledge and developing and maintaining information systems will reinforce African and EU efforts towards sustainable development. This will also support education and capacity-building, enhance media and computer literacy, and promote youth employment and access to high-quality jobs.

PEOPLE

Key findings

Demographic dynamics will be one of the most significant structural changes in the world in the 21st century. Africa's current population of just over 1.2 billion will continue to grow, although different scenarios predict different rates of population change. A medium scenario is that, by 2050, one in four people in the world will be African.

About half of Africa's people live within 100 km of the coast. Between 1990 and 2015, migration from rural to urban areas increased (urban populations grew by over 480 million during this period), but migration between African states fell from 2.1 to 1.4 % of the population. Migration from Africa to surrounding regions, including Europe, remained relatively stable as a share of the population (rising from 0.7 to 0.8 %), although because of population growth, absolute numbers undoubtedly increased.

High-density living puts pressure on the built infrastructure and services, including water and sanitation, education, transport, health, and the labour market. Built area per person varies substantially across the continent. For example, rapid population growth in Ethiopia has been accompanied by the gradual expansion of built-up areas, resulting in high population concentrations with only 2 m2 of built area per person. In comparison, South Africa's built area is an order of magnitude greater, at 29 m2 per person.

Average road density in Africa is just over 20 km of roads per 100 km2 of land, only a quarter of which is paved; the world average is just under 95 km per 100 km2, with over half paved.

In the past 40 years, droughts, floods, disease outbreaks and cyclones have affected almost 500 million people in Africa. In spite of efforts to reduce vulnerability and build resilience, disaster risk is likely to increase, as population grows and becomes more geographically concentrated, as assets increase with the expanding economy, and as the effects of climate change and extreme weather events are felt.

Cereal production in Africa has largely kept pace with population growth. Although some 20 African states have achieved Millennium Development Goal 1 of hunger reduction, undernourishment is still widespread. The food security situation in 2017 is particularly alarming, especially in Somalia, South Sudan and Nigeria.

Gaps, future actions and priorities to be considered

While population growth in the coming years is certain, education has been shown to accelerate fertility transition (as well as reduce mortality rates), and thus improve future population structures by moderating youth dependency rates.

Urban planning to improve access to energy and adaptation to climate change can be supported through shared experience. The Covenant of Mayors for Climate & Energy is one established experience-sharing mechanism. This coalition of cities and local governments shares best practices and a long-term vision for sustainable urban living.

Further expansion of built-up areas and roads will continue to take land away from other uses, such as agriculture and forests. Spatially detailed and regularly updated information on human settlements and road networks, especially when combined with information on the state of the natural environment, can support strategic planning that aims to maximise societal benefits while minimising environmental costs and protecting natural capital.

Assessing exposure and vulnerability to risk of natural and man-made disasters helps to improve preparedness and mitigation efforts. Composite indicators are being developed that enable progress in benchmarking, comparative analysis and mapping, which in turn help assess levels of exposure.

Collaboration between major food-security agencies to provide standardised and synthesised information (such as the Global Report on Food Crises) helps develop coordinated responses. Early-warning systems that facilitate rapid reaction to food-security emergencies are of particular value and should be enhanced wherever possible.

PLANET

Key findings

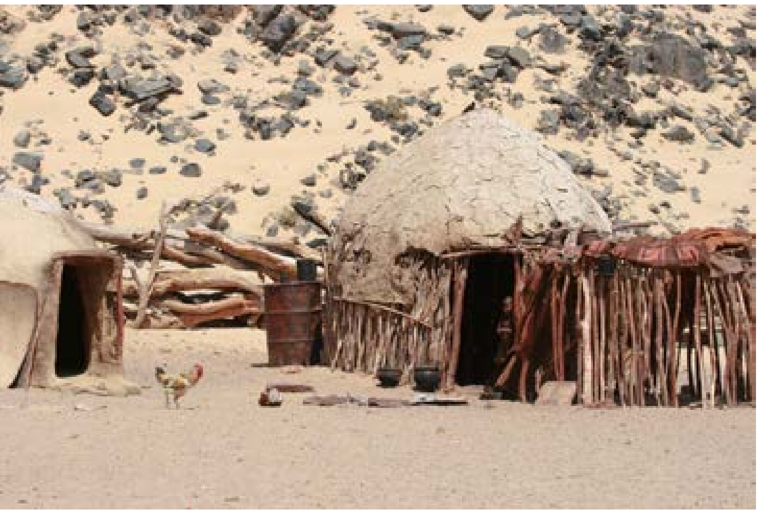
Africa is highly vulnerable to climate change, although the continent's greenhouse gas (GHG) emissions of 4 tonnes per person per year are far below the global average of 7.3 tonnes per person per year. Africa will become hotter by the end of the 21st century – warming of over 3.5 °C is possible for most of the continent for the January-March period, with temperatures in northern Africa and the Sahara increasing by up to 6 °C in the July-September period. Predictions for rainfall change are uncertain for large parts of the continent, although for some areas the predicted changes are robust and significant: models indicate that southern Africa will experience longer dry spells interspersed with more extreme rainfall events.

Deforestation (Africa recorded a net loss of 31 million hectares of forest from 1990 to 2010) generates substantial carbon losses into the atmosphere (estimated at 148 million tonnes per year for sub-Saharan Africa in the 2000s). Beyond the impact on the global climate, deforestation has been linked to local warming of around 1-2 °C in Africa during the period 2002-2013. Expanding urban areas and more roads increase access to forests, and deforestation rises dramatically when population density exceeds 8.5 people per km2.

Fires (most of which are deliberately started by humans) burn between 150 000 and 200 000 km2 of forest, savannah and grassland in Africa each year, which contributes to deforestation, removes carbon sinks, increases black carbon emissions and can drive ecosystem changes over time.

Thirty-eight African countries are coastal. With 700 000 vessels, Africa's fishing fleet is the second largest in the world, although the majority of these are small-scale vessels. Fish accounts for as much as 70 % of the daily intake of animal protein in certain coastal countries. However, fish stocks are in decline, notably in the north-western African coastal and shelf areas and in the Mediterranean.

After Australia, Africa is the driest landmass in the world, although only 5.5 % of its renewable water resources are currently being used. Water distribution across the continent is very uneven, with three major arid regions, several 'water towers' with regular, abundant supply, and large regions where inter- and intra-annual variability are high. Over the past 30 years, Africa's overall surface-water area experienced a small increase of almost 3 % as a result of new dam construction and flood irrigation, although some natural wetlands are contracting and several important aquifers are being emptied faster than they fill. Growing demand for water resulting from population growth, rising living standards, increasing economic activity and reduced availability due to climate change will lead to greater water scarcity in several regions. Droughts are likely to become more severe and persistent..



About 8 % to 13 % of Africa's soils are free of natural constraints to agriculture – the rest needs help, for instance through fertilisation. Yet overall use of inorganic fertilisers in sub-Saharan Africa is the lowest in the world. Some fertile areas are shrinking due to climate change and land degradation, which affects 24 % of cropland and 25 % of rangeland areas, and results in a diminished capacity of natural ecosystems to provide goods and services. However, consistent data on the state of soils is often lacking.

Investment in land has increased and the value of farmland is rising. Clearance for agriculture drives deforestation, while the collection of wood for fuel and charcoal production causes forest degradation.

Forest loss and the degradation and conversion of savannah to other forms of land use are among the threats to Africa's rich and unique biodiversity. Africa has the world's second largest rainforest and vast savannah areas with unique megafauna, yet the continent loses over 3 million hectares of natural habitat each year to other uses, including farmland, roads, built area, logging, mining, dam building and reservoir creation.

Gaps, future actions and priorities to be considered

Climate observations should be enhanced, models improved and climate services put in place to reduce uncertainties, as well as to inform policymakers and support adaptation strategies.

Monitoring, reporting and verification tools can reinforce the effectiveness of treaties and charters instigated to strengthen the sustainable management of natural resources.

Sustainable management of tropical forests will help mitigate global climate change and regulate climates. Measuring forest changes accurately, including forest degradation, is essential to inform decision-making.

Protected area management can counter biodiversity loss, help maintain the ecosystem services on which many communities depend, and promote job creation in sectors such as conservation, park management and tourism. A well-connected system of protected areas at continental scale is particularly valuable, especially when combined with tools to map and monitor protected area management effectiveness and combat wildlife crime.

Mapping large-scale marine features and monitoring potential productivity from fisheries would help fill gaps in fish-stock data and contribute to sustainable marine resource management.

In a context of growing demands and the changing availability of freshwater, mitigating risks to water security requires management strategies that take account of the interdependencies between different uses. Cooperation is also crucial to prevent the emergence of conflicts where water abstraction depends on cross-border supply. Maps and up-to-date statistics are key to informing the decision-making process. Uneven, and sometimes restricted access to water-resource information between countries that share transboundary river basins and between national institutions, as well as

a wide disparity of data, hamper integrated approaches to water-resource management.

Drought forecasts and warnings should be targeted to provide users with key information. Traditional knowledge can be integrated to supplement drought forecasts and early-warning systems.

Information on changes in land cover helps to allocate land among competing uses, especially when combined with cadastre and tenure information. Data-sharing and capacity-building are necessary to ensure equitable access to these technologies, and can also generate considerable education and employment benefits.

Reducing nutrient depletion in soils should increase agricultural production. For Africa, such an increase could be over 5 % within 15 years, compared to the 2010–2012 levels. Incentives would be needed for sustainable soil management and protection practices. Furthermore, harmonised soil-monitoring programmes and strengthened national and regional soil surveys could help assess the suitability of soils for various uses and monitor the effects of land-use policies on soil resources.

PROSPERITY

Key findings

During the last decade, agriculture employed 40 % to 65 % of the labour force in most sub-Saharan African countries. In terms of the farming sector's contribution to sub-Saharan Africa's gross domestic product (GDP), estimates range from 18 % to 25 %. Because of population growth and economic advances, demand for dairy products, meat, fish and eggs is expected to double by 2035; much of the demand will come from expanding urban areas. Production will have to be balanced with growing demands for fibre and fuel. This may lead to competition among production systems (and regions and countries), as well as food-price volatility and inequality between subsistence and commercial farming sectors.

Over 600 million people living in Africa have no access to electricity, and half of the continent's energy consumption comes from biomass (wood, charcoal and dung).

Sub-Saharan Africa has only 0.3 million km of power lines, compared to the EU's 10 million km. Expansion of the grid should be accompanied by renewable energy expansion. Africa has a wealth of renewable energy resources; the same photovoltaic panel in Africa can produce twice the electricity it would in central Europe. To date, only 8 % of Africa's considerable hydropower potential has been harnessed.

Solar power is the most competitive technology option for almost 40 % of the African population. Reducing dependence on wood for fuel and using more efficient stoves will also reduce the negative health impacts of emissions from cooking stoves, alleviate pressure on woodland ecosystems, and free up time spent in gathering wood for fuel.

Over the past five years, 30 % of the world's gas and oil discoveries were made in Africa. While oil production is expected to fall between 2020 and 2040, gas production could continue to grow, although this will require new pipelines.

Africa is a major global supplier of several critical raw materials. Six African countries are in the top 10 of the Mining Contribution Index, which ranks countries according to the importance of mining and metals to their national economies. Exports of EU construction and mining equipment to Africa doubled between 2005 and 2011.

Every year, 1.3 million tonnes of electrical and electronic waste leave Europe, part of which ends up in African countries where it adds to the economy through raw-material recovery, but also has adverse local environmental and health impacts.

Africa has a burgeoning entrepreneurial sector, especially in information and communications technology (ICT), wholesale and retail. Telecommunications networks and broadband internet services are essential for this. In 2012, there were already over 650 million mobile phone subscriptions, and in 2017, more than 60 % of the population has access to ICT infrastructure.

The widespread use of mobile devices, plus a large young population (median age of 19.5 years), mean that e-commerce and online services industries may expand to an estimated US$75 billion by 2025 (EUR 62.25 billion at September 2017 exchange rates), promising to be one of the fastest and strongest boosts for the African economy. Africa is already a world leader in terms of money transfers using mobile phones (14 % of all Africans regularly receive money through mobile transfers), although this also makes mobile devices a target for cybercrime.

Gaps, future actions and priorities to be considered

Sustainable intensification of agriculture (including improved inputs, e.g. through fertilisation, use of quality seeds, and better irrigation), land-management tools and appropriate land-use policies are required to ensure food supplies. Accurate data on agricultural production (area, yields, and location) and food prices help planning, competition and more stable pricing processes.

Land-tenure systems which can be monitored and regulated play an important role because uncertainty concerning land tenure, or the extension of granted tenure, acts as a disincentive for investments such as soil conservation and irrigation schemes.

Improved infrastructure (roads, storage and cold chains) can reduce waste in agricultural produce, increase its value, encourage local markets, and reduce dependence on imports.

Spatial-analysis systems can help evaluate the availability and economic potential of modern renewable energy sources. Off-grid and micro-grid systems, particularly those powered by renewable sources (solar, wind, biomass and hydropower), can complement the development of energy-grid infrastructure. The renewable energy sector is also a major high-quality employer.

Mineral industries can foster economic growth, but different factors influence how they contribute to sustainable development, such as the creation of qualified skills, their environmental impacts and how revenues are used. Geo-referenced information concerning critical raw material sources and exploitation plans, when routinely gathered and combined with trade-flow data, along with information concerning environmental, health and social impacts, can all help informed decision-making concerning the mineral industry.

A favourable business environment and basic infrastructures (electricity and internet access) are also essential for growth and development; mobile telecommunications, supported by an adequate regulatory framework, could improve internet access. In addition, enhanced infrastructure for wireless broadband through spectrum-sharing technologies can improve digital connectivity in remote areas.

Digital infrastructures and ICT services must be secure, parties to digital transactions need to be accountable and identified, and critical services must be standardised.

An overarching cybersecurity strategy helps ensure interoperability, stability and preparedness in case of digital system breaches (e.g. cyberattacks and cyber failures). Monitoring the geographic spread of internet coverage, alongside an assessment of user experience over time, helps track and avoid network congestion and associated reduced performance as the user base expands in any given location.

The increasing use of mobile technology for financial transactions is more sustainable when accompanied by legislation and best practices to promote cybersecurity and fight cybercrime. Digital skills enhancement, awareness training and media literacy programmes also help reinforce the sustainable and socially valuable expansion of the technology.

PEACE

Key findings

Conflicts have a massive detrimental impact on development efforts, and create conditions that lead to population displacement and migration. Worldwide, about one-third of all refugees are African nationals.

The Global Conflict Risk Index, an integrator of known drivers of violence, ranges from 0 (very low likelihood of conflict occurrence) to 10 (very likely). The global average is 3.7 while Africa's average is 5, with only seven African countries falling within the very-low to low-risk categories. Violent histories and environmental factors, such as water stress and hydrocarbon resource locations, are particular contributors to the continent's elevated risk levels.

The diamond trade has helped finance some African conflicts, but the Kimberley Process has reduced the conflict diamond trade to less than 1 % of the overall total.

Over 90 % of Africa's imports and exports are transported by sea. Maritime security is a prerequisite for trade, fishing, tourism, and other sea-based activities. While regional and international cooperation must play a role, a sustainable solution to general maritime security relies primarily on the capacities of national authorities. Technical tools for monitoring the maritime situation at sea, and for sharing and analysing piracy incidents, have been developed and tested over recent years with authorities in several African locations.

The risk of global threats in the chemical, biological, radiological and nuclear (CBRN) area is increasing. In Africa, chemical risks associated with the industrial and agricultural sectors have intensified, and exposure to health risks (epidemics and disasters) remains high.

Radioactive sources are widely used in healthcare institutions and industry. Uranium is mined in many African countries, and there are 10 nuclear research reactors in operation across the continent. However, only South Africa operates a commercial nuclear power plant, while several countries have plans to embark on developing nuclear power production. Safety and security risks associated with the use, transport and storage of radioactive and nuclear material, in particular uranium mines, remain a concern in Africa.

Gaps, future actions and priorities to be considered

Early-warning, supported by tools that provide an integrated view of the factors driving conflict in a specific region at a specific time (such as the Continental Early Warning System) can help in conflict prevention.

Statistical conflict modelling should further investigate the link between natural resource location and armed conflict occurrence. Crowdsourcing and big data analytics can improve such analysis, by providing more and better data to feed conflict-measurement methodologies.

International initiatives (such as the Kimberley Process) must continue to be supported, as these ensure transparency and accountability.

The ongoing development and use of space-based maritime monitoring systems make it possible to collect information about shipping activities over large areas in an affordable manner.

Initiatives that aim to share experience and best practices, and strengthen national policies and capacities – such as the European Union's Chemical Biological Radiological and Nuclear Risk Mitigation Centres of Excellence initiative EU CBRN CoE) – must be sustained. Dedicated instrumentation, procedures, communication campaigns and training should all accompany these.

EU cooperation activities focus on strengthening the capabilities of the national regulatory authorities with respect to nuclear safety and safeguards.

People, planet, prosperity and peace: bringing it all together

During the past decade, African countries have actively engaged in research, development and innovation, although Africa still has less than 100 researchers

per million people, compared to the global average of 1100. The low indicators regarding traditional research and development (R&D) for Africa may not capture the actual dynamics of innovation, especially in the service and informal sectors. Research and innovation capabilities should be monitored and evaluated at different geographic levels. Cooperation in innovation that addresses local population needs and territorial development is a priority; education and research conditions should be improved in parallel.

Knowledge sharing is essential to bring together people and planet and bring about prosperity and peace. This need is reinforced by the recent explosion of information and technological progress. Knowledge sharing includes developing and updating skills through education and training, developing scientific collaboration and networks, and strengthening the science-policy interface through information systems and initiatives such as centres of excellence and regional observatories.

Earth-observation infrastructure in Africa is expanding, with technical assistance from the JRC. Dedicated satellite data transfer and data analysis systems have been installed and are operating in over 180 sites across the continent. These support applications are specifically tuned to local and national needs, and have already provided ICT training for over 2200 Africans.

Information platforms that strengthen the capacity to mobilise and use satellite Earth observations and the information acquired from these data must be further developed and distributed, so that they can be readily accessible to policymakers, managers, researchers and other users across Africa.

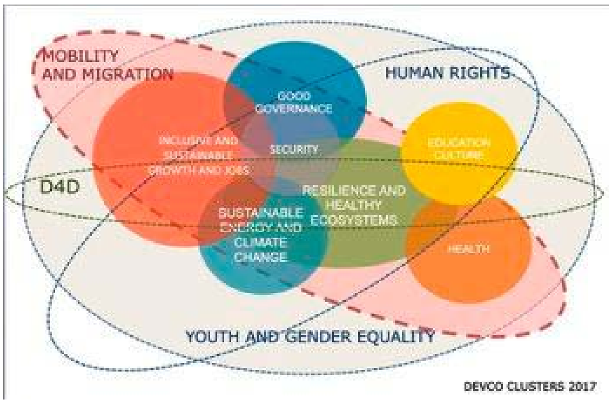
Many of the activities considered under the different priority areas seek to address the drivers of fragility that affect vulnerable populations. Resilience thinking provides a useful system perspective to help develop lasting solutions to complex challenges and make progress towards the achievement of the United Nations Sustainable Development Goals (SDGs).

Resilience-based initiatives, which combine anticipation and crisis response with long-term actions that aim to address the root causes of vulnerability, should be further developed; efforts to better measure resilience can help integrate such an approach into policies.

The means of implementation need to be strengthened if the SDGs are to be fully achieved in Africa and Europe, as recognised by SDG 17: "Revitalise the global partnership for sustainable development". The Africa-EU Partnership can play an important role in supporting initiatives identified under this goal: finance, technology and capacity, policy and institutional coherence, multi-stakeholder partnerships and data, monitoring and accountability.

Most of the key findings, outlook and knowledge needs set out above could be placed under more than one priority area, and some (such as food security) could appear under all four. There is no unique grouping because all four areas are interdependent; people, planet, prosperity and peace cannot be treated in isolation. Similarly, the economic, social, environmental and governance paths followed by the AU and EU aim to be as coherent and synergistic as possible. This connectivity is captured in the current view of the European Commission's Directorate-General (DG) for International Cooperation and Development (DEVCO) on how key policy goals and drivers are interlinked (Figure 1 provides a schematic overview).

FIGURE 1 Connectivity between policy goals and drivers Note: D4D means Digital for Development (Source: DG DEVCO).



The areas of Africa-EU research cooperation discussed in this report can be considered independently, but the main strength arises from the collective picture the chapters paint, and the opportunities for joined-up responses they offer. Three avenues for a connected response are immediately apparent: 1) sharing experience of using scientific evidence for integrated policymaking (where JRC experience can be tapped along with key initiatives such as the International Network for Government Scientific Advice, in particular its Africa Chapter); 2) providing geographic information and knowledge-management systems (such as on human settlements, surface-water occurrence, protected areas, solar energy potential, soils, etc.) through a dedicated entry point and dedicated in-country infrastructure (such as satellite communications systems); and 3) providing customised training and capacity-building linked to avenues 1 and 2.

Collectively, the three actions outlined above would improve access to innovation and education, which in turn would advance knowledge and skills in youth employment areas (such as computer and Earth observation sciences, cybersecurity, eCommerce and the development and roll-out of renewable energy). They would provide the means to map, monitor, report and validate the outcomes of any common charter on the sustainable management of natural resources, strengthen cooperation on global governance issues in the context of multilateral environmental agreements (especially the Rio and Ramsar Conventions), the Sendai Framework for Disaster Risk Reduction and the SDGs, help identify threats and crisis-triggering factors, and lead to more productive and sustainable agriculture.

Other opportunities for harnessing research cooperation for sustainable development are bound to emerge. Partnership is the common thread throughout the work reported here. The scope of this report mainly reflects the evidence collected and the scientific work conducted by the JRC together with its counterparts in Africa and international partners. It aims to present reliable data, information and analysis based on the JRC's expertise in specific domains – while putting it in a broader perspective and referring to a variety of sources. The report will support and inform an evidence-based dialogue and further engagement with Africa's policymaking and scientific communities, and thus further strengthen, with a solid knowledge base, the renewed Africa-EU Partnership.

If you want to go quickly, go alone. If you want to go far, go together.
~ African proverb

Introduction

People, planet, prosperity and peace are four broad priorities recognised by Africa and Europe and highlighted in the United Nations Sustainable Development Goals (SDGs). They are four areas where important opportunities exist for mutually beneficial cooperation. Over the past three decades, the European Commission's Joint Research Centre (JRC) has worked with many African research organisations, universities, international programmes, national services and Regional Economic Communities, as well as with the African Union Commission (AUC) and the private sector.

This report structures the findings and lessons learned from JRC activities carried out in collaboration with African and international partners around these four priorities. It focuses on the African dimension of the partnership, recognising the geographic, demographic and economic differences. Africa is seven times larger than the European Union (EU), with more than twice the population, is the world's most youthful continent and has an economy that is growing on average much faster than Europe.

The report includes a broad range of topics, while putting more focus on the angles covered by JRC scientific activities in collaboration with a variety of partners. Although the findings presented use many sources, the scope of the report is largely based on JRC expertise in specific areas, and does not cover all dimensions of Africa's development or of Africa-EU cooperation. However, the compilation of information and assessments across such a wide range of topics does bring insights. There are significant gaps in the evidence base in a number of areas that need to be addressed if they are to fully inform policymaking. Each individual chapter provides facts surrounding current situations and initiatives, examines the outlook, and identifies possible actions to address gaps and bottlenecks.

While each chapter in the report can be read independently, collectively they examine a number of objectives emerging from the ongoing African Union (AU) – EU dialogue. These include addressing threats and crisis-triggering factors, strengthening maritime security, setting up a common charter on the sustainable management of natural resources, advancing knowledge and skills in youth employment areas (such as computer and Earth observation sciences), and developing renewable energies and sustainable agriculture.

The report shows that a comprehensive sustainable development framework can serve several AU and EU strategic objectives. Research that explores and exposes the interlinkages among the four priority areas can improve policy coherence, both in terms of policy development and implementation. A better understanding of how policies are interlinked will also reinforce effective partnerships between AU entities and their EU counterparts. Research must continue to anticipate, stabilise and reduce threats that challenge societal resilience, and improve capacity to operate within planetary boundaries in both the AU and the EU. For example, Earth observation and geospatial modelling can document environmental changes, such as land degradation, changes in surface-water resources, agriculture and forest land, and changes in the extent of built-up areas and their connectivity, which are essential to sustainable development.

Research must be matched by responses in society that can deal with the increasing frequency and magnitude of change and threats. If research findings are to influence policy development or implementation, research output must be translated into usable knowledge, and must reflect (and keep up with) rapidly changing circumstances.

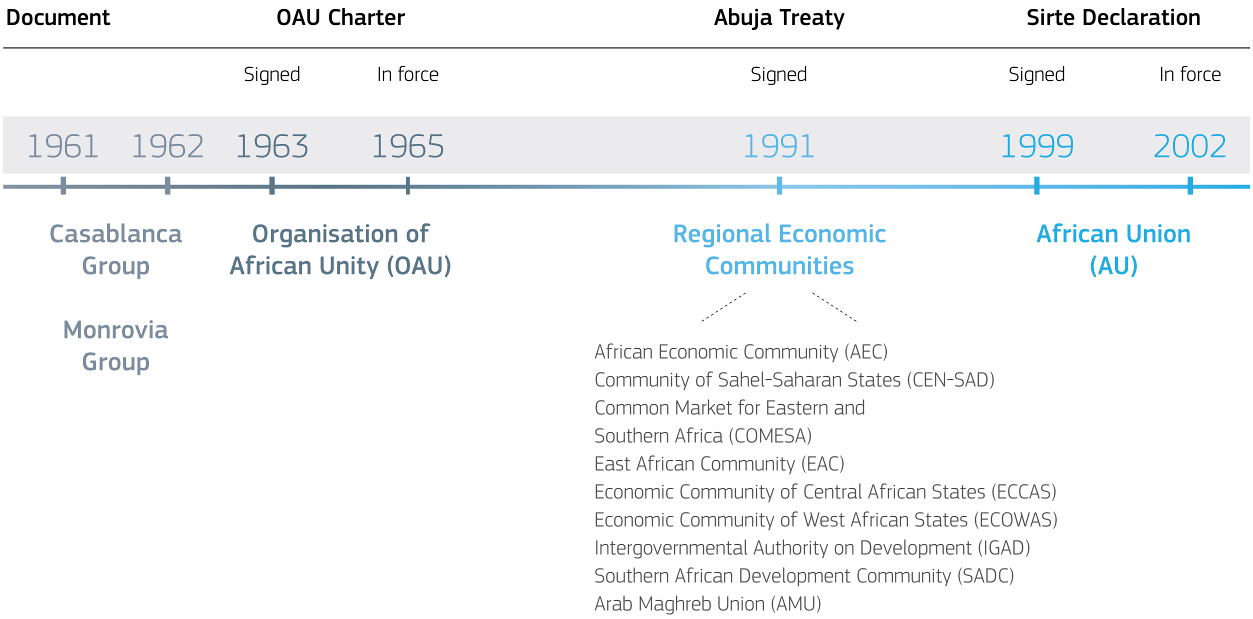
Finally, the report recognises that education empowers people, teaches skills, raises awareness, strengthens public engagement and contributes to the creation of values and norms. It emphasises the importance of knowledge sharing, under different modalities, involving university and research partners as well as policymakers, practitioners and other stakeholders. Efforts should be focused in particular around research themes outlined in this report and diffused as widely as possible, including among university and research partners. In particular, targeted interventions with policymakers and the public are required. Again, the collaborations described in this report can provide a framework for such interventions.

Policy context – Africa-EU: evolution of a strategic partnership

Africa and Europe are bound together by their history, geography and their interconnected futures. They also have shared interests and values, as well as similar political aspirations.

Africa, like its European neighbour, has been steadily pursuing its political and economic integration for several decades. Since the foundation of the Organisation of African Unity (OAU) 50 years ago, and even more so with the creation of the African Union in 2002, pan-African institutions (its regional building blocks), ambitious policies and initiatives have been driving development and integration on the African continent in many key areas.

FIGURE 2 Timeline (1981-2002) showing incremental adoption of the treaties leading to establishment of the Regional Economic Communities and the AU (*Source: JRC.*



These political developments, combined with the prospects of joining forces and developing joint responses to global challenges and emerging threats, have prompted the leaders of the two Unions to upgrade their long-established relationships shaped by the Cotonou framework for sub-Saharan Africa and the neighbourhood policy for North Africa into a strategic partnership with the African continent as a whole. It was in this spirit that the heads of state and government from the AU and EU came together and adopted the Joint Africa-EU Strategy (JAES) at the second Africa-EU Summit in Lisbon in 2007.

Since the Lisbon Summit, the JAES has established the overarching long-term framework for a strategic Africa-EU partnership. More specifically, the JAES aims to:

- reinforce political relations between Africa and the EU, and jointly address common global challenges, such as climate change, protection of the environment, and peace and security. Through joint positions, Africa and Europe have more weight in global fora;
- expand Africa-EU cooperation in traditional development cooperation areas, such as human development and natural resources, into promising new areas of common interest, such as governance and human rights, trade and regional integration, energy, climate change, migration, mobility and employment, science, information and communication technologies and space applications;
- facilitate and promote a broad-based and wide-ranging people-centred partnership, by ensuring the effective participation of civil society and the private sector, and by delivering direct benefits for African and European citizens.

2017 will be a defining year for reshaping Africa-EU relations. The fifth Africa-EU Summit will take place in Abidjan in November against the backdrop of the profound transformational changes that are under way in Africa, the EU and globally.

Adoption of the 2030 Agenda for Sustainable Development (UN, 2015a), the Addis Ababa Action Agenda on Financing for Development (UN, 2015b) and the Paris Climate Agreement (UNFCCC, 2015) has signalled the determination of world leaders to bring global solutions to global challenges. However, more recent political developments seem to have jeopardised this positive impetus towards strengthening international cooperation. While the world has never been smaller or better connected, the return of isolationism has cast doubts over the future of multilateralism. The prosperity of Africa and the EU and their ability to uphold their values on the world stage will therefore continue to depend on their openness and strong links with each other as strategic partners.

2017 has been marked by the appointment of a new African Union Commission, which should provide fresh momentum to the AU's reform agenda. With the reintegration of Morocco, the continent has been reunited and the pan-African institutions are ready to deliver more effectively on the promises of regional and continental integration, primarily on peace and security, as well as economic and trade matters.

Africa has achieved impressive growth over the past 15 years. Financial flows, such as remittances[1] and official development assistance, have risen again after an initial drop during the global financial crisis. But economic gains have not been evenly distributed. Despite overall positive growth rates for the continent, revenues have been dropping in resource-rich, crisis-stricken (i.e. Ebola) and drought/flood-affected countries (AfDB, 2017). Even where economic diversification and greater added value have strengthened the resilience of economies to the drop in the price of commodities such as oil, growing inequalities have hampered progress towards reaching the targets of the 2030 Agenda and the AU's own Agenda 2063

With the fastest-growing population in the world, Africa is certainly well placed to reap the benefits of its "demographic dividend", if this challenge is turned into a positive economic and social opportunity. The effect on growth of increased labour supply will only materialise if enough jobs can be created. Today, ensuring better prospects for a "youthful, rapidly expanding and increasingly mobile populations remains a considerable challenge in all African countries (AfDB, 2017)". The lack of job opportunities, poverty and (most importantly) conflict and political instability remain the main drivers of migration flows within and from Africa. The latest figure stands at 20.3 million for internally displaced persons (IDPs) and refugees (see chapter I.1.2).

A number of changes and more recent trends have also left their mark on the other side of the Mediterranean. In 2016, the EU adopted its new Global Strategy for Foreign and Security Policy (EU, 2016) to engage more strategically with the wider world, including its African partners. As the biggest donor to and first trading partner of Africa, the EU has also started to discuss the future of its relations with the countries of Africa, the Caribbean and the Pacific following the expiry of the Cotonou Agreement in 2020. An important step in the context of the post-Cotonou deliberations has been recognition of the role played by the AU, which should be "reflected in any future partnership decision-making and institutional set-up" (European Commission, 2016).

Aside from these developments, the EU has been repositioning and reinventing itself in the face of a number of significant challenges. Amid celebrations of the 60th anniversary of the Treaties of Rome, the EU has been rocked by uneven economic growth, terrorism and populist movements. The White Paper on the Future of Europe (European Commission, 2017) aims to address these issues and clarify the Union's added value. Its

1 Based on analysis of the Bilateral Remittances Matrices of the World Bank, the cumulative remittances into Africa from the rest of the world reached US$ 51.7 million in 2015, a 28 % increase compared to 2010. During the same period, the ratio of remittances to GDP also increased from 2.0 to 2.4 % for Africa as a whole.

objective is to launch a deep reflection on the state of play of the European project, help the EU-27[2] to consolidate its common vision based on the EU's achievements and strengths as well as on areas for improvement, and to strengthen the resolve to take decisive action to realise the full potential of the EU for all its citizens.

The 5th Africa-EU Summit in Abidjan will address and build on these important global and regional changes. It will provide a platform for African and European leaders to focus more particularly on the aspirations and needs of youth, establishing links with key themes such as human development, migration, education, skills development and employment.

The Summit will not only renew a common understanding of political priorities, but will also agree on a set of concrete actions to be implemented via a number of financial instruments[3] as well as other means of implementation, such as trade, investment and science, technology and innovation.

The Joint Research Centre (JRC), as the in-house knowledge service of the European Commission, has been supporting the cooperation between Africa and the EU for more than three decades. In line with the outcomes of the Lisbon Summit, the JRC has developed multi-faceted levels of cooperation. It has established partnerships with the AUC to strengthen capacities at pan-African level, with the AU's Regional Economic Communities to address specific regional needs, and with national governments, their agencies and universities to tackle local challenges more effectively. This cooperation is fully aligned with the principle of partnership set out in the JAES, and covers multiple priority areas which will be elaborated on in the following chapters.

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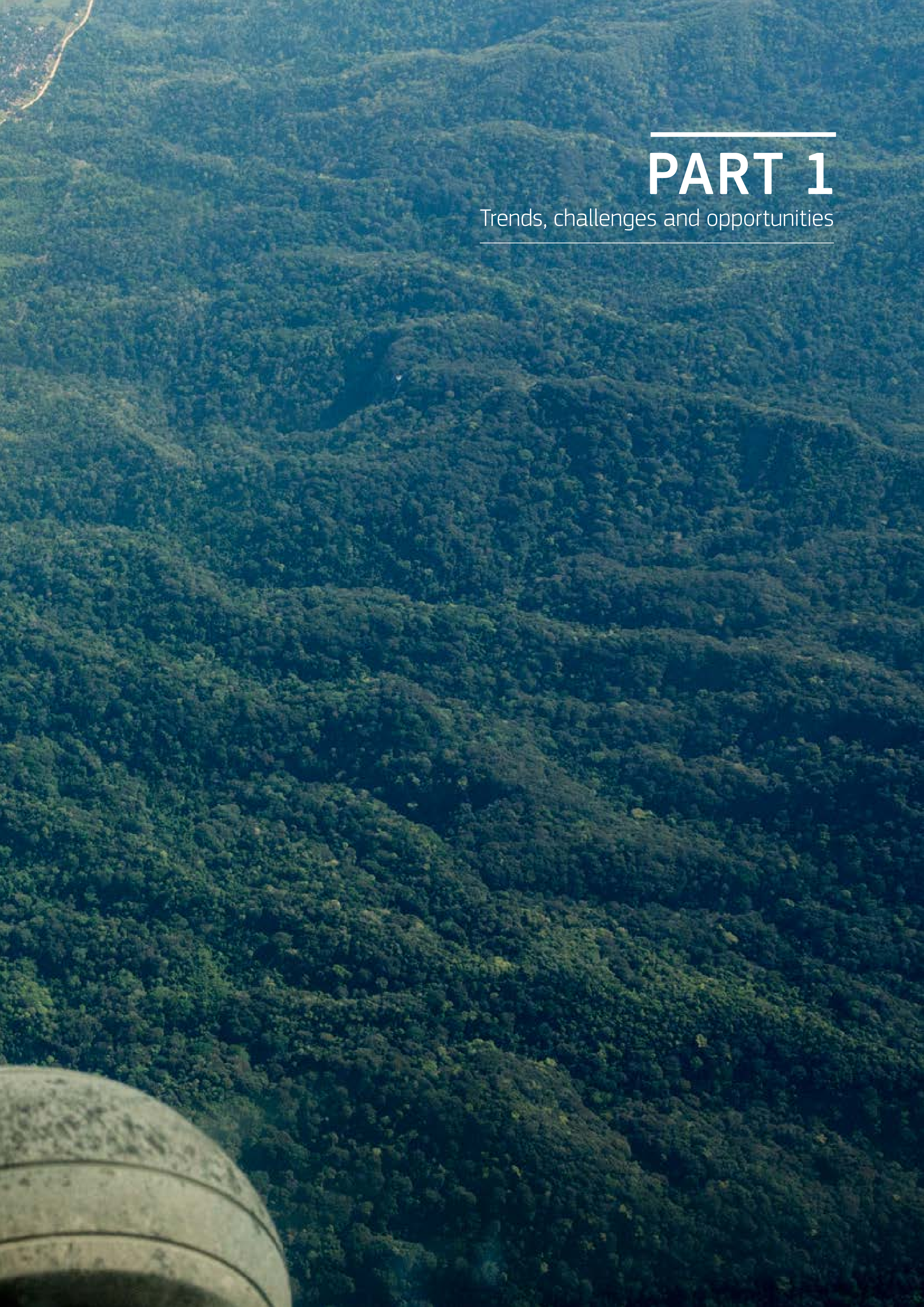
United Nations Refugee Agency (UNHCR) – UNHCR: reporting for Africa 2017 http://www.unhcr.org/africa.html

2 EU-27 denotes the post-Brexit European Union with 27 Member States.

3 The Pan-African Instrument and other EU thematic instruments for continental actions as well as the European Development Fund (EDF) and the European Neighbourhood Instrument for complementary actions at country and regional level.



PART 1

Trends, challenges and opportunities

PEOPLE

"OUR ASPIRATIONS
FOR THE AFRICA
WE WANT:
AN AFRICA
WHOSE DEVELOPMENT IS
PEOPLE-DRIVEN, RELYING
ON THE POTENTIAL OF
AFRICAN PEOPLE, ESPECIALLY
ITS WOMEN AND YOUTH,
AND CARING FOR CHILDREN"

– Agenda 2063


puma

1. Population and migration

1.1. Demographic trends

1) Key findings

Assessment of the situation

According to the International Institute for Applied Systems Analysis (IIASA) projections, in 2050, Africa's population will be around 2018 million, while Europe's population will be no more than 754 million. Africa seems poised to become a much larger part of the world population: its share of the global population will rise from 17 % (as recorded in 2010) to 24 %, which implies that one in four people in the world will be African. Currently, Africa has undergone its mortality transition from high to low death rates, mainly through a rapid decline in child mortality rates: in 2050, life expectancy at birth is forecast to rise from 56 in 2010 to 67 years for females and from 54 to 63 years for males. In contrast to mortality rates, Africa's fertility transition is slow in some regions and has stalled in others (in 2015, Africa's fertility rate was still more than four births per woman). Trends in mortality and fertility rates result in rapid population growth, with direct effects on the labour force: countries with high fertility rates are associated with high rates of youth dependency. If Africa's fertility transition does not accelerate, the resulting increase in youth dependency rates will expose African regions to greater levels of poverty.

> “It is estimated that, by 2050, one in four people in the world will be African.”

Scenarios

A more in-depth understanding of population dynamics can be achieved by adding educational attainment to the conventional demographic population structures by age and sex.

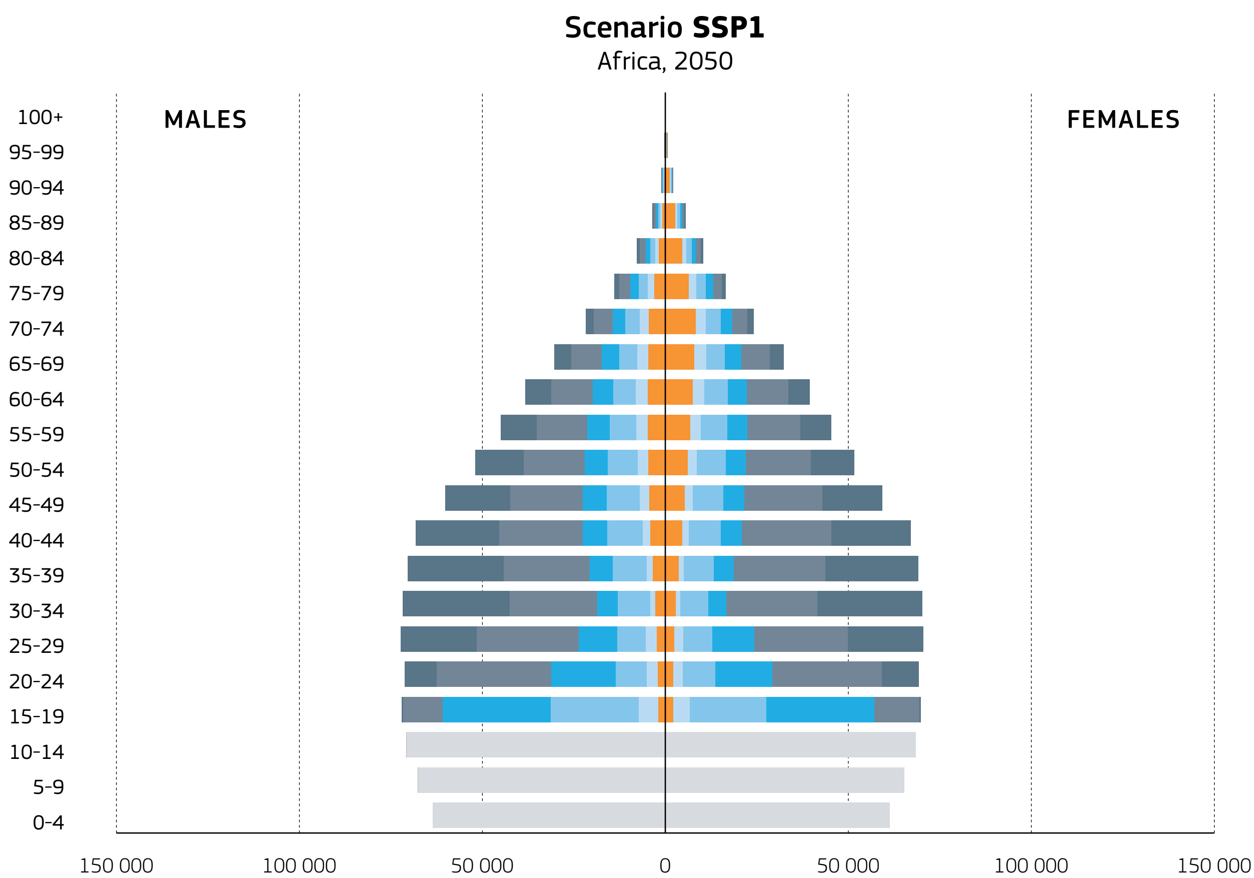
Using 2010 as the base year, IIASA has developed future socio-economic scenarios to project population and demographic changes. Scenarios were defined based on a framework of shared socio-economic pathways (SSPs) adopted by the climate change research community to facilitate the integrated analysis of future climate impacts. The SSPs were designed to include both a qualitative component, in the form of a narrative on global development, and a quantitative component for certain variables. Narratives were developed for five SSPs (O'Neill et al., 2014) with respect to socio-economic challenges and countries' capacities to mitigate and adapt to climate change.

SSP1, the scenario with the most-favourable outcome in terms of development, foresees that education will play a key role in accelerating the demographic transition in Africa, further reducing fertility and mortality rates. SSP2, the medium-development scenario, foresees that fertility and mortality will continue at current trends. These two demographic scenarios assume medium-level migration. SSP3, the scenario for stalled development, foresees that fertility will increase and be associated with high mortality; migration is assumed to be low due to a strong emphasis on security policies. SSP4 and SSP5 describe alternative demographic development pathways with respect to SSP1 and SSP3. The SSP4 scenario envisions a highly unequal world, where governance and globalisation are controlled by elites making the vast majority of the population poor and extremely vulnerable to impacts of climate change. Access to education is limited, leading to high growth rates in low-income and human capital countries; migration is assumed to be at the medium level. The SSP5 scenario envisions a conventional development oriented towards economic growth as the solution to all social and economic problems; a high level of education is achieved, and low fertility and mortality rates are assumed. The emphasis on 'market-solutions' also implies the assumption of high migration rates for all countries. The scenario assumptions are summarised in Table 1.

TABLE 1
Shared Socio-economic Pathway (SSP) definitions

Scenarios	Development	Education	Demographic behaviours		
			Fertility	Mortality	Migration
SSP1	Rapid	High	Low	Low	Medium
SSP2	Medium	Medium	Medium	Medium	Medium
SSP3	Stalled	Low	High	High	Low
SSP4	Limited	Inequality	High	High	Medium
SSP5	Conventional	High	Low	Low	High

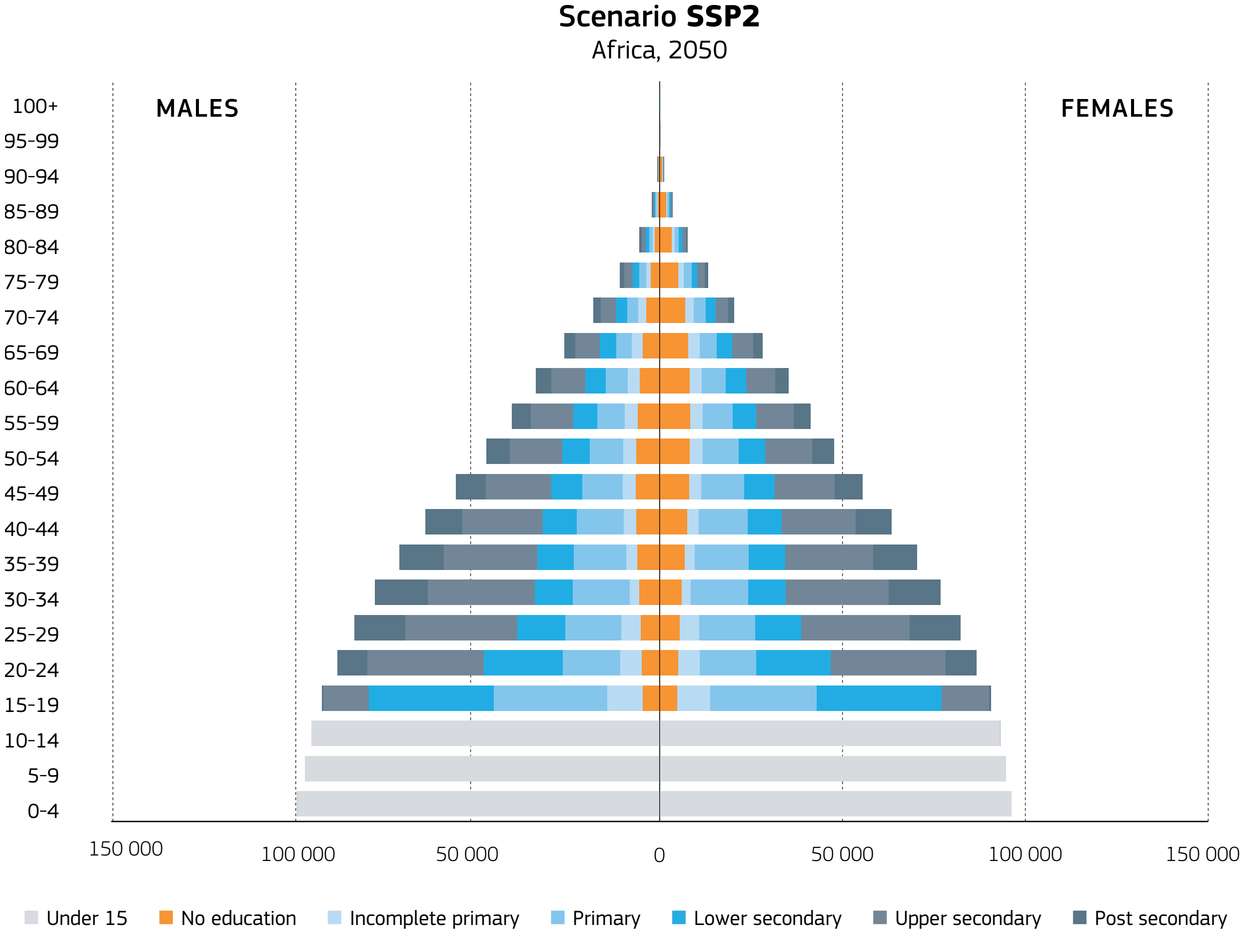
FIGURE 3: Shared socio-economic pathway scenario 1 (SSP1): rapid development, Africa *(Source: IIASA)*



SSP1: rapid development
Under this scenario, the African population will be around 1.8 billion by the middle of the century, and the annual growth rate will decline. Fertility will fall to less than two births per woman (narrowing the base of the pyramid shape in Figure 3), and life expectancy at birth will increase to 75 years for women and 71 for men.

Assuming the SSP1 hypothesis holds true, Africa is projected to experience an increasing rate of school enrolment and consequently a significant drop in the *no, incomplete* and *primary education* rates, which will then be around 9 % for young men aged between 15 and 24, and 8 % for young women.

FIGURE 4: Shared socio-economic pathway scenario 2 (SSP2): medium development, Africa *(Source: IIASA)*

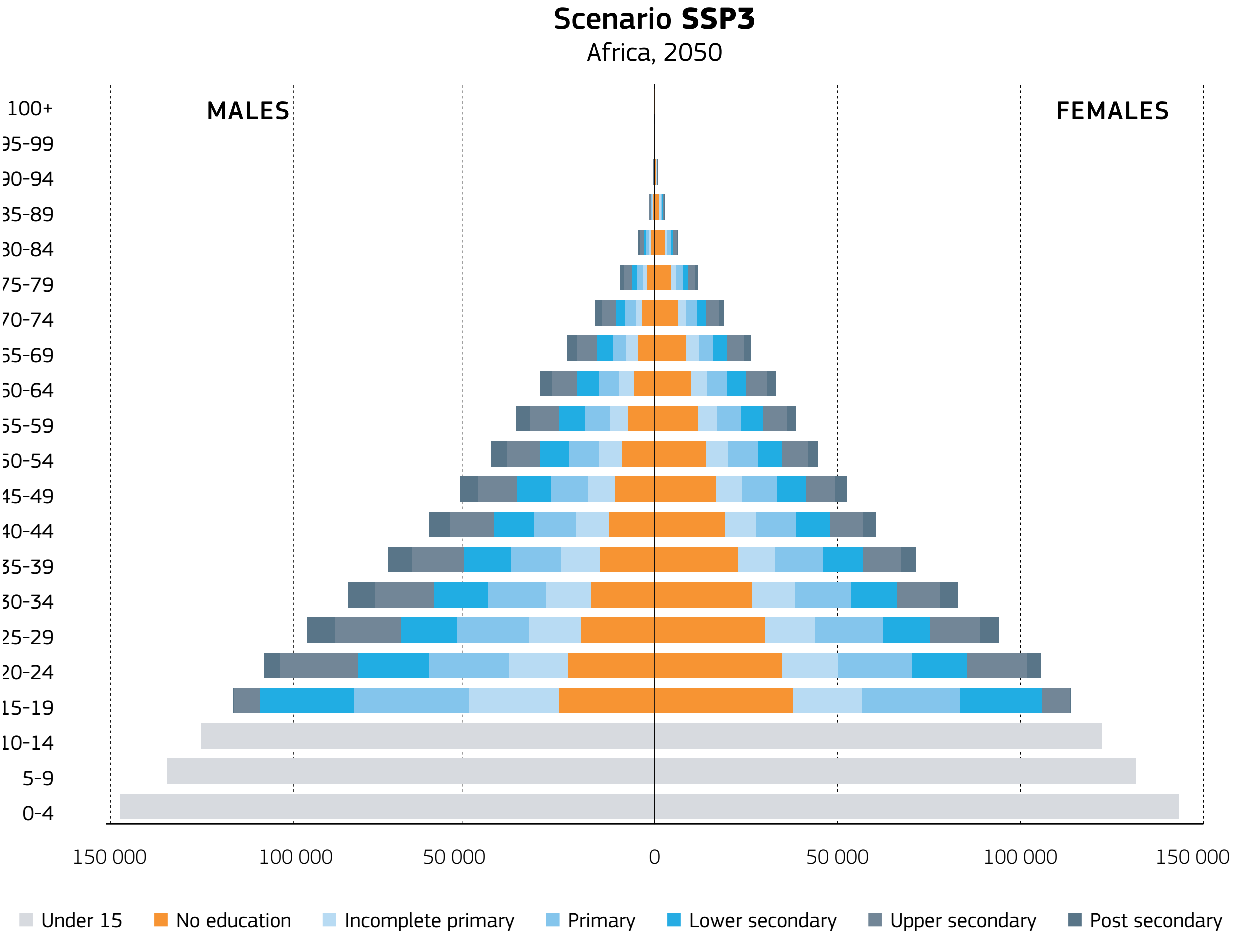


<u>SSP2: medium development</u>

Under this scenario, the African population is expected to exceed 2 billion in 2050, with a total fertility rate reaching a level of just less than three children per woman.

Although the population size increases, the proportion of Africans without any formal education would decline at a slower rate: e.g. the percentage of young men and women aged between 15 and 24 with *no, incomplete* and *primary education* would be 14 %. Under this scenario, 45 % of African women aged between 20 to 64 years (working-age group) will have *upper-* or *post-secondary education*.

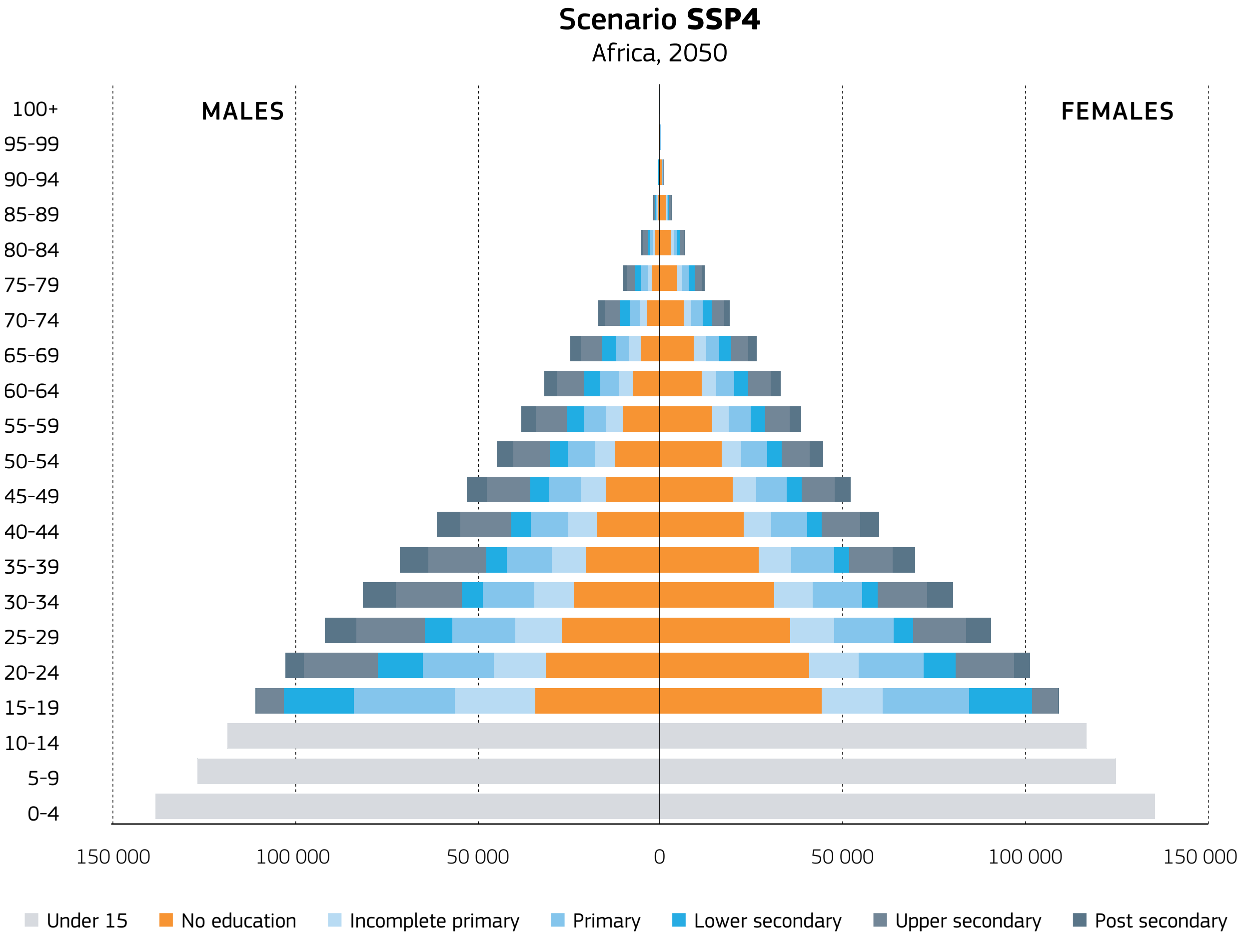
FIGURE 5: Shared socio-economic pathway scenario 3 (SSP3): stalled development, Africa *(Source: IIASA)*



<u>SSP3: stalled development</u>

Under this scenario, the population of Africa will reach more than 2.3 billion by 2050, recording a much faster growth rate due mainly to a slower decline in fertility (total fertility rate reaches 3.67). Life expectancy at birth will be around 58 years for women and 54 for men. No significant progress in education will be achieved; as a result, the combined *no, incomplete,* and *primary education* rate of young men aged between 15 and 24 will be 45 % and 49 % for young women. The education of women will consistently and significantly lag behind that of men, a pattern that is greatly affected by the lack of educational investment, as shown in Figure 5.

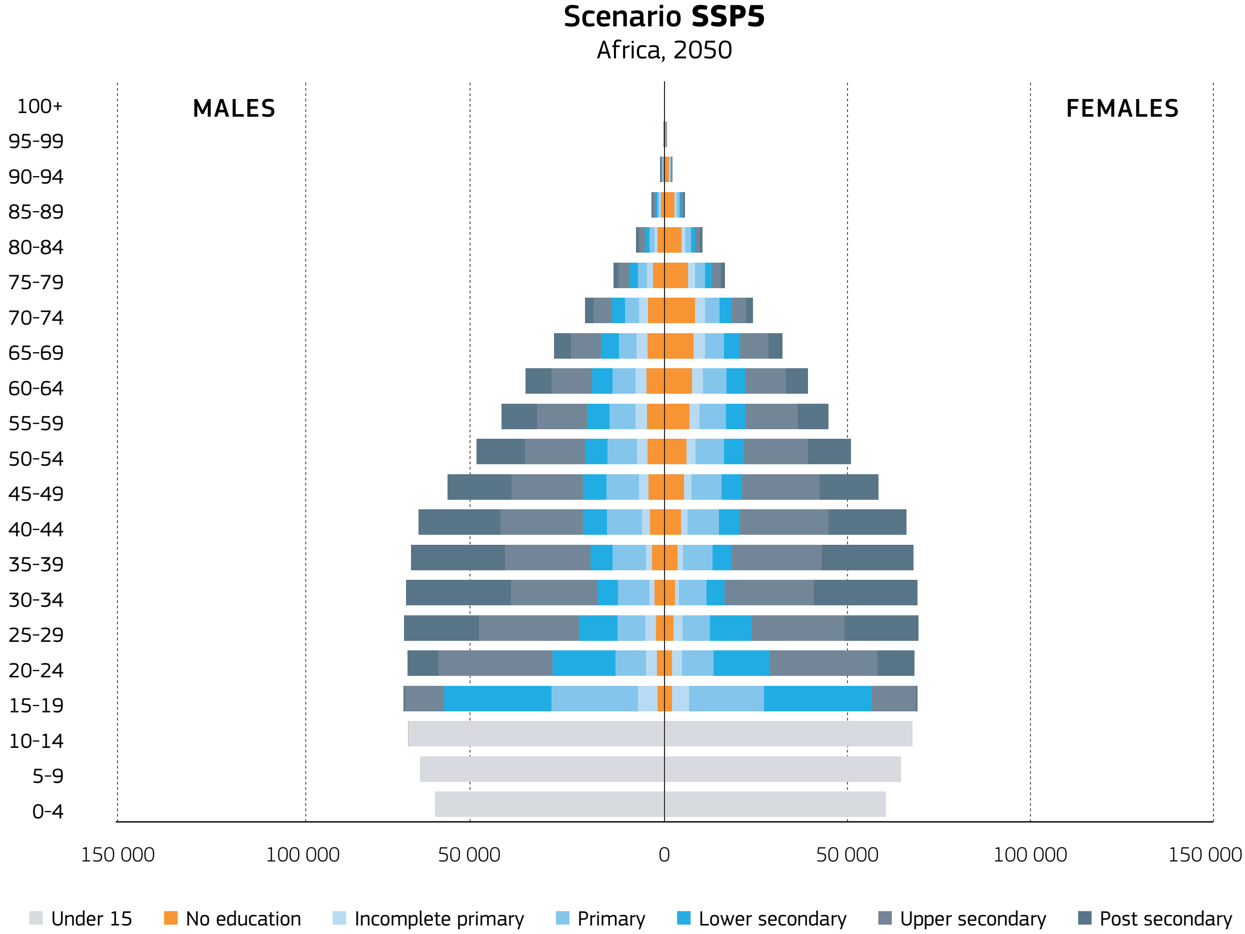
FIGURE 6: Shared socio-economic pathway scenario 4 (SSP4): unequal development, Africa *(Source: IIASA)*



<u>SSP4: unequal development</u>

As foreseen under the SSP2 and SSP3 scenarios, the African population is estimated to reach more than 2 billion in 2050, with a total fertility rate reaching more than three children per woman. According to the inequality assumption, no educational attainment progression is forecast: the proportion of young African women aged between 15 and 24 with *no or incomplete education* would be 55 % and with a *post-secondary education* would only be 2 %. Similarly, only 31 % of African men aged between 20 to 64 years (working-age group) will have more than post-secondary education.

FIGURE 7: Shared socio-economic pathway scenario 5 (SSP5): conventional development, Africa *(Source: IIASA)*



SSP5: conventional development

Similar to the SSP1 scenario, the annual African population growth rate is expected to decline, reaching below 1.8 billion by 2050. Fertility will fall to less than two births per woman, while life expectancy at birth will increase to 79 years for women and approximately 75 years for men. The proportion of younger women (aged between 15 and 24) with *no or incomplete education* will fall to 8 %; at the same time, the proportion of women with an *upper or post-secondary education* will rise to 42 % (compared to 43 % for men). The respective population pyramid is depicted in Figure 7.

Challenges and opportunities

The results of the SSP scenarios show how changes in education for the whole of Africa will impact the evolution of its population. Table 1 shows that, while annual population growth is expected to decline under all scenarios, the population of Africa in 2050 will range from 1779 million in SSP5 and 2323 million in SSP3, depending on educational attainment. All scenarios result in a drop in the total fertility rate, which is projected to range from a minimum of 1.73 (SSP5) to a maximum of 3.67 (SSP3).

TABLE 2
Shared Socio-economic Pathway (SSP) definitions
(Source IIASA)

	Base year	Alternative scenarios to 2050				
	2010	SSP1	SSP2	SSP3	SSP4	SSP5
Africa						
Population size (in millions)	1 022.23	1 801.01	2 018.18	2 323.85	2 251.00	1 779.00
Total fertility rate	4.64	1.82	2.61	3.67	3.38	1.73
Life expectancy at birth						
Men	53.99	71.2	62	54.1	54.5	74.9
Women	56.33	75.1	66.1	58	59	79.1
Net migration flows 2050-55		-4 874	-5 314	-2 506	-5 468	-8 291
Annual growth rate 2050-55	2.2	0.6	1	1.5	1.4	0.6

2) Gaps, future actions and priorities to be considered

Further study of population structure (by age, sex, and level of education), migration behaviours and demographic trends is required to identify the current phase of demographic transition being experienced in African countries. The interactions between social, economic, political and environmental drivers (climate) can be simulated using demographic models to capture the population dynamics and macro-structural changes, which also affect migration towards Europe. The pull-factor analysis in Europe and the push-factor analysis in African regions can contribute to implementation of a structured migration model, building new alternative migration scenarios for the future in the context of an ageing European population and a developing African population.

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1.2. Migration

1) Key findings

While migration cannot be forecast (because it is difficult to predict geopolitical developments and future immigration policies), analysis of past migration data can help to better understand its fundamental drivers, evaluate the different determinants, and develop better future migration scenarios.

Over the past 25 years, the percentage of African emigrants (in terms of stock[4]) with respect to the overall population has been declining for intra-African migration, while for migration to Europe it has remained relatively stable, although in absolute terms this number is growing. Furthermore, worldwide, about one-third of all refugees are African nationals, most of whom live in Africa.

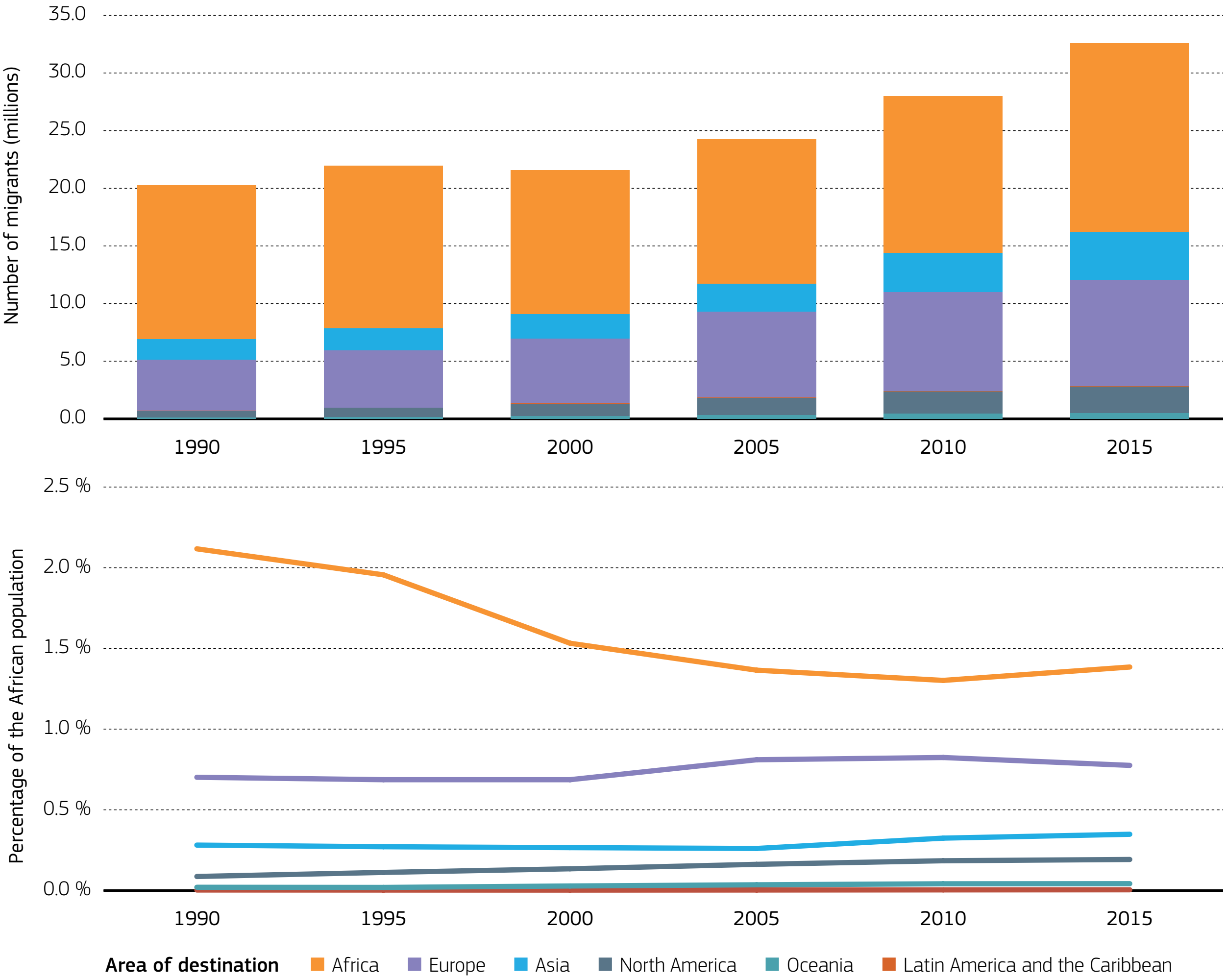
> "Worldwide, about one-third of refugees originate from Africa"

A large part of the displaced and refugee populations can be attributed to institutional fragility in some countries, which can lead to mass violence or localised conflicts.

Migration by African nationals

Between 1990 and 2015, the African-born migrant stock increased in absolute numbers (from 20.3 million in 1990 to 32.6 million in 2015), both inside Africa and in the EU. However, the percentage of the migrant stock with respect to the overall population has been decreasing for intra-African migration (from 2.1 % in 1990 to 1.4 % in 2015), and has remained relatively stable for migration towards Europe in percentage terms, increasing from 0.7 % in 1990 to 0.8 % in 2015 (although given the overall increase in Africa's population, this modest % increase translates into an increase in absolute numbers).

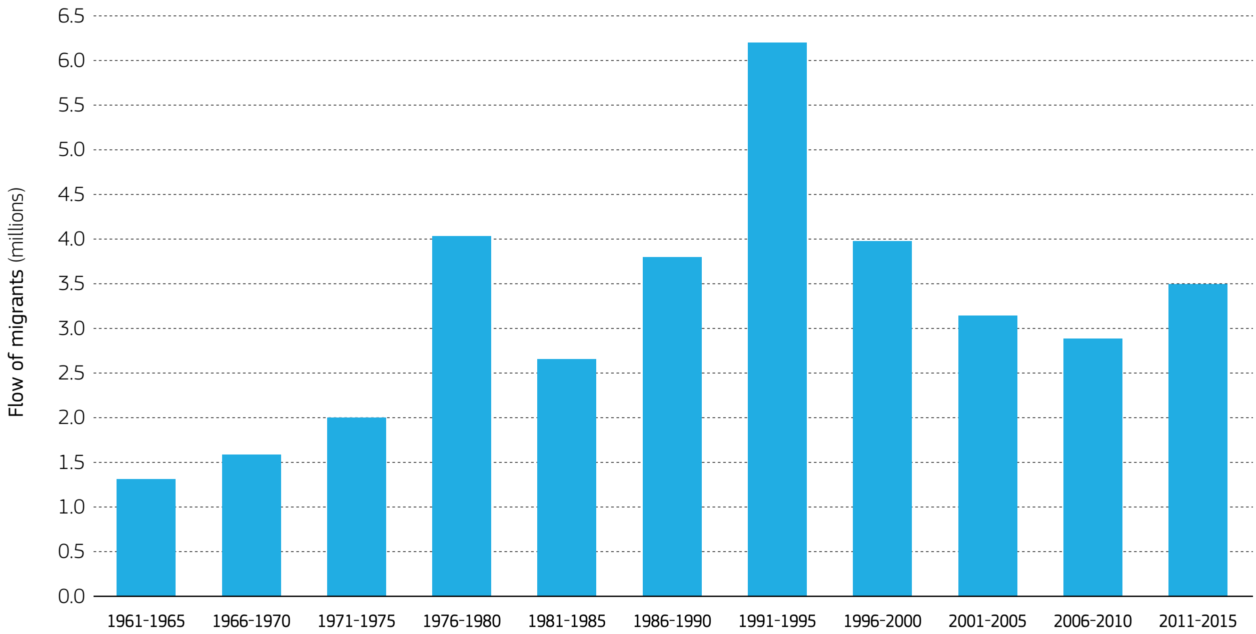
FIGURE 8: Absolute number of Africans living outside their country of birth (bars) and percentage of the African population (lines) by continent of destination *(Source: migrants stock data from the United Nations Department of Economic and Social Affairs – UNDESA)*



4 The migrant stock is the number of migrants living in a country (which is not their country of birth) in a given year.

Data on migration flows within Africa are scarce because of a lack of national official statistical data on emigration and immigration. Recent research (Abel, 2015) estimated bilateral flows between African countries for five-year intervals between 1960 and 2015 based on migrant stock data. In this period, there were two peaks in the flow of African nationals migrating within Africa, one in the period 1975-1980 (at the time of the Ethiopian civil war) and the other in 1990-1995 (at the time of the Rwandan genocide) (see Figure 8). Total intra-African flows are estimated at around 3.4 million migrants for the period 2010-2015.

FIGURE 9: Flows[5] of migrants within Africa for five-year periods *(Source: Abel, 2015)*



Forced displacement in Africa

Forced displacement in Africa attributed to disasters and conflicts has doubled in the 10-year period 2005-2015, according to the Office of the United Nations High Commissioner for Refugees (UNHCR, 2016), from a total of 9.8 million in 2005 to 20.3 million in 2015 (this includes IDPs, refugees, asylum seekers and other categories of people of concern). Disaggregating the figures, a similar trend has been observed for IDPs (from 5.4 million in 2006 to 11.2 million in 2015) and for refugees (from 2.6 to 4.8 million). Over the past 10 years, the absolute number of IDPs in Africa is consistently estimated at two to three times that of refugees.

> “There are two to three times more internally displaced persons than there are refugees.”

The numbers of IDPs are slightly different according to the Internal Displacement Monitoring Centre (IDMC), which estimates that the total number of IDPs in Africa due to conflicts increased from 10 million in 2009 to 12.4 million in 2015. No equivalent figures for IDPs due to disasters are reported by the IDMC. In Africa, contrary to what is observed globally, conflict is the major cause of new flows of forced internal displacement: in 2015, 2.4 million new internal displacements were due to conflict, while 1.1 million were due to disasters (*Source: IDMC*). Conflict also tends to lead to more durable displacement. In fact, Betts and Collier (2017) argue that the condition of being a refugee or displaced derives more from countries' "institutional fragility" and less from political or other forms of persecution by states. Triggered largely by geopolitical events, institutional fragility can lead to mass violence or localised conflicts which, in turn, result in displacement and people seeking refuge, especially in neighbouring countries.

Root causes

A number of factors motivate African migration, either independently or combined. These include aspirations for a better life for individuals and reuniting families, personal ambition, development of skills, lack of economic opportunities at home, institutional fragility, insecurity, violent conflicts, environmental deterioration, as well as lower travel costs and better communications (Adepoju, 2017).

5 The flow is the number of migrants moving from one country to another during a period of one year.

The lack of empirical analysis of the drivers of migration makes it difficult to generate future migration scenarios for Africa. It is not yet known how migration will be affected when many African countries reach a stage in their economic, mobility and demographic transitions that creates favourable conditions for migration. Past data show that development, better infrastructure or access to liquidity will lead to more migration pressure. However, we cannot predict the pace of the above transitions and the geopolitical events and migration policies that will ultimately determine migration flows.

Considering their large populations, it may seem surprising that so few people migrate from African countries to developed countries. Hatton and Williamson (2008) attribute this to poverty, the small size of African diasporas (community networks that are not big enough to facilitate emigration) and barriers to migration in developed countries.

While wage and income gaps are currently much larger than those that drove previous mass migrations, empirical JRC research (Maestri, 2017) found that higher "within-country income inequality" in the origin countries leads to lower levels of emigration, because in such a situation fewer people have access to the liquidity required to bear the costs of migration. This indicates that, in addition to the absolute income differentials between countries, other important factors are at play, such as income distribution, poverty levels and transitions in countries' structural characteristics.

Bole international airport, Addis Ababa, Ethiopia © Raimund Stehmann, GFDL 1.2 (https://commons.wikimedia.org/wiki/Commons:GNU_Free_Documentation_License,_version_1.2)

BOX 1:

The relationship between development and migration

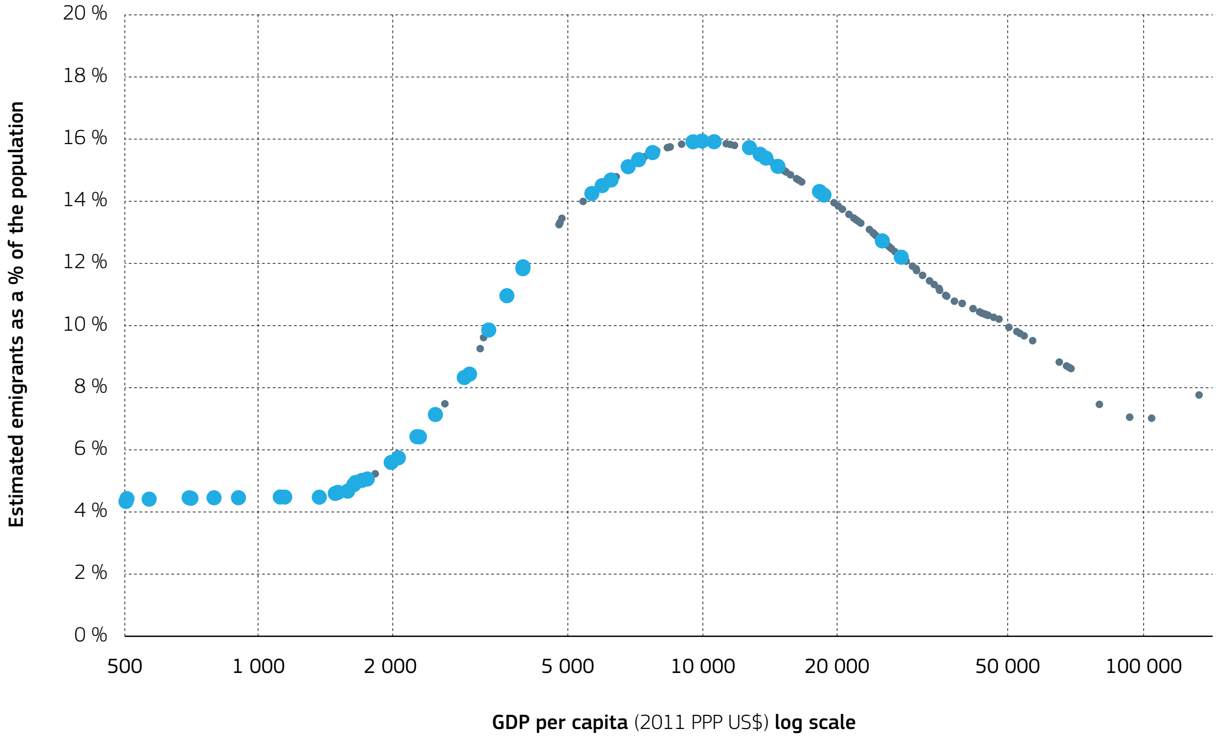
Empirical data shows that the relationship between emigration and economic development in countries of origin has an inverted-U shape, called the "migration hump".

This relationship can be modelled by associating emigrants as a percentage of the population with composite development indicators, such as the Human Development Index (de Haas, 2010) or GDP per capita (Clemens, 2014) as shown in Figure 10 below.

"International emigration ratios are lower in less-developed countries, and increase with socio-economic development."

The migration hump shows that international emigration ratios are lower in less-developed countries and that they increase with socio-economic development; emigration ratios start to fall after socio-economic development has reached a certain level. At the individual level, conditions of poverty and lower development in countries of origin influence both the aspirations and the capabilities of people to migrate. However, besides economic variables (such as GDP per capita), in reality, many more factors need to be considered to capture the complexity of the phenomenon and predict emigration rates with confidence. According to theoretical models (Zelinsky, 1971), there is a strong relationship between the levels of emigration and countries' stages of mobility and demographic transition.

FIGURE 10: Estimated emigration ratios on the basis of GDP per capita in 2015. The large dots represent African countries; the small dots are countries in other continents *(Source: JRC estimates using migration data from UNDESA and GDP data from the World Bank)*



The role of remittances as one of the factors driving development in origin countries is a topic of academic debate. While remittances enhance the economic resilience of families and communities, it is unclear whether or not they also drive development – in the same way as foreign private or public investment or official development assistance. Based on an analysis of the World Bank's Bilateral Remittances Matrices, the cumulative remittances into Africa from the rest of the world reached US$ 51.7 billion in 2015 (equivalent to EUR 46.5 billion at 2015 exchange rates), a 28 % increasecompared to 2010. During the same period, remittances as a percentage of GDP also increased from 2.0 % to 2.4 % in Africa as a whole. However, the average cost of remittances is still high (see chapter III.1).

What will determine the strength of future pressures to migrate out of Africa? Demographic trends will lead to a greater share of the young adult population becoming more inclined to migrate. Creating sufficient job opportunities for these young people is a formidable challenge. Given a surplus of labour supply and falling wages, there will be more economic incentives for young adults to emigrate. Ultimately, the amount of migration to Europe and other continents will depend on how much of the migratory pressure in Africa will lead to intercontinental migration rather than internal mobility and intra-African migration. The size of inter-continental migration may depend more on geopolitical events (such as destabilisation in Libya) or border management and immigration policies, and less on changes in the underlying push and pull factors.

2) Gaps, future actions and priorities to be considered

To date, migration research has focused on outflows from Africa. A comprehensive understanding of both the inflows and outflows is needed, particularly of migration within Africa.

Intra-regional mobility in Africa should be encouraged by reducing barriers to migration and developing further large, open economic areas with opportunities for youth mobility – for instance, for students and researchers. Such mobility would also foster deeper regional integration, economic diversification and the development of entrepreneurial skills, in line with the Aspirations of the African Union's Agenda 2063.

Investing in education is a powerful means to stimulate economic and human development for the benefit of Africans and Europeans.

The European Investment Plan of September 2016 aims to mobilise additional public and private investment in Africa. Through its guarantees designed to improve the business and investment climate, stepping up technical assistance, capacity building, and focusing on job creation, the plan is a promising new EU-level tool for sustainable growth in Africa, assuming that local "conditions for development" (Deaton, 2013) are also favourable.

Reducing the cost of remittances to Africa would surely help address poverty and improve the resilience of households to shocks.

Regarding the EU, well-managed migration from Africa with targeted inflows to fill labour market gaps – including for low-skilled workers in the care, agricultural and tourism sectors – is a feasible option. However, absorption of the large potential number of migrants from Africa will also pose significant challenges to EU societies.

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2. Urbanisation and accessibility

2.1. The dynamics of human settlements and urbanisation

1) Key findings

Urbanisation can contribute to sustainable growth, if managed well. However, the speed and scale of urbanisation can bring challenges, including accelerated demand for affordable housing, transport systems, other infrastructure, basic services and jobs. This chapter focuses on the growth dynamics of settlements in Africa in terms of built-up areas and population, to highlight the need for an African Urban Agenda.

Assessment of the situation

Traffic jam in Accra, Ghana ©EU, by Andreas Brink

Africa's population is the fastest-growing continent in the world today. More than half of global population growth between now and 2050 is expected to occur in Africa (United Nations, 2015). Much of the growth is taking place in urban areas. Between 1990 and 2015, the urban population of Africa doubled, while the continent's overall population increased by 88 % (Figure 11). This significant increase in urban population sets Africa apart from other world regions, including Asia.

If the density of people living per unit area is used as the criterion for the classification of human settlements, Africa is much more broadly 'urbanised' than is generally assumed. Based on the 'Degree of Urbanisation' or DEGURBA model[6] – a people-centred definition of human settlements in three classes as 'cities', 'towns and suburbs' and 'rural'[7] – Africa's population share in the first two DEGURBA classes exceeds 80 %, and is topped only by the urban population shares of Asia and Latin America.

FIGURE 11: Urban and national population growth rates between 1990 and 2015 *(Source: GHSL)*

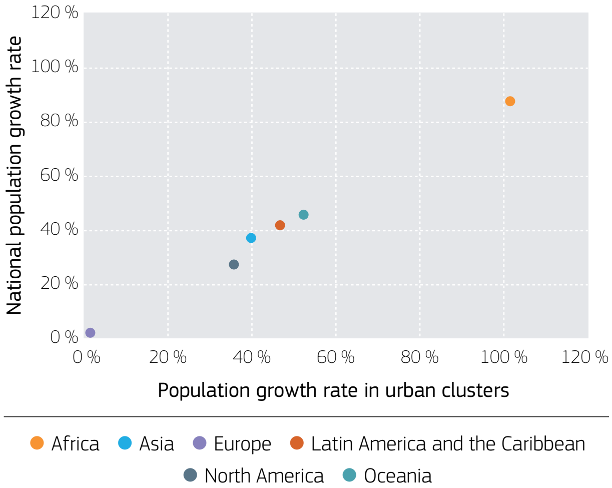
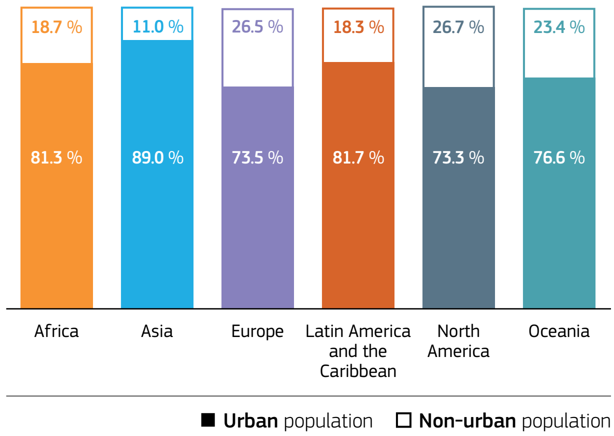


FIGURE 12: Population share by degree of urbanisation per major global region, 2015 *(Source: GHSL)*



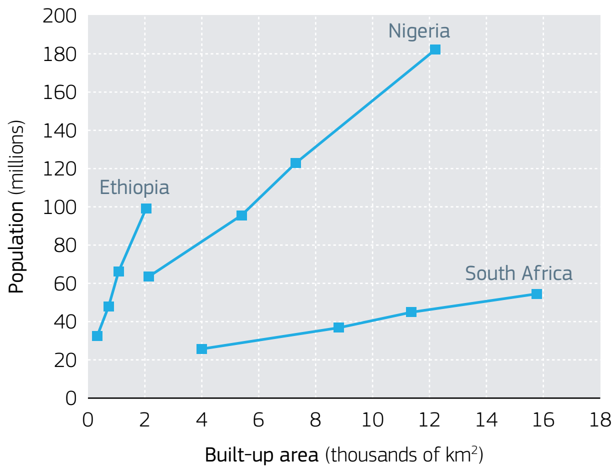
6 http://ec.europa.eu/eurostat/web/degree-of-urbanisation

7 At present, there is no universal definition of urban areas, thus the available data are heterogeneous across countries. The DEGURBA classification scheme has been adopted by the EU and the OECD, and is currently in the process of adaptation and interaction with an enlarged set of national statistical offices in order to be proposed as a global definition at the UN Statistical Commission in 2018-2019 (see below, Challenges and opportunities). It is worth noting that in the usual formulation of the DEGURBA classes, 'cities' and 'towns and suburbs' both belong to the broader 'urban' class used in the accounting of 'urbanisation' rates. In Africa, the DEGURBA classification 'towns and suburbs' may actually cover a large part of rural towns and densely inhabited rural areas (for example: the 'traditional areas' in South Africa), which may lack infrastructure and thus cannot be considered as 'urban' in the full meaning of the word.

There are, however, strong variations within Africa (Figure 13). For example, the population of Ethiopia is increasing very quickly, with only a slight increase in built-up surface area. In contrast, South Africa's population is growing relatively slowly, with a significant increase in built-up area. The built-up area and population of Nigeria are increasing at a similar rate. The different growth scenarios lead to very different living conditions. While there are on average 29 m^2 of built-up area per person in South Africa, there are only 7 m^2 per person in Nigeria, and 2 m^2 per person in Ethiopia.

"While there are on average 29 m^2 of built-up area per person in South Africa, there are only 7 m^2 per person in Nigeria, and 2 m^2 per person in Ethiopia."

FIGURE 13: Trends in built-up area (x-axis) and population (y-axis) from 1975 to 2015 for Ethiopia, Nigeria and South Africa *(Source: GHSL)*



Outlook

With a continuously fast-growing population in Africa, urbanisation rates are also likely to rise, as population pressure pushes people into cities. This presents both challenges and opportunities. If managed well, the urbanisation process may contribute to sustainable growth. However, much of the urbanisation in Africa today is generally happening in an unplanned, unsustainable way, leading to the growth of overcrowded slums that lack access to water, sanitation and services such as education, transportation and often access to the labour market, too.

Challenges and opportunities

The balance of opportunities and challenges that cities offer is determined by how they are planned, designed and built. Urban and regional planning can help to develop opportunities if they include a sustainable, inclusive dimension that also benefits all citizens, including the urban poor. Adequate planning requires an appropriate policy framework, sufficient funding, a participatory approach and the means to monitor and enforce implementation.

High-resolution and up-to-date spatial data on human population are a prerequisite for the accurate measurement of the impacts of disaster events, for monitoring changes and for planning interventions. One example is the eradication of poliomyelitis. Today, polio is only found in Afghanistan, Pakistan and Nigeria. Polio-vaccination campaigns can achieve the required immunisation coverage, but they require detailed information about the population's whereabouts. The Bill and Melinda Gates Foundation supported the WorldPop project to produce such population distribution maps for Nigeria and East Africa (Tatem et al., 2007). As input, WorldPop uses high-resolution settlement data from the Global Human Settlement Layer (GHSL) developed by the JRC and the Global Urban Footprint produced by the DLR – the German Aerospace Center (Esch et al., 2012). The GHSL data are available at local, regional and global level (see Box 2 for details) (Pesaresi et al., 2013; Florczyk et al., 2015). The focus has always been on the most vulnerable part of the population, such as those living in slums or refugee camps, and internally displaced persons (Kemper et al., 2011).

In October 2016, the JRC launched the GHSL at the third United Nations Conference on Housing and Sustainable Urban Development, Habitat III, in Quito (Ecuador). This dataset shows the spatial distribution of settlements and population over the past 40 years at an unprecedented level of detail (see Box 2). In addition to the dataset and the website, an 'Atlas of the Human Planet' was presented that illustrates the findings from the past 40 years of urban development.

"The Global Human Settlement Layer shows the spatial distribution of settlements and population over the past 40 years at an unprecedented level of detail."

BOX 2

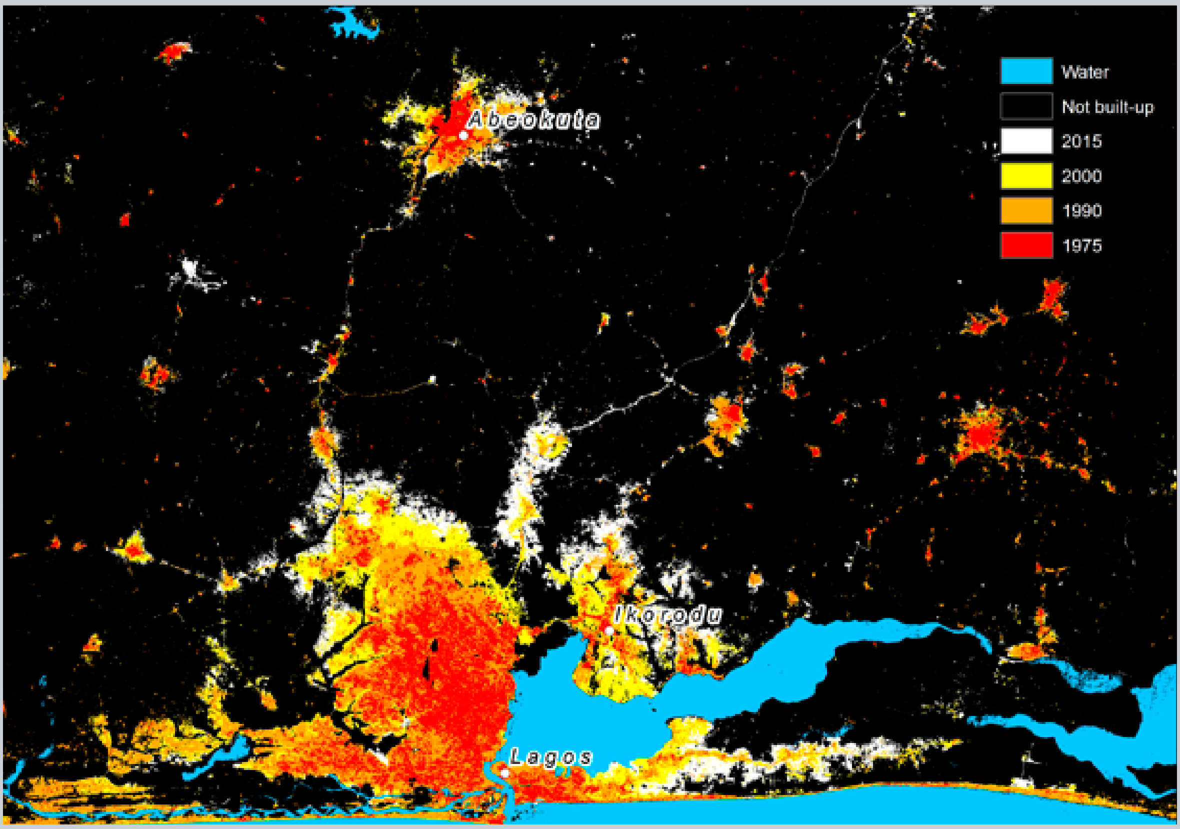
The Global Human Settlement Layer

The Global Human Settlement Layer (GHSL) is the most complete and consistent, global, free and open dataset on human settlements. It helps answer questions such as: how much of the Earth's surface is covered by settlements? By how much and how quickly are settlements growing? Where are they growing most? Where are settlements growing unsustainably? The GHSL combines information from different satellite sensors with census information and crowd-sourced data (e.g. OpenStreetMap) to provide information on the presence of settlements and populations at an unprecedented level of detail for the years 1975, 1990, 2000 and 2015 (Figure 14). This facilitates information generation at global, regional and even local levels.

The new generation of human settlement information, which includes maps, statistics and indicators, can support the monitoring of many aspects of sustainable development, from health status and food security to natural resource management. The information provided by the GHSL can be used to construct spatial metrics and indicators related to population and settlements, and to model the access (to services, market, industrial infrastructure, food, water, land), exposure (to natural disasters), and impacts (on ecosystems, water, land degradation) of human settlements.

“The population of Lagos increased from about 2 million in 1975 to 13 million in 2015.”

FIGURE 14: Output from the Global Human Settlement Layer for Lagos (Nigeria) and its hinterland. The population of Lagos increased from about 2 million in 1975 to 13 million in 2015, as reflected in the increase in built-up areas. Note the growth corridors along the major arterial roads and the creation of large satellite cities *(Source: GHSL)*



Policy framework

Work related to human-settlement mapping relies on the recently adopted international frameworks based on the 2030 Agenda for Sustainable Development: the Sendai Framework for Disaster Risk Reduction, the Paris Agreement, the Sustainable Development Goals (SDGs) and the New Urban Agenda.

The Sendai Framework for Disaster Risk Reduction deals with populations and buildings exposed to natural hazards. It assesses the impact of climate change on the population and the built-up environment. SDG 11 (Make cities and human settlements inclusive, safe, resilient and sustainable) is dedicated to sustainable urbanisation. Human settlement mapping could directly help to measure the SDG indicator on land-use efficiency (SDG 11.3.1: Ratio of land consumption rate to population growth rate). The global definition of cities is also crucial for a number of indicators that require a disaggregation of urban and rural population (for example, SDG indicator 9.1.1. requires calculating the rural population that lives within two km of an all-weather road). It can also be used to measure other indicators, in particular for countries for which data are scarce. In addition, such maps are involved in the global definition of cities in the context of the New Urban Agenda.

2) Gaps, future actions and priorities to be considered

Information is available on the area covered by buildings, but not on their height. For a more complete description of the distribution of population, such information is crucial. Among other applications, for instance for civil protection purposes, this allows for the calculation of floor area per person. If the use of the buildings (e.g. residential, commercial, industrial) were known, the changes in day and night population could also be calculated.

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2.2. Urban-rural connectivity

1) Key findings

Assessment of the situation

Transportation infrastructure has a pivotal role in human land use, and roads are increasingly being developed over much of the Earth's land surface. While road development can generate substantial social and economic benefits, strategic planning is often lacking, and many roads remain unmapped. The relative benefits and disadvantages of road development can also differ greatly between urban and rural environments. Globally, at least 25 million kilometres of new roads are anticipated by 2050 (Laurance et al., 2014), the linear equivalent of 30 round trips to the moon!

Africa is currently in a very active phase of road building, which should greatly facilitate its economic and social development. According to a report for the World Bank, average road density in Africa is 20.4 kilometres of road per 100 square kilometres of land area – only a quarter of which is paved. In contrast, the world average is 94.4 kilometres per 100 square kilometres, more than half of which are paved.

Accessibility has a major impact on livelihoods. According to Teravaninthorn and Raballand (2009), it is estimated that on average, farmers located four hours from a major city, produce at 45 % of the theoretical agronomic potential. This percentage drops to 20 % when the farmer is six hours away, and 12 % when eight hours away. Road development also increases quality of life through improved mobility, better access to services such as health and education, lower transportation costs, and greater household income and consumption.

Building a new road in Uganda means improved accessibility for people, but new threats to wildlife ©EU, by Andreas Brink

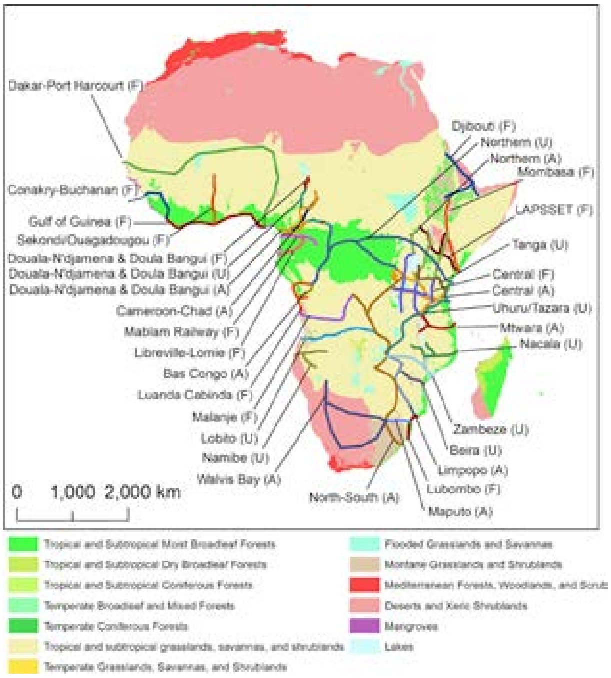
These positive outcomes must be balanced with an assessment of the potential negative impacts of road building, both direct (land consumption, vegetation clearance, soil compaction, pollution) and indirect. Indirect effects can include greater deforestation and forest degradation, fires, poaching and land speculation. Within this context, it is especially important to balance the assessment of the impact of official, planned roads compared to unofficial or illegal road development. One of the most effective ways to conserve important ecosystems is to keep them road-free.

However, it is difficult to accurately estimate the impact of infrastructure improvement in Africa, especially roads, due to data limitations and methodological constraints, in particular the ability to handle the vast range of factors affecting the outcomes of road and related projects, many of which are simply not measured.

Outlook

Large-scale expansion of infrastructure (including roads, railways and pipelines) is expected in the near future, including in Africa's major 'development corridors' (Figure 15), to increase agricultural production, mineral exports and economic integration. The African Union Commission's Programme for Infrastructure Development in Africa (PIDA), funded mainly by African governments with the support of international banks, governments and funding agencies, was launched in 2010 and is due for completion in 2040. PIDA provides a common framework for African stakeholders to build the infrastructure necessary for more integrated transport, energy, information and communications technology (ICT) and transboundary water networks to boost trade, growth and job creation. Transport makes up 30 % of PIDA's current budget, and roads are a big part of this. It is planned to expand the existing 10 000-km network of major roads to between 60 000 and 100 000 km – either by upgrading existing poor roads or building new ones. In addition, 250 000 km of smaller roads will be built or upgraded to connect smaller cities to the main arteries, plus another 70 000 km in rural areas. Figure 15 shows the main corridors identified at the continental scale.

FIGURE 15: Development corridors in sub-Saharan Africa; current status of each corridor classified as (A): already active, (F): planned for future, (U): upgrade planned or under way *(Source: Laurance et al., 2015)*

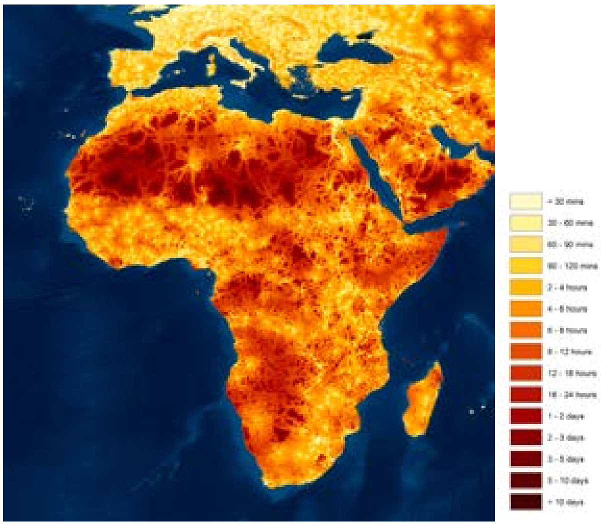


Challenges and opportunities

The key challenge is to maximise the societal benefits of new or improved transportation projects while minimising their environmental costs and protecting natural capital. The JAES Roadmap 2014-2017 includes a commitment to strategic cooperation in the field of transportation, in coherence with PIDA, EU development policy and other guiding policy frameworks. A clear opportunity arises to "strive for the reduction of transport costs and boosting of intra-African trade by bringing regional transport corridors to an adequate level of service, which is sustainable, safe and reliable. More attention will be given to the economic, social and environmental dimensions of transport." This implies a need for improved regional data and the analysis of how these transport dimensions interact, including the consideration of multi-modal transportation linkages. A better understanding of the current situation regarding accessibility, and its likely future evolution across the continent, can be a key predictor for many analyses in fields such as development, epidemiology, conservation, forestry and agriculture.

For example, the actual and predicted impact of road development on forest ecosystems can provide a possible early indicator of the efficiency of REDD+ (Reducing Emissions from Deforestation and forest Degradation and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries) activities and EU sectoral policies (in particular, biodiversity and climate change). It addresses the fundamental data limitations, by enhancing existing road databases and developing innovative techniques to identify road features from satellite imagery. It will also create a new 'Global Accessibility Map' (Nelson et al., 'Travel time to major cities: A global map of Accessibility' – see Figure 16), using new and improved data sources, including the Global Roads Open Access Data Set and the higher-resolution, community-led, Openstreetmap (web links to both are given below). This new accessibility map has been developed with Oxford University's Malaria Atlas Project, illustrating the broad scope of applications ranging from epidemiology to conservation and development.

FIGURE 16: Travel time to major cities: the map shows overland travel time to cities with populations of over 50 000; darker colours represent longer travel times *(Source: Nelson et al., 2009)*



Policy framework

Ultimately, all of these policies contribute to the achievement of multiple Sustainable Development Goals (SDGs), in particular SDG 9 on 'Industry, Innovation and Infrastructure', and SDG 11 on 'Sustainable Cities and Communities'.

2) Gaps, future actions and priorities to be considered

More information on the fundamentals of the existing road infrastructure is needed to support basic questions on accessibility, especially at the local scale, since not all roads are well mapped or well documented with key attributes such as road type and road condition. Information on condition must also be regularly updated; funding for initial construction may not automatically be followed by funding for maintenance, yet when roads fall into disrepair their benefits are dramatically curtailed. In addition, a more coherent knowledge base on planned infrastructure developments at the continental scale, especially concerning the major planned inter-regional transport corridors, would support better assessments of their impact. Therefore, improved road mapping and condition monitoring is a priority.

Tools based on the OpenStreetMap platform offer the potential to fill this gap. In 2017, the release of a new accessibility map with the associated interactive tools will allow for a more dynamic view of accessibility issues. Targeted mapping campaigns will also be needed, either to capture missing data or to improve the quality of existing data. In particular, there are many opportunities to enrich the data attributes for roads where the location is known, but information is lacking on key characteristics, such as road-surface type, speed limits, road condition, etc.

Continuation of work on issues related to accessibility in the context of socio-economic development, and improving the continent-wide gathering and standardisation of transportation infrastructure data, would provide a solid basis for the further modelling of existing and planned developments. Increased involvement by African partners would be beneficial in this respect, potentially bringing together the worlds of citizen science and crowdsourced data-gathering with official sources of transportation and accessibility data.

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3. Disaster risk

1) Key findings

Assessment of the situation

Africa is currently the continent most at risk of disasters and humanitarian crises. The combination of conflicts and natural hazards often causes complex and protracted crises. In the past 40 years, over 400 million people in Africa have been affected by droughts, 68 million by floods, 13 million by disease outbreaks and 13 million by tropical cyclones (Guha-Sapir et al., 2017). Economic losses are estimated at EUR 6.5 billion per year for floods alone (Alfieri et al., 2017). The Global Assessment Report 2015 (UNISDR, 2015), a United Nations (UN) assessment of disaster risk, estimated that the risk of economic loss from cyclones has doubled in sub-Saharan Africa since 1980. The same report estimates that, by 2050, 40 % of the global population will be living in river basins that experience severe water stress, particularly in Africa and Asia.

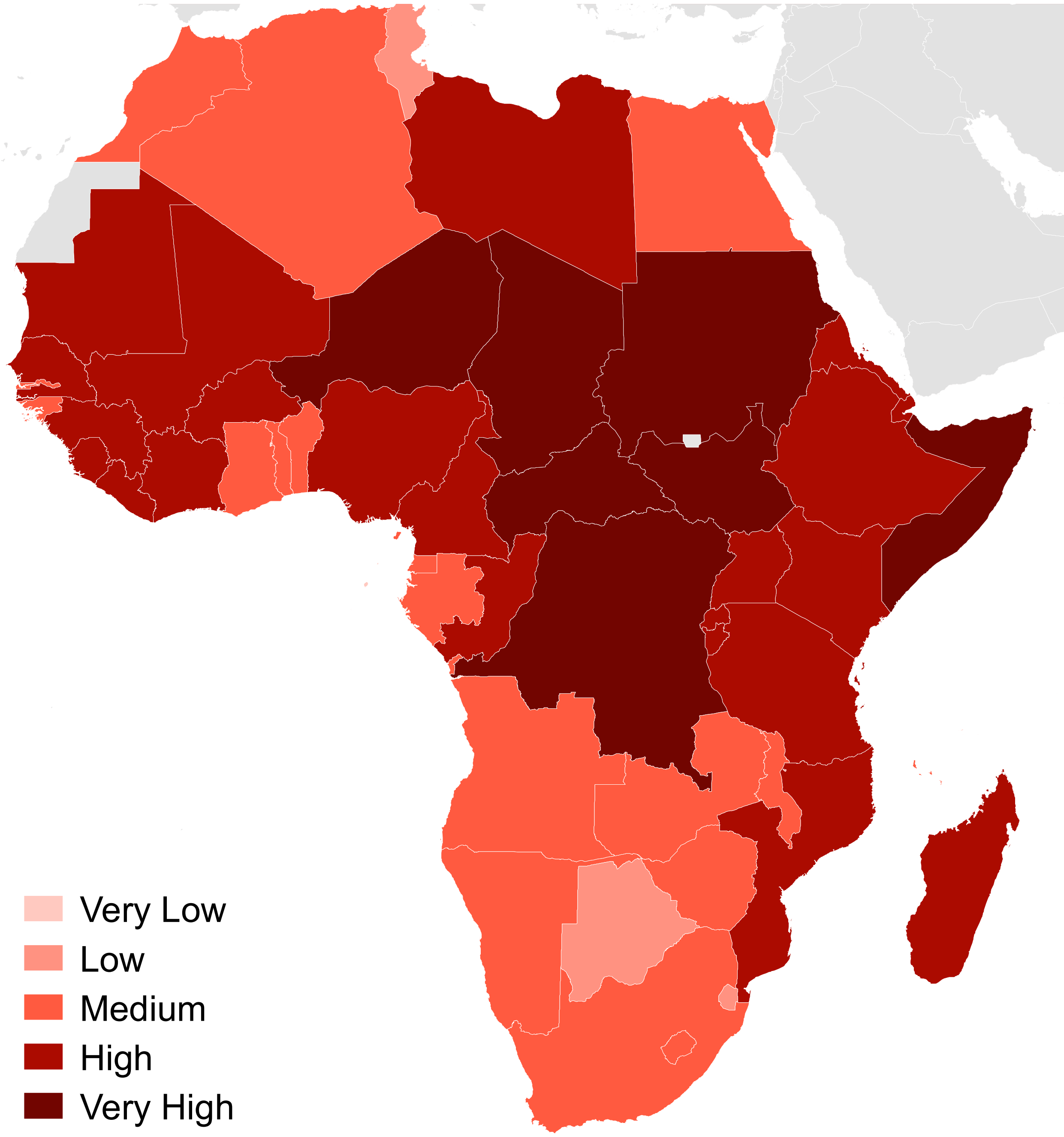
> “In the past 40 years, over 400 million people in Africa were affected by droughts, 68 million by floods, 13 million by disease outbreaks and 13 million by tropical cyclones.”

Disasters occur when a shock (natural or man-made hazard) affects a society beyond its capacity to cope. The risk of disasters is thus influenced not only by the hazards, but also by the population size, its vulnerability to hazards and the coping capacity of the society (or resilience – see chapter II.4). Although the occurrence of natural hazards is lower in Africa compared to other continents (Asia and Latin America are particularly prone to hazards), lack of coping capacity, vulnerability and conflict prevalence add to the African continent's overall disaster risk.

Drought in the Dodoma region, United Republic of Tanzania ©EU, by Paolo Ronco

All African countries have signed up to the Sendai Framework for Disaster Risk Reduction (DRR), a voluntary agreement to reduce the global impact of disasters by 2030. African countries will face strong challenges in reducing disaster risk given their growing populations (see chapter I.1), greater exposure of assets due to economic development, increased hazards due to climate change, and high prevalence of conflict situations (see chapter I.16), all of which compromise good risk governance.

FIGURE 17: INFORM risk index for Africa: Niger, Chad, Sudan, South Sudan, Central African Republic and Somalia feature in the highest risk category, 2017 *(Source: INFORM)*



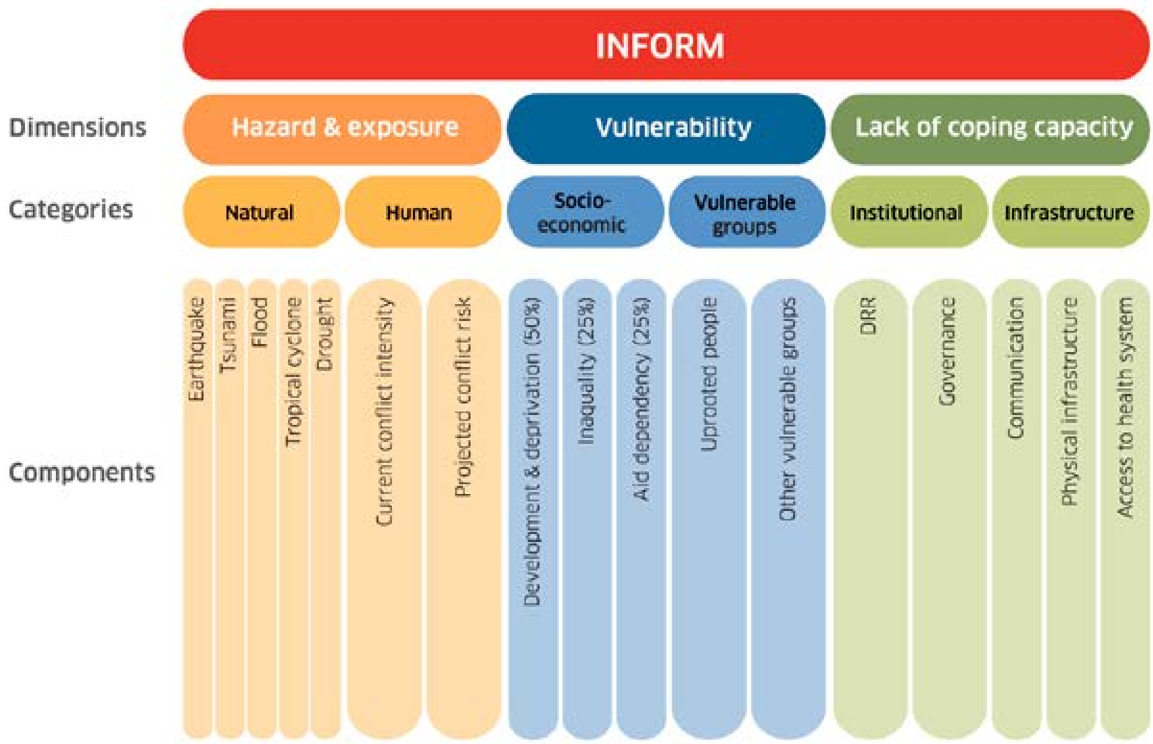
Outlook

Measuring disaster risk

One widely used risk metric focusing on the humanitarian aspects is the Index for Risk Management (INFORM), a composite index8 developed by the JRC. The overall INFORM risk index identifies countries at risk of humanitarian crises and disasters on a scale of 0 (no risk) to 10 (very high risk). It comprises three dimensions: hazards and exposure, vulnerability, and lack of coping capacity. These dimensions are measured using more than 50 indicators, based on open data and a transparent and internationally agreed methodology (see Figure 18). A similar approach is taken by the World Risk Index (UNU-EHS, 2016), with greater emphasis on climate change adaptation. Other risk metrics that consider economic aspects of risk are favoured by the World Bank (Halgatte et al., 2017) and the United Nations (UNISDR, 2015).

8 INFORM is the first global, objective and transparent tool for understanding the risk of humanitarian crises, developed as part of a collaboration of the Inter-Agency Standing Committee Task Team on Preparedness and Resilience, the European Commission and other international partners.

FIGURE 18: INFORM methodology: dimensions, categories and components of risk. More at http://www.inform-index.org

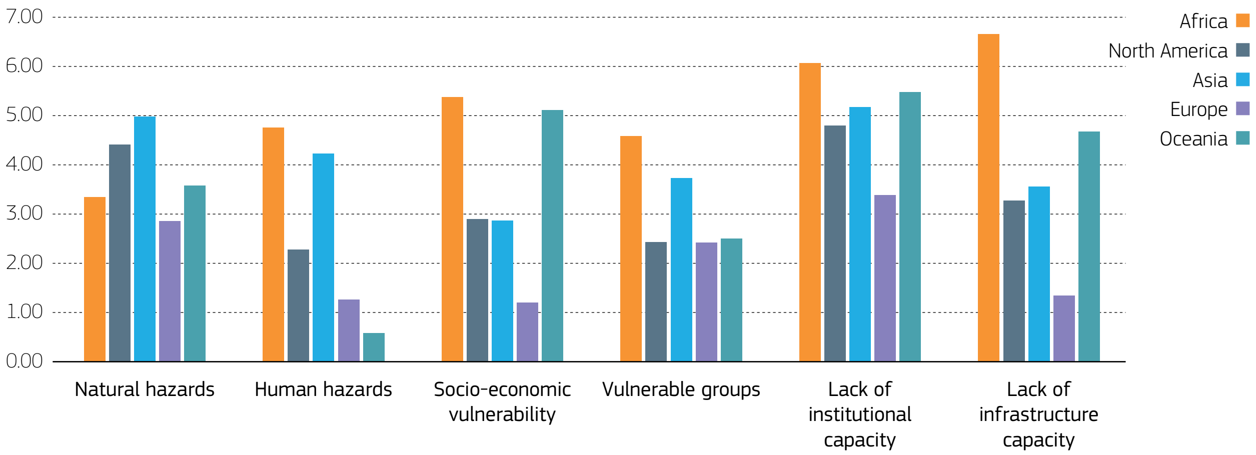


What increases the risk of humanitarian crises and disasters in Africa?

The INFORM index places 50 % of the countries identified as being at very high risk worldwide in Africa. While the average global INFORM risk is around 3.7 (medium risk), it is 5 (high risk) for Africa. Nowadays, of the 54 countries that make up the African continent, only seven are considered to be at low or very low risk, mainly in the southern region. Africa is prone to natural and human hazards (including conflicts), but it is the combination of hazard, vulnerability and lack of coping capacity that puts several of Africa's countries in the 'very high risk' category. According to INFORM, African countries have the highest vulnerability and lowest coping capacity of all world continents (see Figure 19). A World Bank study that quantifies resilience in terms of well-being finds that 15 of the 24 world countries in the lowest resilience class are in Africa (Hallegatte et al., 2017). The same study reports that reducing poor people's exposure to disasters could prevent up to 25 % of current economic losses in countries such as Mali and Niger.

“According to INFORM, African countries have the highest vulnerability and the lowest coping capacity of all world continents.”

FIGURE 19: Components of risk: hazard and exposure (to natural and human hazards); vulnerability (socio-economic vulnerability and vulnerable groups); and lack of coping capacity (institutional and infrastructure capacity) *(Source: INFORM)*

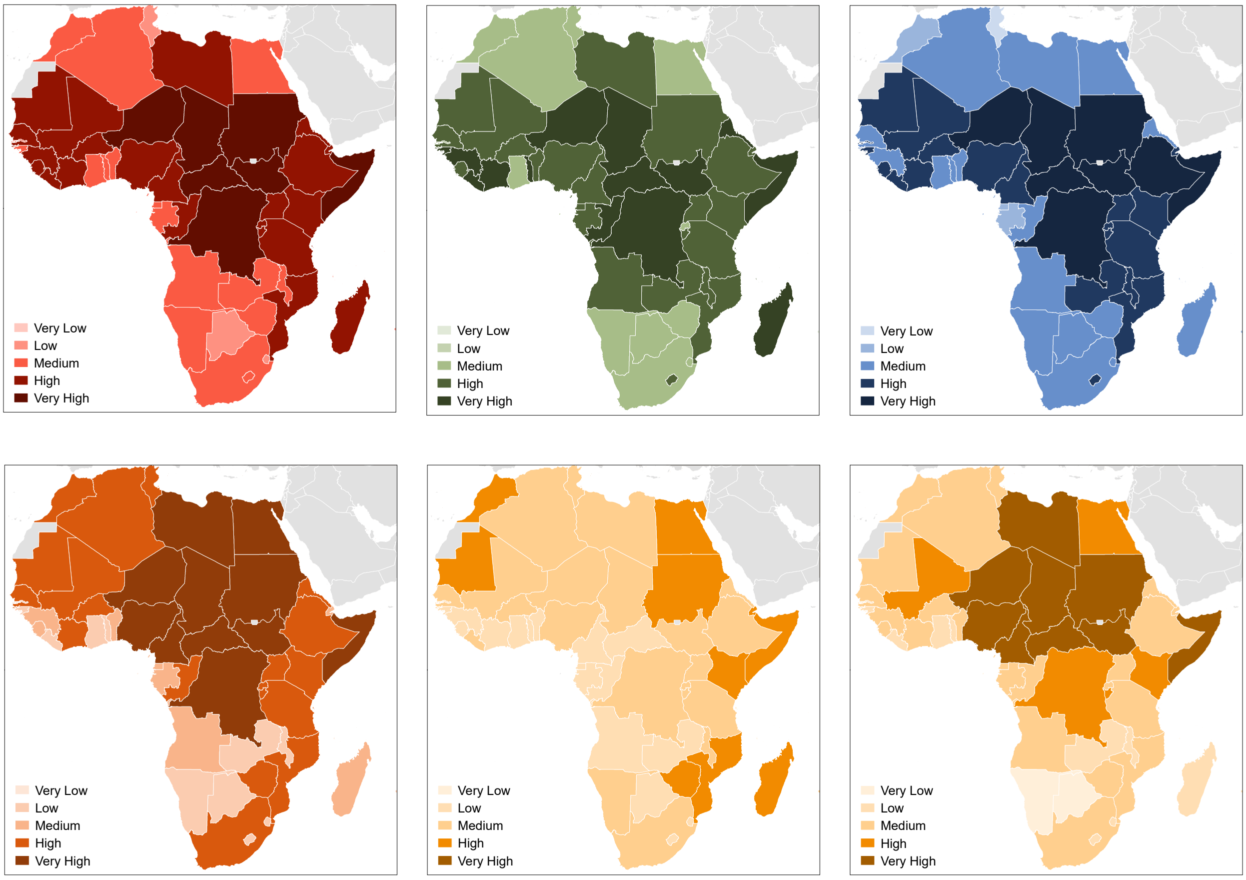


Where is the risk greatest?

Coping capacity, which measures both institutional capacity (such as governance) and infrastructure capacity (such as access to health care), is lowest in Somalia, Eritrea, Niger, Chad, the Central African Republic and South Sudan. Vulnerability is also highest in these countries, as well as in Sudan and Ethiopia. This reflects both socio-economic vulnerability (e.g. poverty) and the presence of vulnerable groups (e.g. uprooted people). These factors, combined with human and natural hazards, create a cluster of high-risk countries in the centre of Africa.

> “Coping capacity is lowest in Somalia, Eritrea, Niger, Chad, the Central African Republic and South Sudan.”

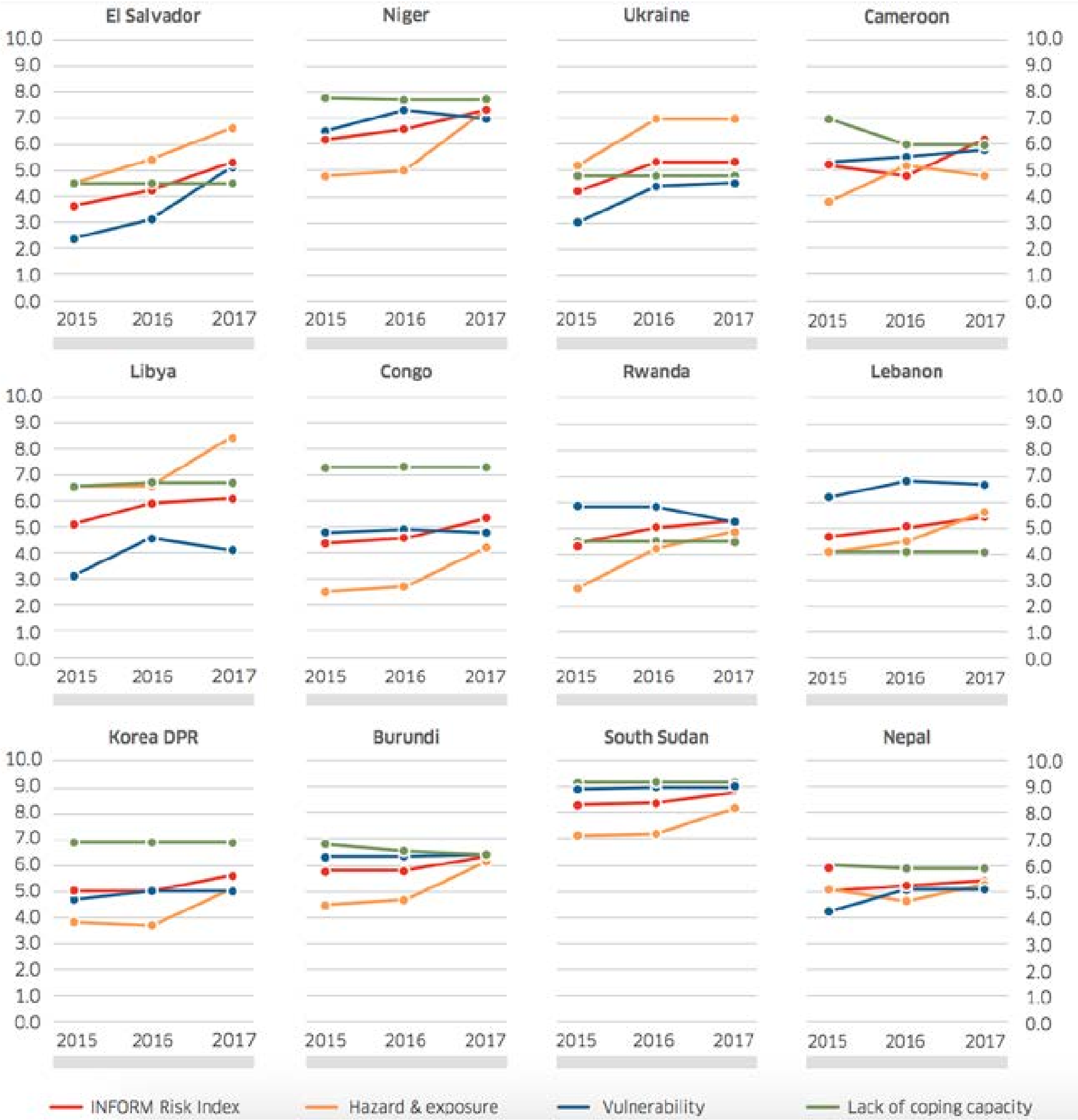
FIGURE 20: Location of risk, 2017: (clockwise from top left) overall risk; lack of coping capacity; vulnerability; overall hazard; human hazard; natural hazard. Lack of coping capacity and vulnerability are key drivers in the countries most at risk of humanitarian crises and disasters *(Source: INFORM)*



Where is risk expected to increase?

The disaster risk situation is worrying in many African countries. Three-year INFORM trends in the countries with the highest growth in risk generally show that rates of vulnerability and lack of coping capacities are static or falling, but not by enough to counterbalance the rates at which exposure to hazards is increasing. Africa’s rapid population growth and economic development create more new risk in spite of efforts to reduce vulnerability and build resilience.

FIGURE 21: Examples of changing risk *(Source: INFORM)*



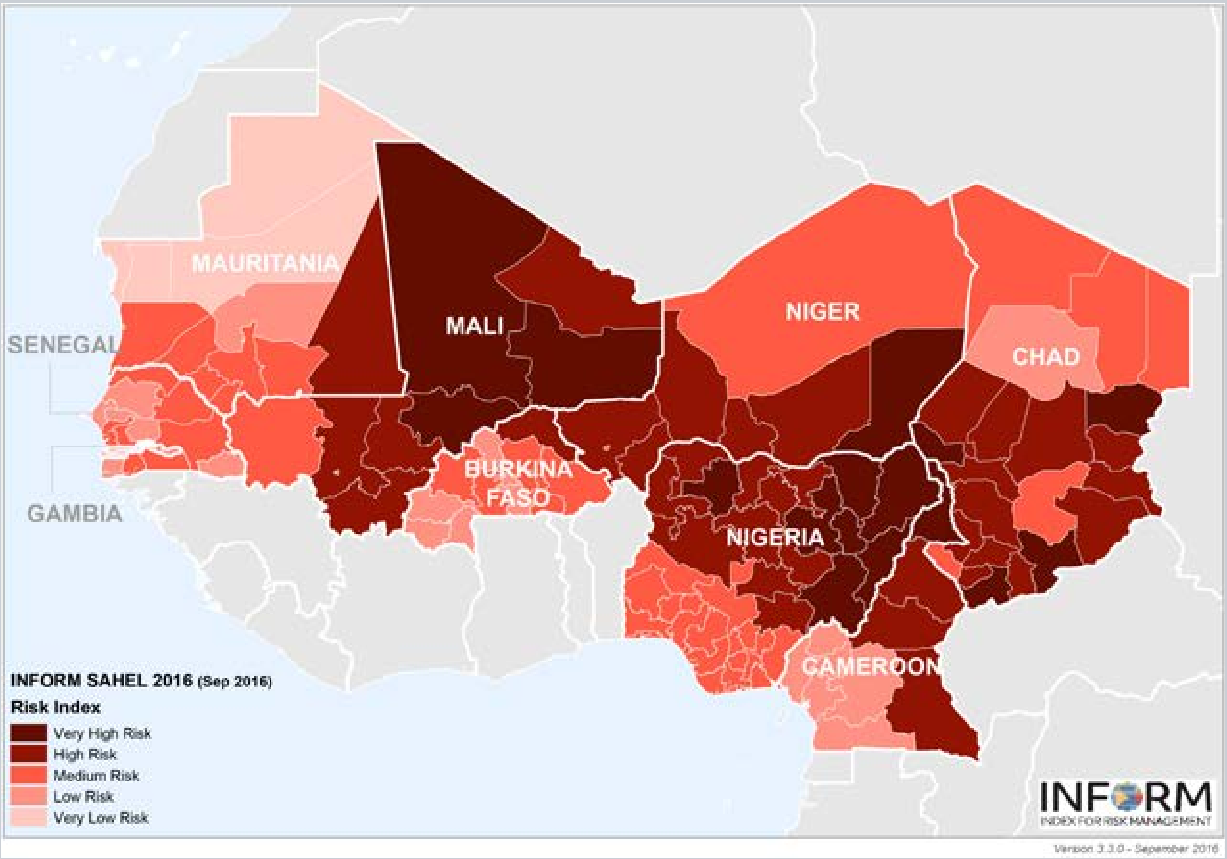
Global climate change is expected to modify hazard levels in Africa through changing temperatures, precipitation and sea levels, among other factors. By 2050, it is estimated that 40 % of the global population will be living in river basins that experience severe water stress, particularly in Africa and Asia (UNISDR, 2015). Droughts, and associated crop yields, are expected to be influenced negatively (IPCC, 2014) with strong regional variability. Similarly, changes in flood risk will vary regionally (Alfieri et al., 2017). At the same time, an enormous amount of capital is expected to flow into urban development in the coming decades, particularly in South Asia and sub-Saharan Africa. Some 60 % of the area expected to be urbanised by 2030 remains to be built. Much of the growth will occur in countries with weak capacities to ensure risk-sensitive urban development (see chapter I.2).

BOX 3

Case study: Sahel

More detailed results are available through the regional Index for Risk Management (INFORM) Sahel model, which was initiated by the Emergency Response and Preparedness Group of the regional Inter-Agency Standing Committee of the United Nations and is managed by the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA). This model is being used to support the UN humanitarian programme cycle and to help coordinate preparedness actions. Partners, including the European Commission's Directorate-General for European Civil Protection and Humanitarian Aid Operations (DG ECHO), use the model to improve cooperation between humanitarian and development actors in managing risk and building resilience across the region. The INFORM Sahel model was developed in a series of workshops involving local and international partners. These partners built consensus on the risk factors in the region, and contributed with sector-specific datasets. The INFORM Sahel model drills down to the subnational level, and also describes region-specific components of risk, including food insecurity, land degradation and droughts.

FIGURE 22: Overall risk of humanitarian crises and disasters in the Sahel region, as calculated by the INFORM Sahel model *(Source: INFORM)*



Challenges and opportunities

Disaster risk cannot be measured directly. A composite index, such as INFORM, uses proxy indicators based on available data. With new data-collection initiatives under the UN Sustainable Development Goals, the Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework), and the UN Global Climate Action Agenda, it is expected that models like INFORM will improve rapidly. Global models are of limited use to national governments, but INFORM Subnational[9] already demonstrates that regional and national models relevant to national actors can be developed. Only by involving national governments as actors in the process will risk assessments be relevant to national policy.

Increasingly, new data is also being provided through remote sensing. The Copernicus Emergency Management Service (EMS) has been triggered 20 times for the African continent since it started operations in 2012. The EMS service does not only provide rapid maps in the aftermath of disasters, but also has a component for risk and recovery mapping. The latter component can generate necessary data for risk assessments at local or regional level.

Policy framework

The Sendai Framework for Disaster Risk Reduction sets the goal of preventing new disaster risks and reducing existing disaster risk. It promotes a shift from disaster management to disaster risk management, which involves promoting a better understanding of the risks and raising awareness in order to be able to manage them. Science can deliver robust facts and knowledge about current and future risks. Managing disaster risk is also a pervasive element of the Sustainable Development Goals, the UN Climate Change agenda, and the New Urban Agenda.

Policy priorities include the establishment of disaster loss databases at national level and the development of national risk assessments. The European Commission is funding related capacity-building programmes for African countries.

2) Gaps, future actions and priorities to be considered

Our current understanding of disaster risk and the options to reduce it is based on sparse data and models that can be further refined. It is imperative that better data is collected and shared at local and national level on the many elements that contribute to disaster risk. In 2015, all countries committed to collect such data under the SDGs and the Sendai Framework for Disaster Risk Reduction. Disaggregated socio-economic data, detailed disaster-loss data and better physical data are required to better model risk in African countries. In Africa's challenging environment, with rapid socio-economic development, increasing population and changing hazards due to climate change, more evidence is vital for good risk governance.

Supporting references and web links

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9 An INFORM Subnational risk index shows a detailed picture of risk and its components within a single region or country.

4. Food security

1) Key findings

Assessment of the situation

Over the past 55 years, total cereal production in Africa has increased fourfold, closely following population growth (see Figure 23). In many African countries, agricultural area per capita is declining due to population growth, competition for land and the impacts of climate change, putting pressure on households' livelihoods and overall food security.

> *"Cereal production has quadrupled in Africa since the 1960s, in line with population growth."*

The determinants of cereal production, i.e. yield and harvested area, have been growing roughly at the same pace (except during the period 1974-84), reaching twice their 1960 values in 2014.

FIGURE 23: Trends in cereal production, area harvested and yield in relation to population growth (1962-2014; reference year: 1961) *(Source: FAOSTAT)*

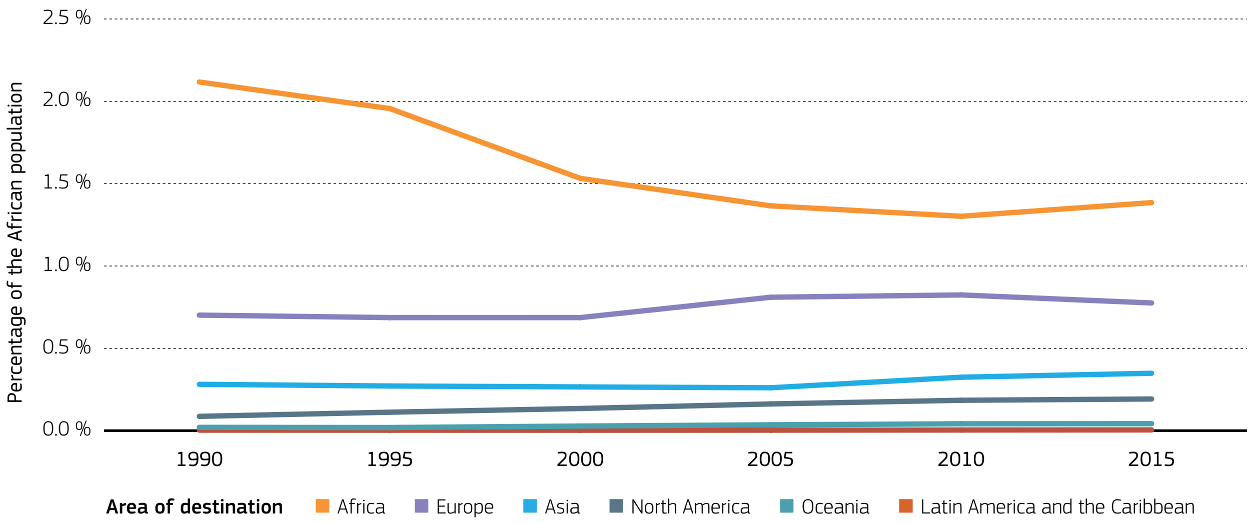
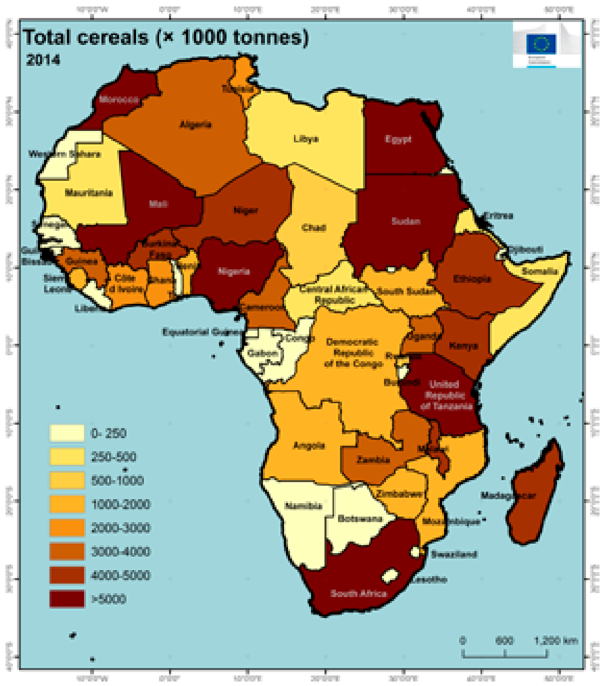


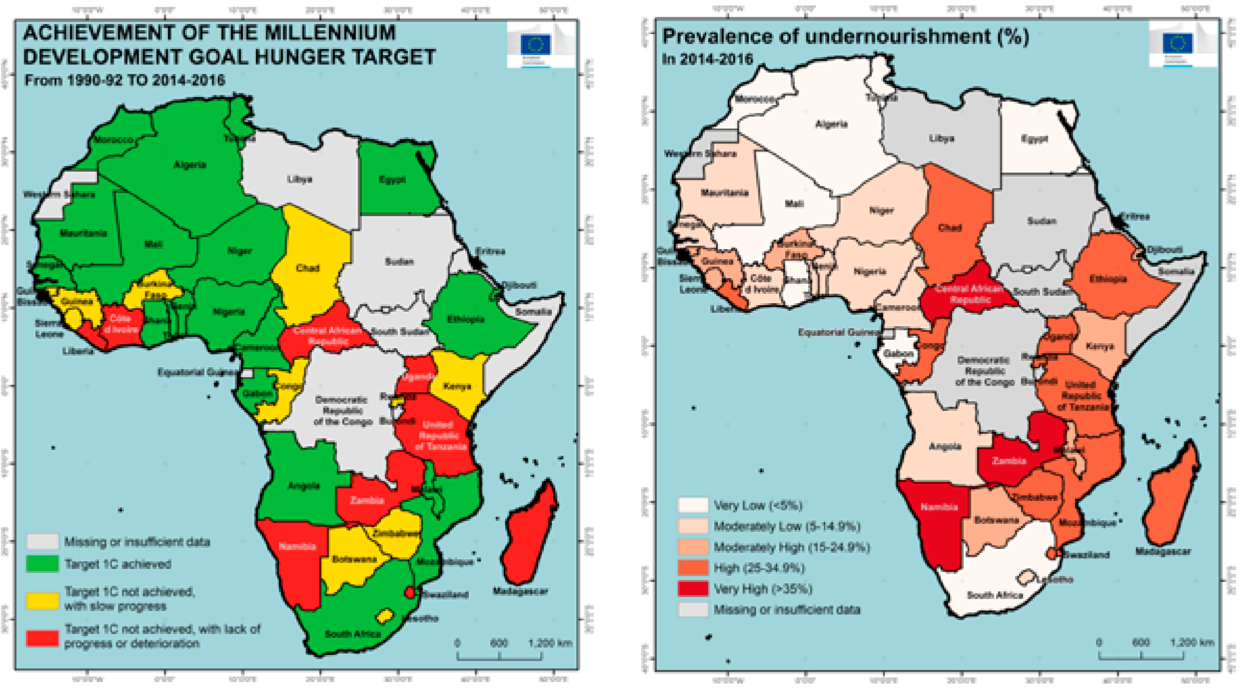
FIGURE 24: Cereal production in Africa (2014) *(Source: FAOSTAT)*



However, this overall situation masks the many disparities between countries. For example, average yields progressed from roughly 1 000 kg/ha to 4 000 kg/ha in South Africa, while they stagnated at around 500 kg/ha in Niger. Figure 24 shows the levels of production per country in 2014.

In 2015, the Food and Agriculture Organization of the United Nations (FAO) reported that 22 countries in Africa had reached the Millennium Development Goal of hunger reduction (FAO, IFAD, WFP, 2015), i.e. halving the prevalence of undernourishment during the period 1990-2015. Figure 25 below (left) illustrates this point, with all countries in green having achieved the goal.

FIGURE 25 (left): Achievement of the Millennium Development Goal target for hunger reduction, from 1990-1992 to 2014-2016; (right) Prevalence of undernourishment (%) in 2014-2016 *(Source: FAO)*



Child helping to grind cassava ©EU, by Andreas Brink

However, the percentage of undernourished remains high to very high in many countries (respectively above 25 % and 35 %) – as shown in Figure 25 (right). It should be noted that the prevalence of undernourishment can vary significantly from one year to the next due to food crises. In addition, as shown on this map, statistical reference data are missing for specific countries where undernourishment levels are particularly high, e.g. Somalia, the Democratic Republic of the Congo (DRC), Burundi and South Sudan. The map is based on data and definitions from the FAO Statistics Division (FAOSTAT)10.

> “Although almost half of all African countries reached the MDG of hunger reduction by 2015, undernourishment is still rife in many countries.”

At the continental level, efforts to overcome undernourishment have had mixed results. While the prevalence of undernourishment has fallen to about 19 % in the continent as a whole, the overall number of undernourished is still on the rise, reaching about 230 million people (including 218 million in sub-Saharan Africa) in 2014-16.

10 Undernourished refers to the condition of people whose dietary energy consumption is continuously below a minimum dietary energy requirement for maintaining a healthy life and carrying out light physical activity (*Source: FAO Statistics Division*).

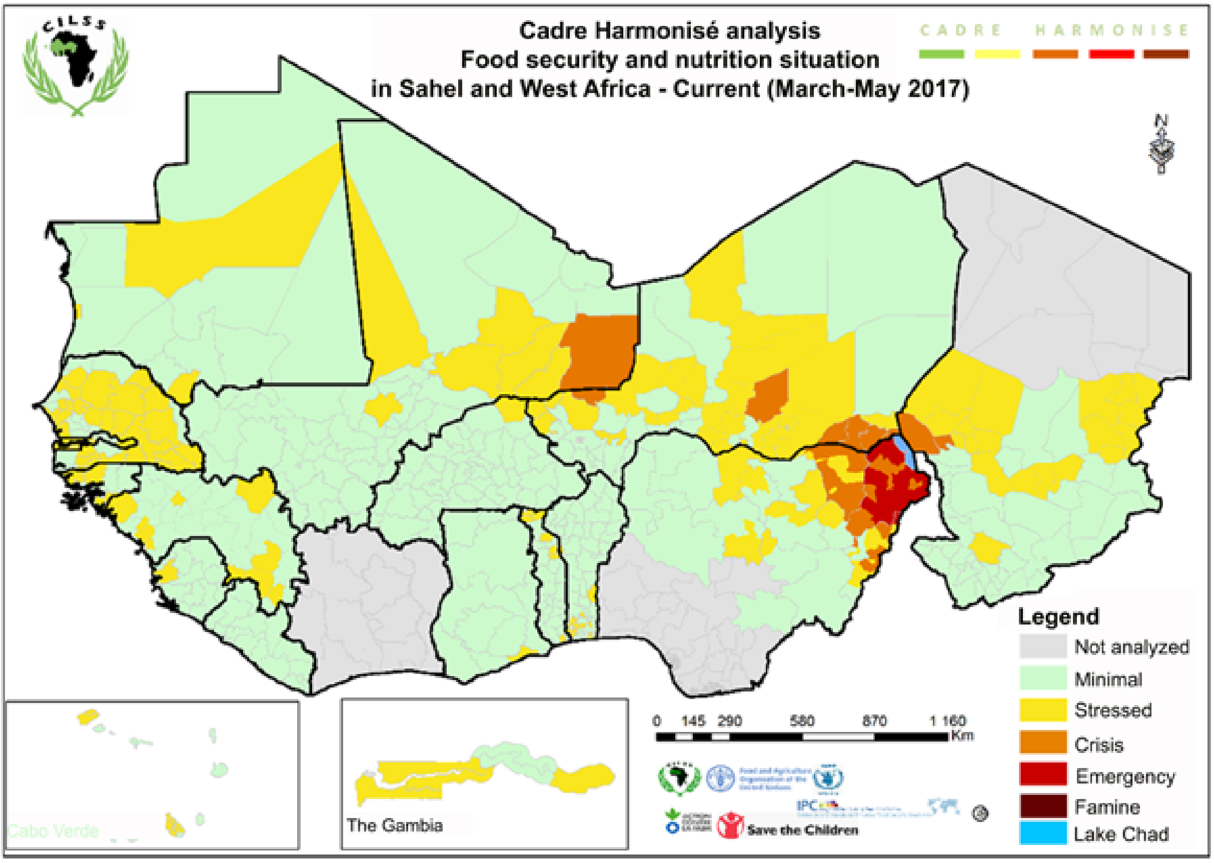
Outlook

The 2017 food security situation in Africa is extremely alarming, with famine, or a high risk of famine, faced by three countries (Somalia, South Sudan and Nigeria). As of early 2017, a total of about 108 million people were reported to be affected by food crises, a substantial increase over the 2016 assessment of 80 million people. This increase is due to the intensification and extension of armed conflicts and political unrest, the consequences of El-Niño-induced drought, and the drought in Eastern Africa driven by the La Niña phenomenon.

> “Several African countries are in severe food crisis/famine situations due to armed conflict, political unrest and drought.”

This situation further highlights the importance of having a common standard against which to analyse and compare the food-security situation in different countries, to allow for the prioritisation and scaling of intervention measures. To address this, the JRC and 11 other major food-security agencies developed the Integrated food security Phase Classification (IPC), which began in 2006. The IPC has since become the *de facto* international standard for classifying food insecurity. It classifies the severity of the food-insecurity situation into five categories, ranging from minimal (1) to famine (5). Analyses are carried out by national, multi-stakeholder, technical working groups, in which governments have a central role. A similar and fully compatible system has been put in place for West Africa: the Cadre Harmonisé. Figure 26 shows the results of the regional analysis carried out for West Africa for the period March-May 2017, to which the JRC directly contributed.

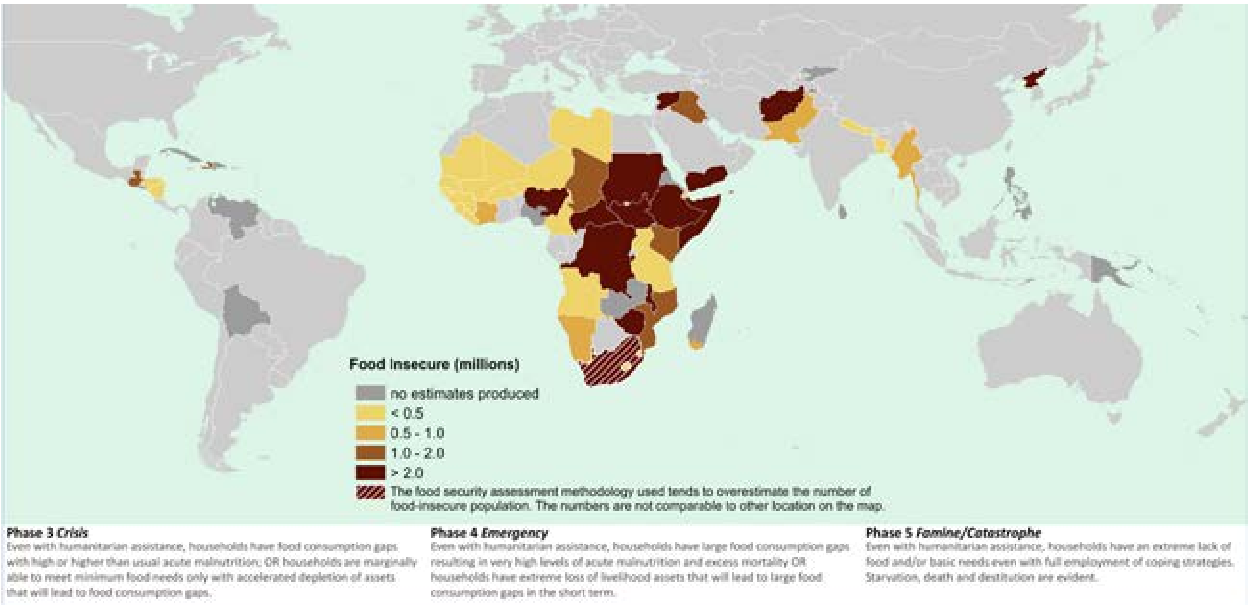
FIGURE 26: Food and nutrition situation in the Sahel and West Africa (March-May 2017) *(Source: Cadre Harmonisé)*



Since 2014, an annual Global Report on Food Crises is prepared on the initiative of the European Commission's Directorate-General for International Cooperation and Development (DG DEVCO) and the JRC, based on the IPC/Cadre Harmonisé standard. This report collates, analyses and synthesises information on food crises globally through a collaborative process between major food-security agencies. It provides vital information for the Global Network against Food Crises, which was launched by the EU, the FAO and the World Food Programme (WFP) at the World Humanitarian Summit in May 2016. The Global Network against Food Crises aims to jointly assess and analyse global food-crisis situations in order to develop more effective and coordinated responses.

The 2017 issue of the report was launched on 31 March 2017 in Brussels. Figure 27 presents the global map of food crises as of January 2017. All countries in dark red have at least 2 million people in food crisis (IPC phase 3 or more). Ten such countries are located in Africa.

FIGURE 27: Most countries facing severe food insecurity in January 2017 are located in Africa



Challenges and opportunities

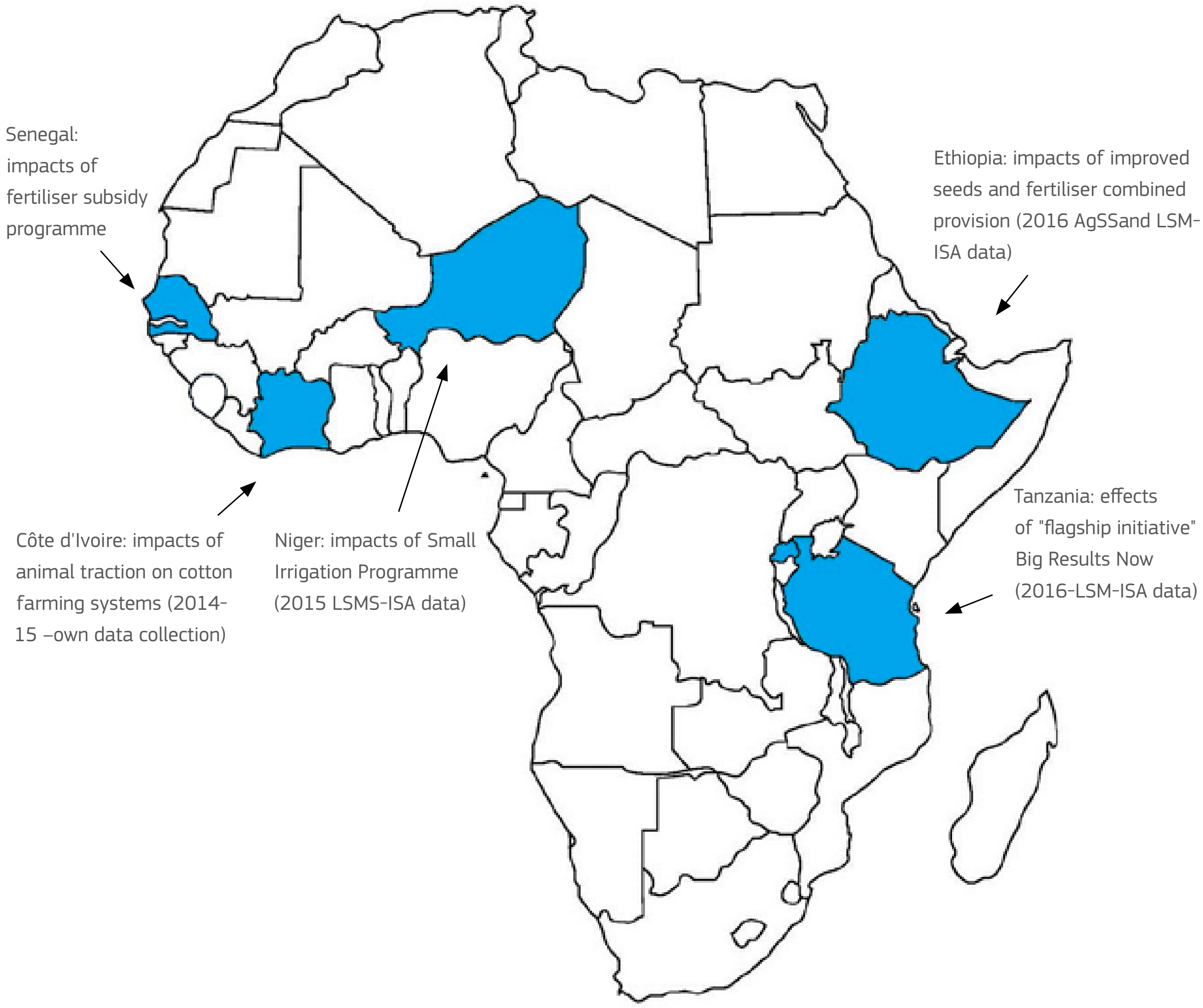
To improve medium- and long-term responses, tools are needed that can develop and test policy options for improved food and nutrition security. In particular, the potential economic and social effects of national policies (e.g. agricultural inputs and investment programmes, investments in infrastructure, education and health, social protection, trade and food aid, and rural development programmes) should be better understood.

Such analysis can be performed on individual countries using a general equilibrium model. For example, such a model is currently being applied to analyse agricultural policy reforms in three countries (Kenya, Senegal and Ethiopia) regarding input subsidies (fertilisers and seeds), investment (irrigation and rural infrastructure), extension services and fiscal policy (agricultural exemptions, direct taxation and social transfers).

In addition, farm-household models can be used to analyse a wide range of agricultural and food policies. They enable flexible assessment and simulate the distributional effects of policies on the population of farm households, which can inform policymakers on how changes in prices, technology, food and agricultural policies might affect the viability and food security of heterogeneous sets of farming households, which characterise the agricultural sector in sub-Saharan Africa.

Such a modelling exercise is ongoing in five countries, namely Côte d'Ivoire, Niger, Tanzania, Senegal and Ethiopia. Together with the associated institutional and technical cooperation activities, it will provide local administrations with a better understanding of the possible impact of various policies being implemented.

FIGURE 28: Countries selected for the simulation of the impact of agri-food policies (Source: JRC)



Policy framework

The overarching international policy framework is defined by the United Nations Agenda 2030 and SDG 2 adopted in September 2015 by the United Nations (UN) Sustainable Development Summit: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture". The 2016 Global Strategy for the European Union's Foreign and Security Policy and the new European Consensus for Development adopted by the Council in May 2017 give the reference European framework, with the main instruments of the European Development Fund and the Development Cooperation Instrument (DCI).

2) Gaps, future actions and priorities to be considered

In the future, action should continue on key issues such as the sustainability of food-information systems, the harmonisation and comparability of information, the link between relief, rehabilitation and development, the coordination of responses to crises, the availability and quality of basic data, the accessibility of areas of conflict, capacity building, the measurement of resilience and social transfers and safety nets.

In addition, emerging issues are to be addressed. On 27 April 2017, the High Level Panel of Experts (HLPE) of the Committee on World Food Security issued its 2nd Note on Critical and Emerging Issues for Food Security and Nutrition (FSN). After a wide consultation process, the HLPE identified nine main chapters that need further consideration: anticipating the inter-connected future of urbanisation and rural transformation; conflicts, migrations and FSN; inequalities, vulnerability, marginalised groups and FSN; impacts of trade on FSN; agroecology for FSN in a context of uncertainty and change; agrobiodiversity, genetic resources and modern breeding for FSN; food safety and emerging diseases; from technology promises towards knowledge for FSN; and strengthening governance of food systems for an improved FSN.

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Sustainable Development Goal 2:
https://sustainabledevelopment.un.org/?page=view&nr=164&type=230&menu=2059

PLANET

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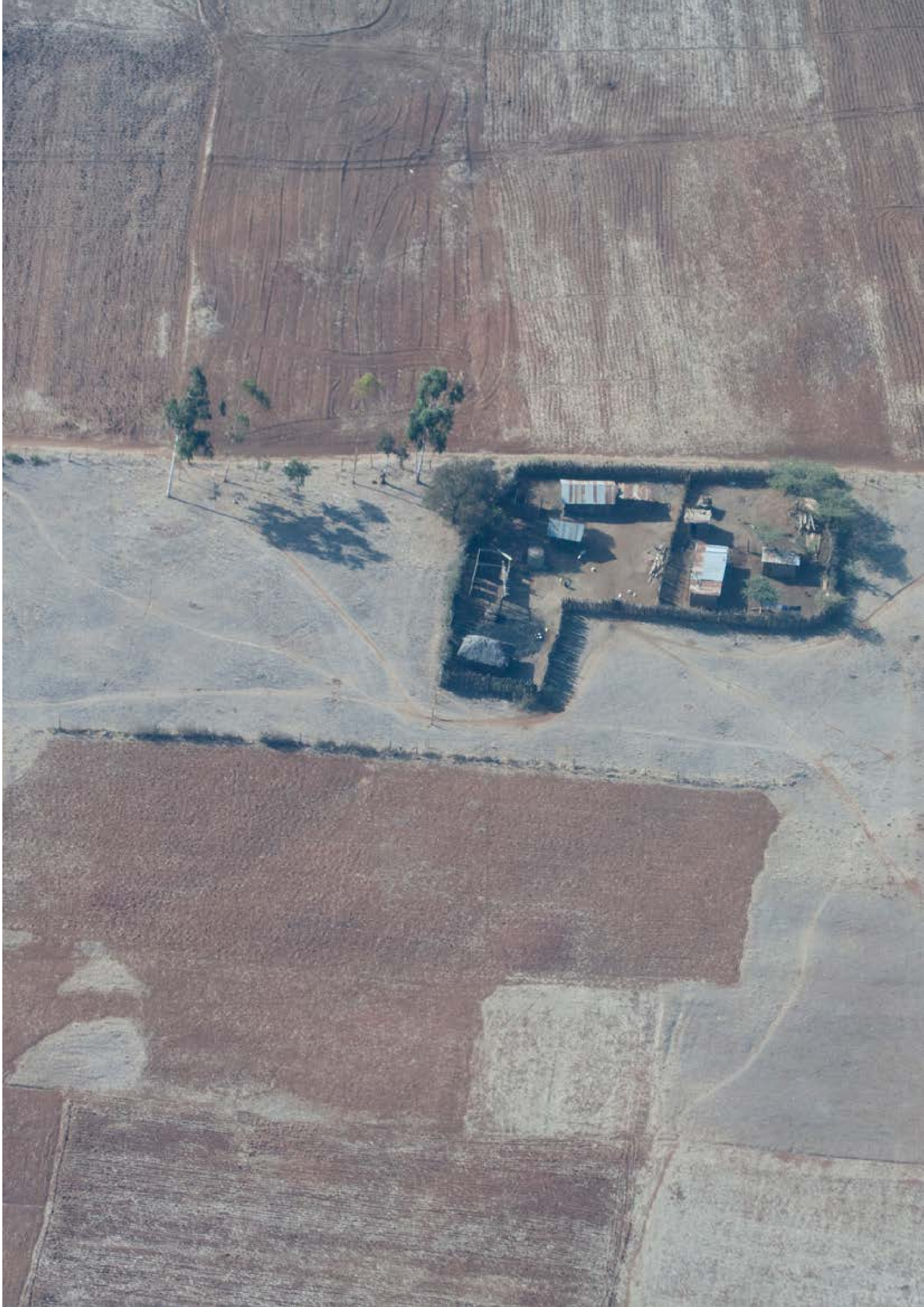
NATURAL ENDOWMENTS, ITS
ENVIRONMENT AND ECOSYSTEMS,
INCLUDING ITS WILDLIFE AND
WILD LANDS ARE HEALTHY,
VALUED AND PROTECTED, WITH
CLIMATE RESILIENT ECONOMIES
AND COMMUNITIES"

– Agenda 2063



5. Climate and climate change

5.1. Projections of future climate change

1) Key findings

Assessment of the situation

Africa, the second-largest continent on Earth, has a wide variety of climate zones11, ranging from tropical rainforests to deserts, from Mediterranean to savannah, from highlands to steppe. The diversity of climates is evident, for example, in the variation in temperature and precipitation. The highest temperature on record in Africa reached 57.8 °C (Libya, 1922, although this may have been subject to measurement errors) whereas the lowest was -24 °C (recorded in Morocco in 1935). Total annual rainfall in the arid deserts of the northern part of the continent can be as low as 50 mm, whereas tropical rainforests in central Africa can receive over 4 000 mm of rain in a year[12].

The African climate is driven by complex interactions between the atmosphere, ocean, and land surface. These generate weather phenomena such as the West African monsoon – a seasonal change in predominant winds associated with high temporal and spatial variability in precipitation (Browne Klutse et al., 2016).

> “Although almost half of all African countries reached the MDG of hunger reduction by 2015, undernourishment is still rife in many countries.”

Africa is one of the continents most vulnerable to weather and climate variability (IPCC, 2007; IPCC, 2013), with several million people regularly suffering the impacts of extreme weather events. One-third of the people in Africa live in drought-prone areas and are vulnerable to droughts. Over the past century, West Africa has been affected by significant climate anomalies which have led, for instance, to the severe droughts of the 1970s and 1980s. Other areas, such as the Horn of Africa and southern Africa, have also suffered serious droughts, particularly since the end of the 1960s. On the other hand, severe floods (which can result in substantial economic and human losses) have even affected countries located in dry areas, such as Algeria, Tunisia, Egypt and Somalia (IPCC, 2013).

> “Given the low adaptive capacity, future climate change may lead to even more severe impacts on many vital sectors such as agriculture, water management, and health.”

Outlook

Future climate change and low adaptive capacity may lead to even more severe impacts on many vital sectors, such as agriculture, water management and health. A brief overview of the expected changes in average climate and extreme events, as projected by state-of-the-art climate models, is presented below.

Projected change in temperature

Africa will become hotter: at the end of the 21st century, under the most severe climate change scenario evaluated by the Intergovernmental Panel on Climate 1Change (IPCC) (Representative Concentration Pathway 8.5 – RCP8.513), climate models project that a warming of more than 3.5 °C will occur in most of the African continent in the northern hemisphere winter (January-March). Temperatures may increase by up to 6 °C in the summer (July-September) in much of northern Africa, the Sahara and the Arabian Peninsula (Dosio, 2016; Figure 29a).

The most severe effects of global warming, however, will be related to the frequency and severity of extreme events, such as heatwaves, which have increased in number and spatial extent in recent decades (Ceccherini et al., 2017). For instance, in 2002, north-eastern Nigeria suffered one of the hottest and driest spells in living memory, with recorded temperatures of over 50 °C. Dozens of people died as a result14. Future projections suggest that, by the end of the century, heatwaves (i.e. days when the temperature is higher than the current top 10 % of all occurrences) may become extremely long (more than 60 consecutive days) and frequent (once every two years, Figure 29c) in large areas of central

11 Since climate determines the type of natural vegetation that grows in an area, vegetation can be used as an indicator of climate type.

12 Our Africa, Climate: http://www.our-africa.org/climate

13 Representative Concentration Pathways are a set of scenarios used by the IPCC, which provide trajectories over time of atmospheric greenhouse gas (GHG) concentrations. RCP8.5 assumes high population and relatively slow income growth with modest rates of technological change and energy-intensity improvements, leading to high GHG emissions in the absence of climate change policies.

14 http://news.bbc.co.uk/2/hi/africa/2038164.stm

Africa, the Sahel, the Horn of Africa, and the Arabian Peninsula (Dosio, 2016).

Projected change in rainfall

The projected change in rainfall varies widely, depending on the region and season. For some areas (e.g. the Sahel), climate models show significant uncertainty about how much precipitation will change. For certain regions (e.g. central Africa), some models show a significant reduction in precipitation, and others an increase.

Dust devils occur more frequently during prolonged drought periods, Ethiopia ©EU, by Grégoire Dubois

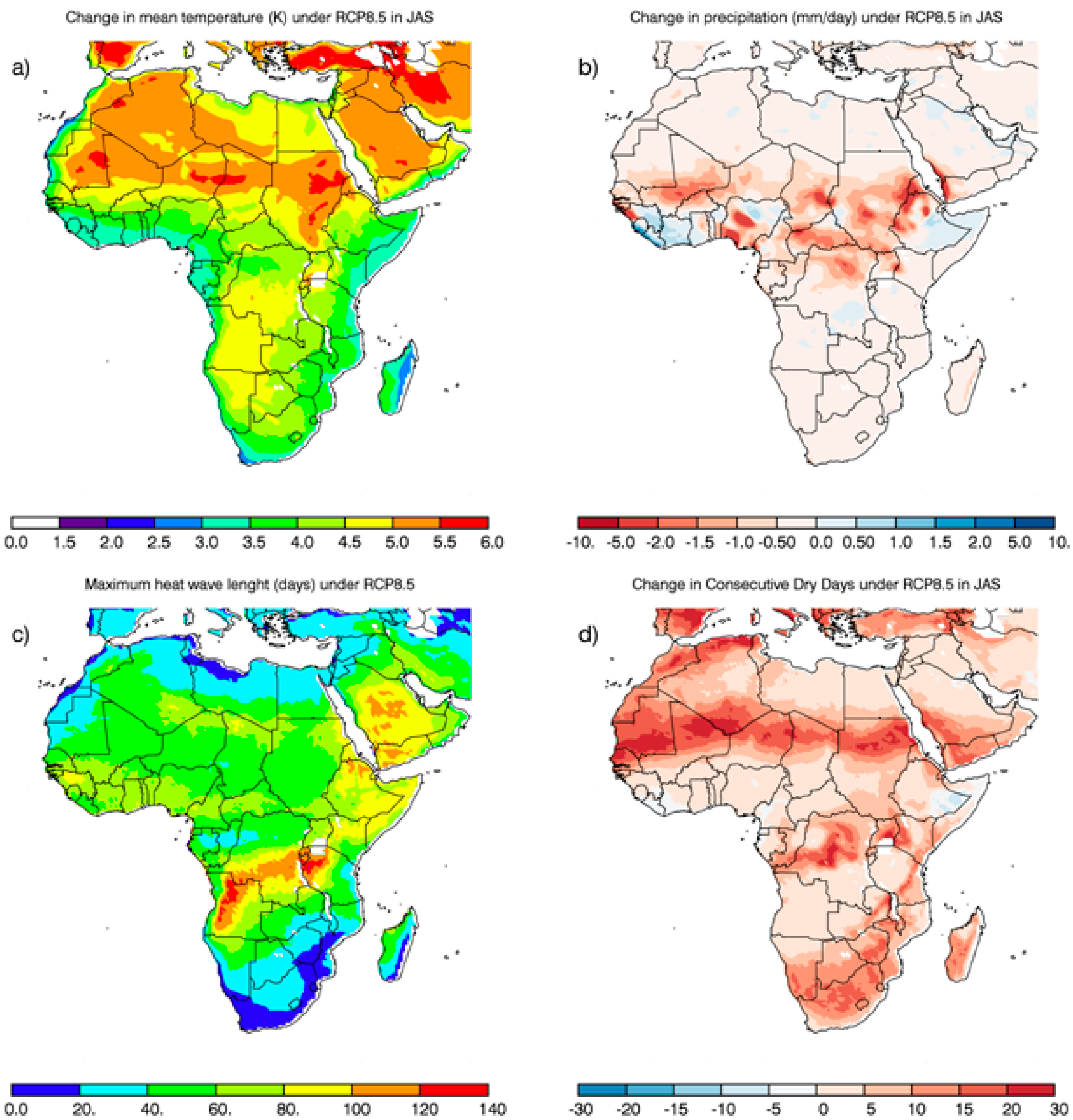
However, there are areas where the precipitation change projected by climate models is statistically robust and significant and the results are more trustworthy. For instance, a fall in total annual mean precipitation is expected for southern Africa, together with a rise in the magnitude of extreme precipitation events. As a consequence, dry spells will become longer, and precipitation may be more extreme when it occurs (Dosio and Panitz, 2016; Figures 29b and 29d). An increase in average rainfall is expected in the eastern part of the Horn of Africa, especially from October to December, associated with a faster warming rate in the western parts of the Indian Ocean and a change in the magnitude and frequency of El Niño[15] events (Endris et al., 2013).

Over the last decade, the scientific community has made a comprehensive effort to collect data and carry out modelling activities, focusing primarily on West Africa. These activities included the West African Monsoon Modelling and Evaluation initiative, the African Multidisciplinary Monsoon Analysis and the Ensembles-based prediction of climate changes and their impacts.

Recently, a new initiative has emerged, endorsed by the World Climate Research Programme, which aims to foster international collaboration on producing improved climate change projections at regional scales: the Coordinated Regional Climate Downscaling Experiment (CORDEX). Due to its vulnerability to climate change, the projected significant impacts of climate change, and the general lack of climate projections based on Regional Climate Downscaling tools, Africa was selected as the first target region for the CORDEX activity.

15 The El Niño phenomenon is an ocean-atmosphere climate interaction linked to a periodic warming in sea-surface temperatures in the central and east-central Equatorial Pacific, which can significantly influence global weather patterns.

FIGURE 29(A): Projected change (with respect to the present climate) in average June-August-September (JAS) temperature; (b) daily precipitation, by the end of the century under the RCP8.5 emission scenario; (c) projected maximum duration of heat spells occurring, on average, once every two years, at the end of the century; (d) projected change in the number of consecutive dry days by the end of the century (modified from Dosio, 2016 and Dosio and Panitz, 2016)



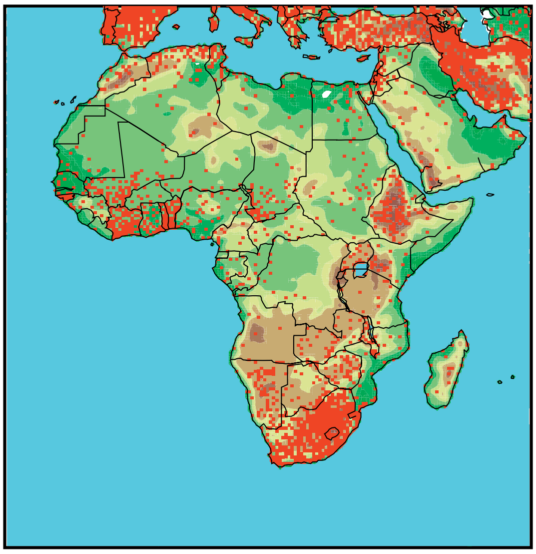
2) Gaps, future actions and priorities to be considered

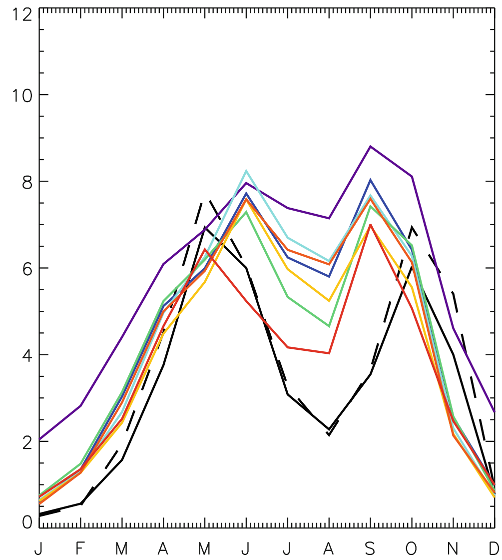
Climate model deficiencies

To properly simulate the climate of such a large and heterogeneous continent, models need to correctly replicate the many physical processes and their complex interactions. Although climate models can replicate in general the main characteristics of the African climate, they still present significant deficiencies. For instance, the large majority of models overestimate precipitation by more than 20 % on average (and in some cases by as much as 80 %) in large areas that often extend into equatorial Africa (IPCC, 2013; Gbobaniyi et al., 2014; Pinto et al., 2016). In addition, model projections are often uncertain and, in some cases, contradictory (Dosio and Panitz, 2016).

Research is still needed to assess the robustness of the climate change signal and to try to identify and quantify the many sources of uncertainty that remain.

FIGURE 30 (left): Availability of the Global Precipitation Climatology Centre (GPCC) gauge stations in January-March for the period 1998-2008. Red dots show the locations where at least one gauge is available for at least one month *(Source: adapted from Nikulin et al., 2012. ©American Meteorological Society, used with permission)*; (right): annual cycle of daily precipitation (unit: mm/day) in the Gulf of Guinea (1989-2008). Each coloured line represents a different observational dataset (re-analysis, satellite product, or gauge-based product). The uncertainty can be very large, reaching e.g. nearly 4mm/day in July-August. The black lines show the results of a climate model *(Source: adapted from Panitz et al., 2014 ©Springer, used with permission)*





Observational deficiencies

Observations are fundamental to both assess the main characteristics of the past and present climate and evaluate the ability of the models to simulate them correctly.

High-quality observational datasets for Africa are scarce: although satellite-based products have become available in the past decade, ground-based observations are particularly problematic, as only a very few countries possess a spatially and temporally homogeneous network of measurement stations (Nikulin et al., 2012; Figure 30).

In addition, different observational products show substantial systematic differences, not only in mean rainfall, for example (Figure 30), but especially in higher-order statistics, such as the frequency and duration of wet and dry spells (Sylla et al., 2012, Panitz et al., 2014).

Interpreting climate information and integrating it into policy

As already mentioned, the projected future change of variables such as precipitation may be very uncertain, or even contradictory for certain regions. In addition, decision-makers usually need information at a scale (local, urban) that is more precise than that provided by climate models. The challenge is therefore twofold: to translate the knowledge of climate science into meaningful, reliable and useful information and to integrate this knowledge into policy- and decision-making.

To address this topic (identified as a 'grand challenge focus' by the World Climate Research Programme), an ongoing project funded by the United Kingdom's Natural Environment Research Council, Future Resilience for African Cities and Lands, aims to advance scientific understanding of the African climate and better integrate this science into medium-term investments, policies and plans. The intention is to foster strong collaboration between researchers, city government officials and other key decision-makers to co-produce relevant knowledge that will support resilient development pathways in selected southern African cities (Lusaka, Maputo, Windhoek, Blantyre, Gaborone, Harare, Cape Town, eThekwini and Johannesburg). If successful, the methodology of the project and its outcomes may be extended to other African cities, although dedicated funding opportunities and research projects are needed.

Expected impacts of climate change and adaptation options

Climate variability (including extreme events) and the projected climate change may result in increased stress on several sectors, such as water availability and accessibility (which could become problematic for millions of people), energy production, agriculture, health and ecosystems. However, sector-specific studies are scarce, and model results must be treated with caution because of the uncertainties involved (starting from the climate change projections and the underlying emission scenarios).

Another possible consequence of climate change that requires further research is the increasing number of people expected to move in search of new settlements. These migration patterns may not only be limited to long-term migration, but may also include repetitive (or circular) migration (as part of the ongoing adaptation to climate change) and short-term shock migration (responding to a particular climate event) (see also chapter I.1.2.).

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5.2. Collecting climate observations and building climate services

1) Key findings

Assessment of the situation

The AU and the EU have committed to international global governance initiatives, including the United Nations Framework Convention on Climate Change (UNFCCC) and its associated bodies. In this context, a coordinated approach by Africa and Europe would lead to regional and global benefits, including understanding the benefits of mitigation measures, improved projections concerning climate change, more reliable information to inform adaptation measures, better communication on the state of the climate, and more accurate measurements.

Gaps in the climate-observation record can result in insufficient data to calculate trends. This leads to uncertainty in planning policy responses to climate change, be they for mitigation or adaptation. Observation gaps also compromise the efficacy of climate models. Unfortunately, climate observations for much of Africa are scarce. Gaps in observation networks (such as the Global Terrestrial Network for Glaciers) also occur throughout the continent, and information needed for formal reporting to the UNFCCC (such as inventories of greenhouse gas sources and sinks) can be incomplete.

> “Gaps in the climate observation record can lead to uncertainty in planning policy responses to climate change.”

African and European national meteorological services have a role as keepers of national climate records. However, more reliable systematic climate observations must be developed. Climate observations include atmospheric variables (such as air temperature and wind speed), oceanic variables (such as sea-surface temperature and sea level), and terrestrial variables (such as river discharge, soil moisture and land cover). The World Meteorological Organization and its Global Climate Observing System (GCOS) identify the full list of variables that need to be observed, and provide an internationally agreed framework linked to the UNFCCC within which such development can take place.

There is an old adage that says: "climate is what you expect, and weather is what you get". Climate services provide climate information to help decision-makers plan for the weather they are likely to experience. They provide details such as the likelihood of changes, the direction of change (e.g. drier/wetter, hotter/colder), the magnitude of changes, locations of change and the occurrence of severe or extreme events. The services are linked to specific users' needs, which can vary enormously (typical uses may include seasonal variations in the reliability of rivers for transport, seasonal variation in the carrying capacity of grazing land, likely variations in crop yield, and likely incidence of savannah and forest fires), and are always based on scientifically credible information and expertise. They inform policy and priority-setting at national, regional and continental levels. They can also help increase resilience, which is particularly needed by those most vulnerable to the impacts of weather and climate-related hazards such as droughts and flooding. Such climate services are being developed in Europe and Africa; opportunities to reinforce links between these should be further explored.

> “Climate services will assist decision-making by governments, organisations and individuals as climate changes and adaptation is required.”

Elephants at a waterhole during the dry season in Botswana ©EU, by Grégoire Dubois

Outlook

In 2016, the GCOS submitted a new Implementation Plan to the UNFCCC's Subsidiary Body for Scientific and Technological Advice, outlining steps that the international community needs to take to improve the completeness, quality and relevance of systematic climate observations. The 22nd Conference of the Parties (COP 22) to the UNFCCC adopted this plan through a draft decision in Marrakech in November 2016.

Observations need to be coupled with climate services. Significant progress is being made here, too. Important initiatives were launched in the last decade to address climate change issues in Africa and worldwide. Among them, it is worth mentioning ClimDev-Africa and the Global Climate Change Alliance Plus (GCCA+). ClimDev-Africa is an initiative of the AUC, the United Nations Economic Commission for Africa (UNECA) and the AfDB, which aims to improve the provision of climate information for Africa, strengthen the use of such information in decision-making, and improve analytical capacity, knowledge management and dissemination. The EU has provided support for ClimDev-Africa, particularly in the setting-up of the African Climate Policy Centre. The GCCA+ was established by the EU in 2007 to strengthen dialogue and cooperation with developing countries. Its activities are centred on three key areas: mainstreaming climate change into poverty-reduction and development efforts; increasing resilience to climate-related stresses and shocks; and supporting the formulation and implementation of concrete and integrated sector-based climate change adaptation and mitigation strategies. The GCCA+ work programme is in place until 2020.

Europe is putting in place a dedicated climate change service in the context of its Copernicus Earth observation programme. In 2015, the European Commission and the Africa, Caribbean and Pacific Secretariat jointly decided to launch an important programme under the auspices of the World Meteorological Organization's 'Global Framework for Climate Services' (GFCS). The programme is expected to further strengthen the link between data providers and users by ensuring a close link with the information produced and disseminated by the data providers, particularly Copernicus. Regional climate centres will further develop and customise the existing climate information to user needs, and will deploy a broad capacity-building programme to enforce national and regional capacities in the use of climate information for decision-making and strategic planning. Both the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) and the JRC will be actively involved in technological development and training activities. The JRC is expected to play a central role in maximising the link with Copernicus and with the other key Earth observation programmes recently undertaken in Africa, such as the 10th European Development Fund project Monitoring for Environment and Security in Africa (MESA) and Global Monitoring for Environment and Security in Africa (GMES and Africa), both implemented by and through the AUC.

Challenges and opportunities

Together, African and European counterparts can take responsibility for the actions outlined in the GCOS plan. This will have multiple benefits for the two regions and the global community, by ensuring that the climate system continues to be accurately monitored, and that global, regional and local long-term climate forecasts are improved with better and more comprehensive data. The latter is ensured by refining and tailoring observation requirements and parameters to various users, by improving techniques and addressing the global climate cycles more holistically, by providing observational evidence and getting this to the users, and by improving communication on the state of the climate across Africa, Europe and the world.

> “African and European actions to implement the GCOS plan will help ensure that the climate system is accurately monitored, and that climate forecasts are improved with better and more comprehensive data.”

The Copernicus Climate Change Service and Global Land Service provide a number of key climate observations. In addition, the Climate Change Service provides reanalysis, seasonal forecasts, climate projections and climate indicators (indicators of the causes and effects of climate change). Links may also be established with users of climate services within individual nation states (such as those responsible for the management of water, agriculture and forestry), and training provided along with access to the services.

The infrastructure developed by MESA can also play a role. MESA has developed the eStation. This is a stand-alone computer system that can receive and process satellite imagery along with environmental information directly via satellite telecommunications. This means that the systems can operate without internet access (although they can retrieve data via the internet where connections exist). The system offers analysis tools that can be adapted to conditions in any particular African country or region. The eStation has been developed by the JRC in line with the 4th Africa-EU Summit (Brussels, 2014) which called for the "establishment of a coherent framework for the development of Earth observation activities in Africa so that space strategically contributes to Africa's socio-economic development". The eStations have been successfully deployed in 47 sub-Saharan countries in over 180 institutions, at the regional and national level. MESA and Copernicus provide a framework within which to further develop cooperation between African and European counterparts.

The 'Climate Services Adaptation Programme in Africa: Malawi & Tanzania' was the first multi-agency initiative to be implemented under the global framework. The programme focuses on user-driven climate services for food security, health and disaster-risk reduction. While the initial geographic focus is on Malawi and Tanzania, this could be expanded in the future.

Policy framework

As Parties to the UNFCCC, the AU and the EU Member States endorsed the GCOS 2016 Implementation Plan at the 22nd session of the Conference of the Parties (COP22) in Marrakech in 2016. The COP decision (UNFCCC, 2016) encourages Parties to the Convention to fully embrace the Implementation Plan and to consider what actions they can take. It also emphasises the need to maintain, strengthen and build capacities for climate observations, monitoring and data management, including data recovery, digitisation, analysis, archiving and sharing, and to build capacity in developing countries through existing relevant mechanisms.

Under the UNFCCC, National Adaptation Programmes of Action provide a process for least-developed countries to identify priority activities that respond to their urgent and immediate needs with regard to adaptation to climate change – those needs for which further delay could increase vulnerability or lead to increased costs at a later stage. Over 50 African countries have submitted programmes to the UNFCCC. The priority needs identified in these programmes include improved observation systems in relation to adaptation, food security, water-resource management and vulnerability to sea-level rise, and improved early-warning of extreme events.

Small-scale irrigated agriculture in Benin ©EU, by Andreas Brink

2) Gaps, future actions and priorities to be considered

The 2016 GCOS report on the Status of the Global Observing System for Climate identified significant gaps in the climate-observing system in Africa. Many of these are due to a lack of equipment, funding and skills.

The ClimDev-Africa programme echoes the above, and suggests that improving and linking existing national and regional networks could create a pan-African hydro-meteorological network. Improvements would include ground-based systems, internet and mobile phone systems, and the use of satellite products, services and infrastructure. The services and infrastructure could build on the existing MESA programme and Copernicus service.

Indeed, ClimDev-Africa highlights the lack of appropriate climate information and services as one of the main challenges. In turn, the lack of services contributes to insufficient awareness of the existence of climate information, a lack of access to information and data, a lack of capacity to use climate information, reluctance to incorporate climate issues into management practices, and limited capacity to deal with scientific uncertainties.

The GCCA+ initiative highlights the need for greater engagement with non-state actors (including the private sector) and the importance of monitoring and evaluating climate services.

Greater coordination and cooperation are required to fill the gaps identified by the GCOS 2016 Implementation Plan. Specific actions can include the provision of equipment, equipment maintenance, training of personnel, and awareness-raising among governments and policymakers. Bilateral AU-EU partnerships, projects with international partners (especially ClimDev-Africa and GCCA+), and e-learning programmes (such as that started with MESA) also have a role to play in enforcing the Implementation Plan.

Improved climate databases and information sharing are important, too. Indicators and measures should be developed, aligned to the ClimDev-Africa and GCCA+ objectives, the SDGs and progress reporting for the UNFCCC.

Regional climate centres (operating within the Global Framework for Climate Services) and national meteorological services can enhance capacities for adaptation to climate change, as focused climate services are put in place. Enhanced cooperation with the Copernicus services should be envisioned.

Supporting references and web links

Climate for Development in Africa (ClimDev-Africa) Programme: http://www.climdev-africa.org

Climate Services Adaptation Programme in Africa: http://www.wmo.int/gfcs/Norway_2

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5.3. Anthropogenic greenhouse gas and air pollutant emissions

1 Key findings

Greenhouse gas emissions

Africa is severely exposed to the negative impacts of climate change, even though it makes only a minor contribution (8.2 %) to global greenhouse gas (GHG) emissions: 1.3 % from northern Africa (690 million tonnes), 1.9 % from eastern Africa (990 million tonnes), 2.1 % from southern Africa (1070 million tonnes) and 2.9 % from western Africa (1470 million tonnes).

BOX 4

Greenhouse gases and global warming

GHGs absorb solar radiation and emit infrared radiation into the atmosphere, which leads to the warming of the Earth's atmosphere. They include carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), fluorinated gases, ozone and water vapour emitted by anthropogenic and natural sources. The most abundant anthropogenic GHGs are CO2, CH4 and N2O. CO2 is mainly emitted by combustion activities (the burning of fossil and biofuels), but is also produced by certain chemical reactions (e.g. in cement production). CO2 is absorbed (and therefore removed) from the atmosphere by plants as part of their biological carbon cycle. CH4 is mainly emitted during the production and transportation of fossil fuels, and from mining activities, landfills and agricultural sources such as livestock. N2O is emitted by agricultural and industrial activities and fossil-fuel combustion processes.

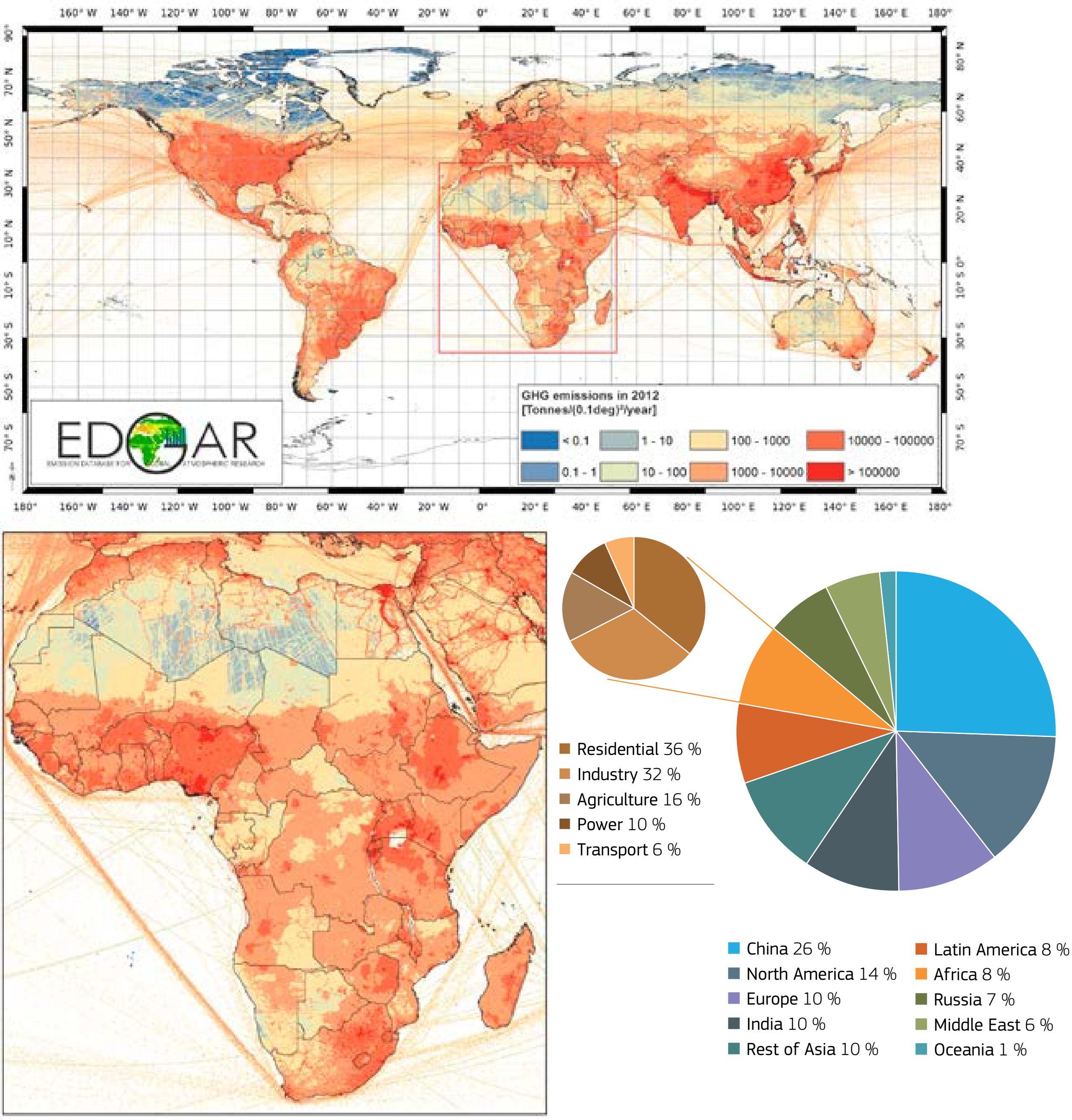
GHGs have different effects on the Earth's warming, due to their varying radiative efficiency and lifetime in the atmosphere. The global warming potential is a metric used to compare the impact of the different GHGs on global warming by giving total GHG emissions in terms of their equivalent in CO2 (CO2eq). It gives a measure of the energy absorbed by 1 tonne of a certain gas relative to that absorbed by 1 tonne of CO2 over a given period (usually 100 years). CO2 has a global warming potential of 1, by definition, and has a lifetime of thousands of years. CH4 absorbs more energy than CO2 but has a shorter lifetime (about 10 years) – it has a global warming potential of 28 (IPCC, 2013). N2O has a potential of 298, and remains in the atmosphere for more than 100 years.

Figure 31 shows a map of global GHG emissions in 2012, as estimated by the Emissions Database for Global Atmospheric Research (EDGAR; preliminary results). The lower map shows the regional shares and the contributing anthropogenic emission sectors in Africa (excluding land use, land-use change and forestry sources and sinks). Most emissions from Africa are generated by the domestic sector (36 %, mainly the result of burning wood for fuel), followed by industry (32 %), agricultural activities (16 %), power generation (10 %) and transport (6 %)[16].

The countries that emit the most in Africa, accounting for almost 50 % of African GHG emissions, are Nigeria (11th in the world ranking), South Africa (17th), Ethiopia (30th) and Egypt (32nd). However, African regions have much lower emissions per capita (3.4 to 5.3 tonnes of GHG/person per year) compared to other world regions (the global average is 7.3 tonnes GHG/person per year). The average annual growth rate in emissions, based on observations from 1970 until 2012, is 2.9 % for southern Africa, 4.5 to 5.1 % for both eastern and western Africa, and 5.9% for northern Africa. These rates are much lower than those observed for other regions, including China and the Middle East, both of which are at around 9 %, while they are quite high compared to countries such as the United States of America (USA) and the EU, which show a rather stagnant pattern.

16 Source: all the numbers in this chapter are JRC in-house estimates from the EDGAR project, publicly available and documented on edgar.jrc.ec.europa.eu

FIGURE 31: Putting Africa's anthropogenic activities in a global perspective using CO2eq. The maps show global GHG emissions (expressed as CO2eq) in 2012, regional shares and sector contributions in Africa (Source: based on EDGARv.4.3.2 data)



Air quality in Africa

The World Health Organization (WHO) identifies air pollution as the major environmental cause of health impacts, inducing strokes, heart disease, lung cancer, chronic and acute respiratory diseases, in people exposed to high levels of pollution in industrialised and developing countries. The WHO has formulated 'Air quality guidelines' which set thresholds for pollution levels that are harmful to health (WHO, 2006). Air pollutants can either be directly emitted into the atmosphere as primary pollutants, or they can be produced in the air through secondary formation processes, such as chemical reactions, nucleation, condensation and coagulation (Seinfeld and Pandis, 2006). Air pollutants can be emitted in the gaseous (e.g. SO_2, NOx, CO, NMVOC, NH_3, mercury, etc.) and particulate (e.g. black carbon, organic carbon, particulate matter, mercury, etc.) phases by natural (e.g. volcanoes, sea, deserts, etc.) and anthropogenic sources (combustion processes, industrial activities, etc.).

> “African and European actions to implement the GCOS plan will help ensure that the climate system is accurately monitored, and that climate forecasts are improved with better and more comprehensive data.”

Dust and vehicle emissions have major environmental and human impacts ©EU, by Andreas Brink

Black carbon is one of the most damaging air pollutants in terms of human and environmental health. It is emitted in particulate form by combustion processes, and negatively affects human health, the environment and climate warming (as it absorbs solar radiation) (UNEP/WMO, 2011; WHO, 2012). Figure 32 shows total black carbon emissions in Africa in 2012, and the sector-specific emission grid maps (savannah burning and forest fires are not included). This gives a very different picture to that in the map showing all GHGs (Figure 31): Africa contributed 16.8 % of global black carbon emissions in 2012, mainly from the domestic sector (66 % of African black carbon emissions) and the industrial sector (26 %), followed by the transport sector (5 %). The dominant source is the combustion of fuel wood (vegetal waste and dung). These high black carbon emissions also reflect a lack of abatement measures and low combustion efficiency. In addition, eastern Africa (Ethiopia, Kenya and Sudan), western Africa (mainly Nigeria, Côte d'Ivoire, Ghana and the DRC) and southern Africa (South Africa, Angola, Zambia and Tanzania) contribute significantly to global black carbon emissions from charcoal production (included in the solid-fuel transformation industry sector, which represents 64 % of total global black carbon emissions).

In 2012, 65 % of total African black carbon emissions were produced by only eight of Africa's 54 countries: Nigeria (27 %), Ethiopia (11 %), the DRC (6 %), Tanzania and South Africa (5 % each), Kenya and Uganda (4 % each) and Sudan (3 %). Lower emissions are recorded from northern Africa (about 10 times less than those of the other three African regions), where they are produced by different sectors, primarily the transport sector (which represents more than 50 % of the region’s emissions) and the residential and industrial sectors.

From 1970 to 2012, black carbon emissions increased by a factor of four in northern Africa, 2.8 in eastern Africa, 3 in western Africa and 1.7 in southern Africa. Africa is characterised by the highest annual per capita emissions of black carbon in the world (0.74-0.84 kg/person per year). As shown in Figure 32, the highest annual per-capita emissions come from the residential sector (0.46 kg/person per year). However, industrial activities in Africa also emit more black carbon per unit of GDP than anywhere else in the world.

FIGURE 32: Black carbon (BC) emissions from Africa, and contributions by anthropogenic sectors (Source: based on EDGARv4.3.2 2012 data)

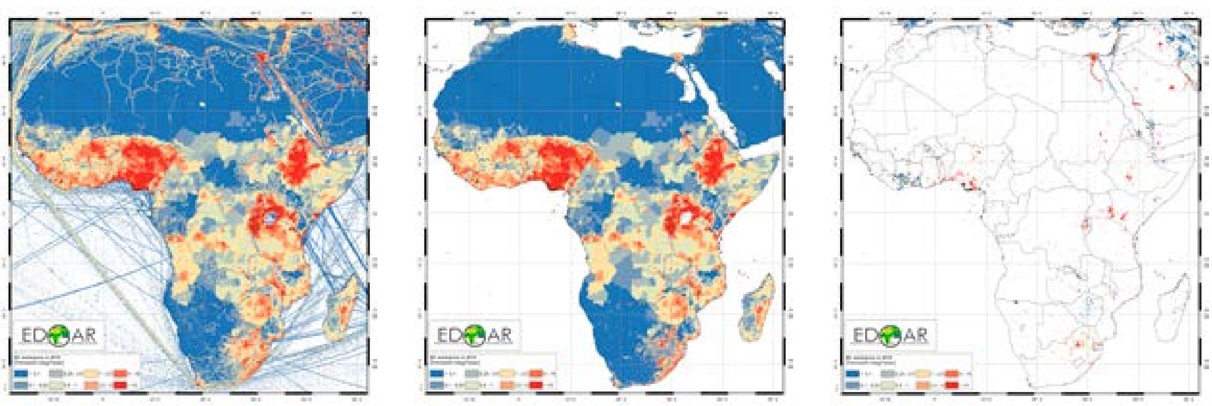
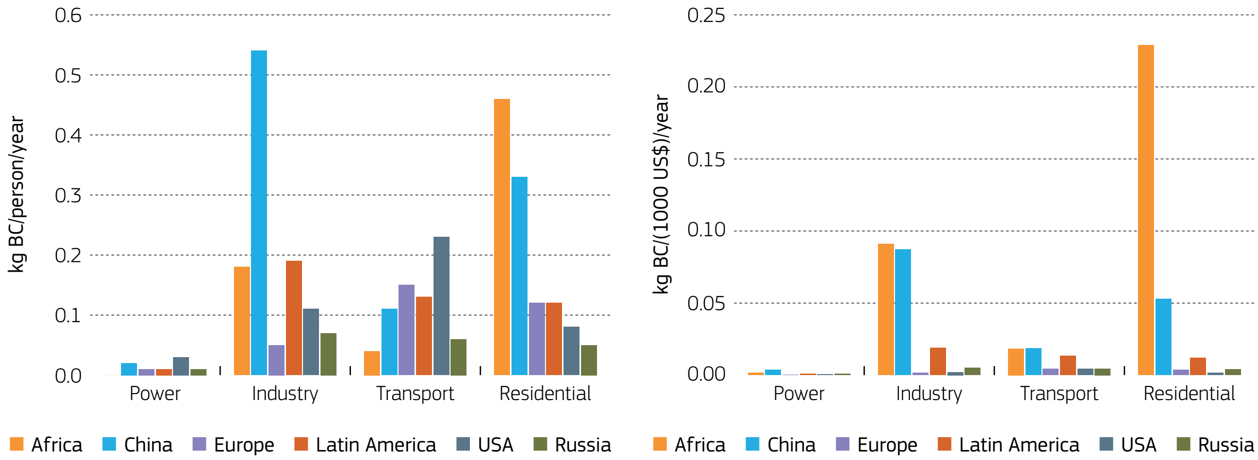


FIGURE 33: Annual black carbon (BC) emissions per capita (kg BC/person/year, upper panel) and per GDP (kg BC/US$1 000/year, lower panel) of major world regions by sector *(Source: based on EDGARv.4.3.2 data)*



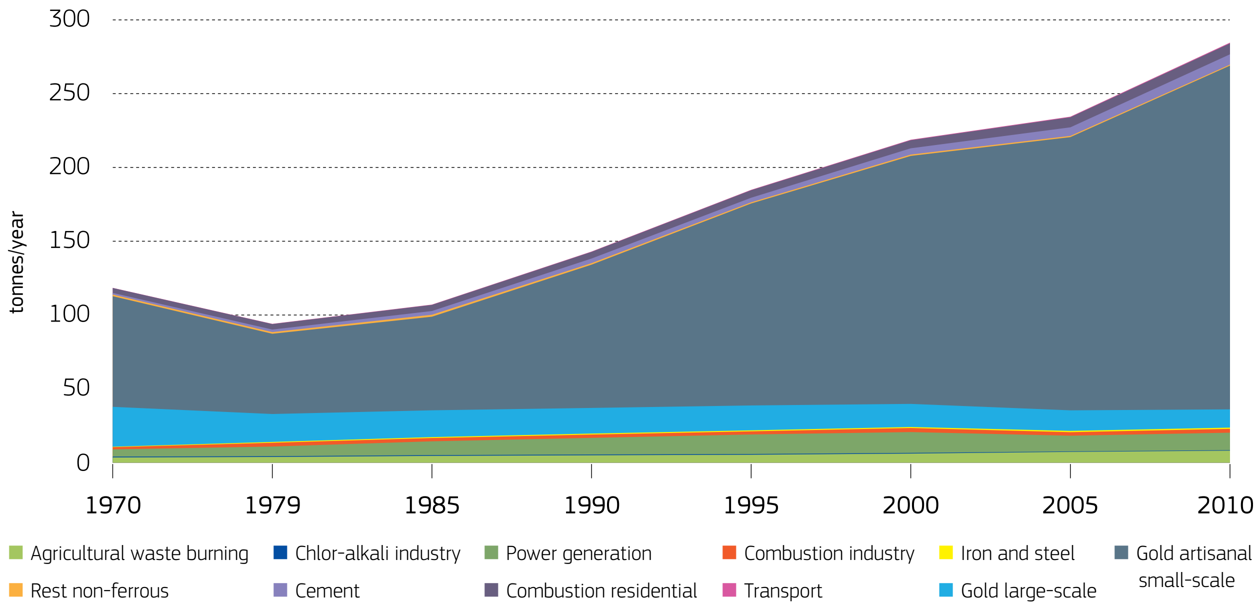
Global mercury (Hg) emissions

Mercury is emitted as an element, gas and particle, from both natural and anthropogenic sources, and can be transported over long distances in the atmosphere, ultimately affecting ecosystems and humans.

Africa emits significant amounts of mercury, mainly from artisanal small-scale gold-mining activities, as shown in Figure 34 ('gold A' in blue) and reported by Muntean et al. (2014). This sector accounted for 32 % of total global mercury emissions into the atmosphere in 2010. Emissions from gold extraction (amalgamation) using mercury have significant effects both locally (by contaminating the air, soil and water and thus damaging the health of people working and living in mining areas) and globally (through long-range transport, by bioaccumulation in seafood and finally in humans).

Although there is a lack of detailed information enabling the quantification of health impacts, many workers in the gold-mining sector remain highly exposed. For example, in Burkina Faso, about 200 000 miners were directly involved in mining activities and up to 1 million in the secondary economic sector that relies on output from the mines (AGC, 2012). In Tanzania, the United Nations Environment Programme (UNEP, 2012) estimates the number of miners to range from 500 000 to 1.5 million, and in Sudan over 1 million people (Ibrahim, 2016) are directly involved in gold mining and extraction. The gender impact reported in ELI (2014) indicates that more than 40 % of the African gold-mining workforce is female.

FIGURE 34: Sector-specific mercury emissions into the atmosphere from Africa *(Source: based on data from EDGARv4.tox2)*



Policy framework

The Paris Climate Agreement calls for a transparency framework and a global stocktake of GHG emissions. EDGAR aims to help countries with poor statistical infrastructure to develop their emission inventory reports for the United Nations Framework Convention on Climate Change (UNFCCC). Most African countries only reported a GHG emissions inventory for a base year of more than 10 years ago, and several have not yet started reporting.

The Convention on Long-range Transboundary Air Pollution (CLRTAP) is a mature policy framework that covers Europe, Central Asia and North America. Similar regional agreements have emerged in other regions, and there are a number of African framework agreements: in southern Africa (Lusaka Agreement), in East Africa (Nairobi Agreement), and in West and Central Africa (Abidjan Agreement).

The United Nations Environment Programme (UNEP), in consultation with expert groups, organised an integrated assessment of black carbon and tropospheric ozone and highlighted the importance of reducing black carbon emissions as a short-lived climate forcer (in addition to reducing methane emissions).

As regards mercury, the recent UNEP Minamata Convention (UNEP, 2013b) aims to protect human health and the environment from anthropogenic emissions. It bans the trade of various mercury-containing products by 2020, and mandates controls on mercury in specific sectors. It includes control measures on mercury emissions to air, land and water, and regulates the artisanal small-scale mining sector.

2) Gaps, future actions and priorities to be considered

The UNEP (2011) Integrated Assessment of Black Carbon indicated the great potential to reduce black carbon as a short-lived climate forcer. It is evident that the uncertainties regarding black-carbon emissions are very significant. Outreach activities and building capacity for producing emission inventories according to the European Monitoring and Evaluation Programme (EMEP) and UNFCCC standards are envisaged under the Task Force on Hemispheric Transport of Air Pollution, but more could be done.

Studies on the socio-economic impacts of artisanal small-scale gold-mining activities in different countries cannot be performed due to incomplete information (WGC, 2015). Similarly, the results of complex analyses on the local impacts of mercury emitted (UNEP, 2016) are characterised by large levels of uncertainty.

Publically available databases such as EDGAR could be used to independently verify African emission inventories and provide support in further developing local emission estimates through the application of a consistent methodology across all African countries. Emissions per capita and per GDP could also be calculated to further compare countries within Africa and even on the global scale.

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6. Forests

6.1. The state of the forests

Forests are a major component of the biosphere, providing a wide range of services. They provide habitats and nutrients for organisms (forests contain roughly 80 % of the world's terrestrial biodiversity), modulate hydrologic flow, and help conserve soil resources. They deliver support services such as carbon storage (thereby helping to regulate the climate), and purify water and mitigate natural hazards such as floods. Forests also deliver provisioning services (timber, non-timber forest products, medicines), and cultural/recreational services (homes for many people, are of spiritual value, provide a classroom for traditional knowledge, etc.).

Forest in Tanzania ©EU, by Andreas Brink

Accurate information on the state and evolution of tropical forests at the national, regional and continental scale is essential in order to analyse forests' diversity and dynamics, and to assess deforestation and forest degradation processes, their impact on ecosystem services and their biophysical impacts on the climate. This information can form part of the evidence base on which forest management decisions can be made. Moreover, 'regional forest observatories' in Central and East Africa provide decision-makers, researchers and civil society with comprehensive information on the state of forests, as well as relevant institutional information.

1) Key findings

Assessment of the situation

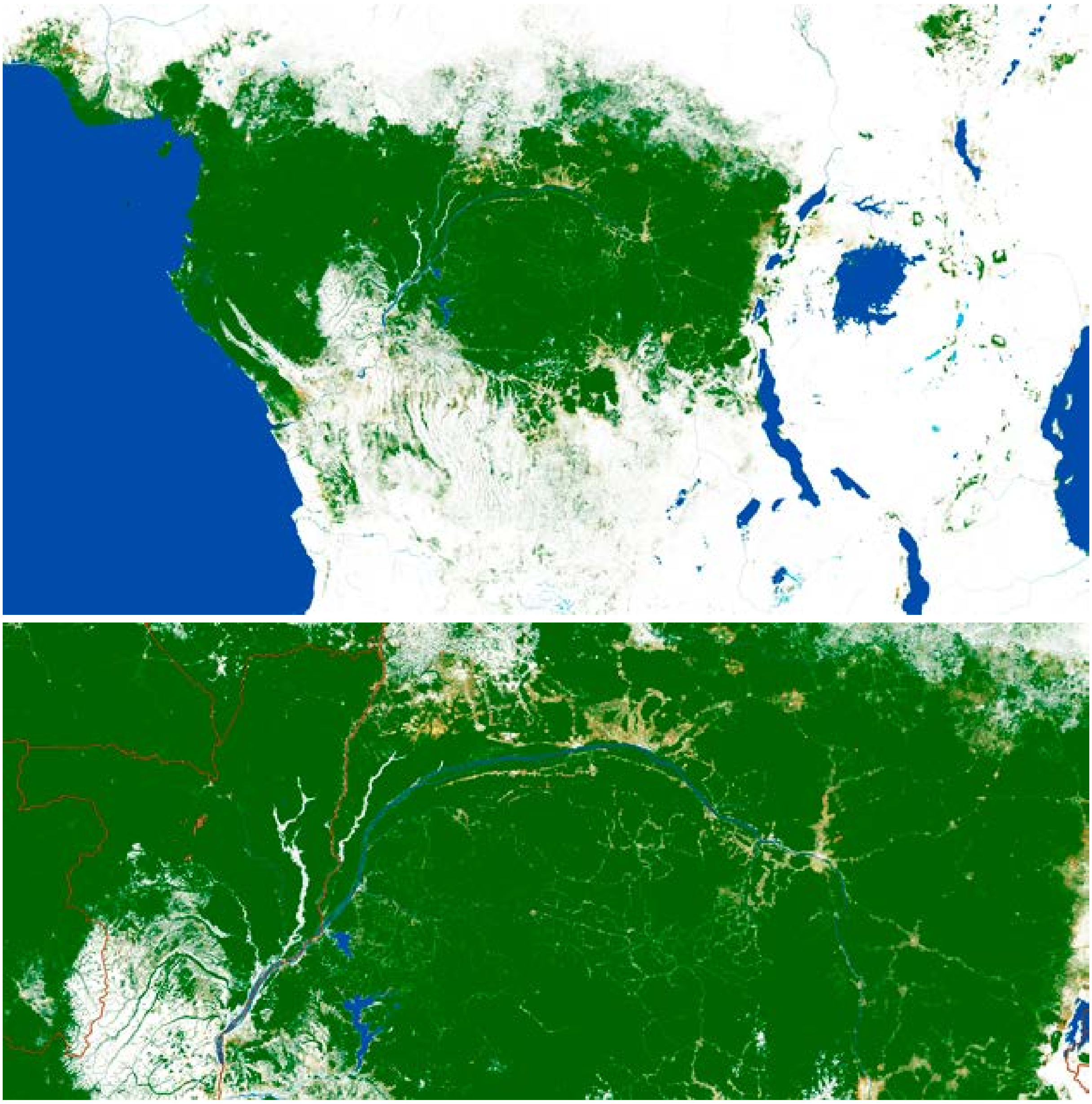
African forests make up about one-third of global tropical forests, the Congo Basin being the second-largest area of tropical humid forests after the Amazon Basin. In 2010, in sub-Saharan Africa there were 275 million ha of tropical forest and 631 million ha of 'other wooded land' in the dry domain, and 210 million ha of tropical forest and 52 million ha of 'other wooded land' in the humid domain (Achard et al., 2014).

> "31 million hectares (almost the area of Poland) of tropical forests were lost from Africa between 1990 and 2010."

Satellite data to help monitor and measure changes in tropical forests are essential for producing extensive historical and up-to-date estimates of forest changes (de Wasseige et al., 2014; Verhegghen et al., 2016). The mapping of evergreen and semi-deciduous forests at fine spatial resolution (Figure 35) helps better characterise the changes and disturbances that have occurred in recent decades in Africa's tropical humid domain. The remaining evergreen and semi-deciduous forests are found mainly in Central Africa, and in some areas of West Africa and Madagascar. The map also helps identify linear features, such as gallery forests, and disturbance events of small extent, such as logging roads (Vancutsem et al., 2017).

Overall, Africa experienced a net loss of 31 million ha of tropical forests between 1990 and 2010. The annual gross loss of tropical humid forests fell from 0.70 million ha in the 1990s to 0.36 million ha in the 2000s, while the annual gross loss of tropical dry forests rose from 1.33 million ha in the 1990s to 1.47 million ha in the 2000s. More recently (2010-2015), Nigeria and the Democratic Republic of the Congo are among the top 10 countries with the greatest reported annual net loss of forest area (FAO, 2016). Forest losses in 'other wooded land' areas are geographically more widespread, with significant losses occurring in most of the dry domain (1.37 million ha per year during the 2000s).

FIGURE 35: Map of intact tropical humid forests of Central Africa (top) with a close-up of intact tropical humid forests in the Republic of the Congo and the DRC (bottom) *(Source: JRC)*



Deforestation in Gabon ©EU, by Grégoire Dubois

Unlike other tropical regions, deforestation and forest degradation in Africa are mainly caused by small-scale processes rather than large-scale agriculture; thus, deforestation here is more closely related to the livelihoods of subsistence farm1ers, small-scale charcoal producers and the gatherers of wood for fuel. About 60 % of new agricultural land came from intact forests in the 1980s and 1990s, and was mainly used for small-scale and subsistence agriculture and farming (Gibbs et al., 2010). Forest degradation is not always a precursor of deforestation, in particular in many woodland areas of Africa where the main drivers of forest degradation are the collection of wood for fuel and charcoal production (Brink et al., 2014).

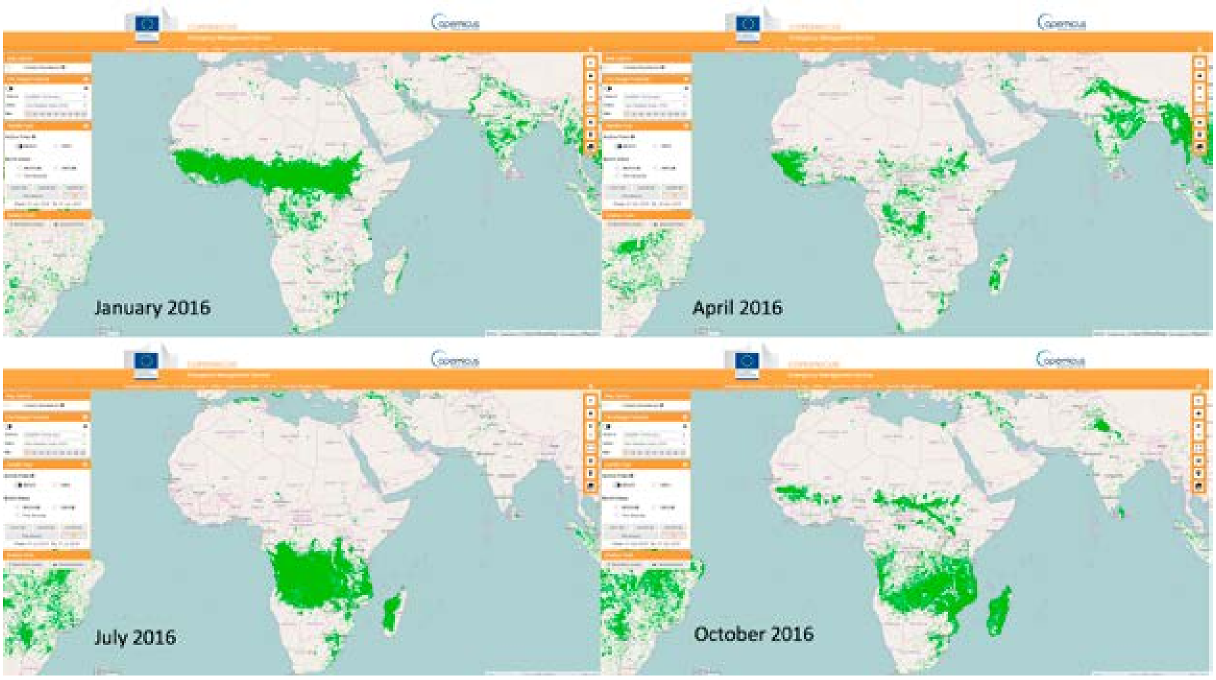
The expansion of cropland areas, a growing population and the expansion of urban infrastructure bring African humid forest areas closer to urban boundaries, which increases the human pressure on them – in fact, all three factors are key drivers of deforestation (Mayaux et al., 2013). Deforestation increases dramatically when rural population density exceeds 8.5 people per km2, and declines as travel times to cities increase (see chapter I.2.2).

Agricultural expansion is the main driver of deforestation in the forests and woodlands belonging to the Miombo ecosystem in southern Africa, although the extraction of wood for fuel (firewood and charcoal for urban areas) is also a major contributor to both forest degradation and deforestation (Bodart et al., 2013). In West Africa in particular, the conversion of natural vegetation (such as forests and other wooded land) to agriculture has largely continued unabated.

Fires are a recurrent phenomenon in Africa, and affect large areas of forests, savannahs and grasslands every year. The annual area burned fluctuates between 150 000 and 200 000 km2 (van Lierop et al., 2015). This represents between 2 and 3 % of the continent's total forest area. Fire activity in Africa has a marked seasonality throughout the calendar year (Figure 36). As with other Mediterranean countries in Europe, North Africa is mainly affected in the summer season when high temperatures and the lack of precipitation provide favourable conditions for the ignition and spreading of fires (San Miguel-Ayanz et al., 2016). In sub-Saharan Africa, fire distribution is driven by weather conditions, hunting and traditional vegetation management practices (whereby fires are used to clear scrublands, for weed control and to regenerate grasslands).

“Wildfires burn 2-3% of total African forest area every year. Most are man-made.”

FIGURE 36: Wildfire activity in Africa in 2016, as gathered by the Global Wildfire Information System (GWIS). Areas affected by wildfire activity are shown in green for January, April, July and October. From January to April, wildfires impacted the southern Sahara region, in the latitudinal belt between Guinea and Ethiopia. Fire activity extended further south into the Congo Basin and Angola during the second and third quarters of the year, extending towards South Africa. *(Source: GWIS)*



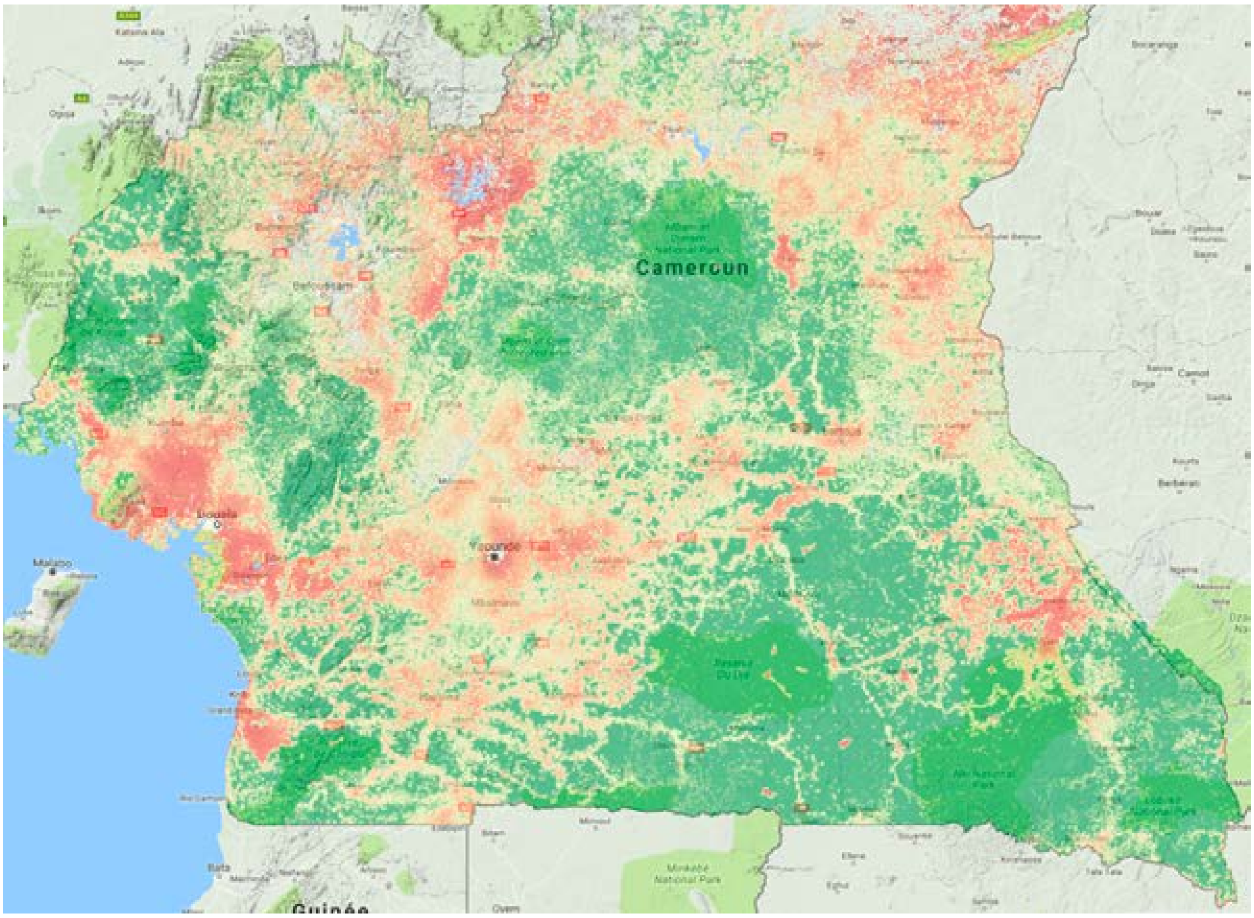
As most fires are caused by humans, it is essential that fire-prevention measures (or other policies, such as prescribed periods for burning) are undertaken in cooperation with national and regional fire managers. The use of fire has to be balanced with minimising negative environmental impacts.

Wildfire in South Africa ©EU, by Grégoire Dubois

Outlook

Population growth and density, weak governance, corruption, low administrative capacity, uncertainty in land-tenure systems and inadequate planning or monitoring of natural resource use are all important factors in tropical deforestation and forest degradation (Kissinger et al., 2012). Maps of potential deforestation provide spatial information about high-risk areas, and highlight the risk to biodiversity areas and carbon stocks (Vieilledent et al., 2013). Such maps can be produced from the continental to national level (Figure 37).

FIGURE 37: Map of the probability of deforestation for central and southern Cameroon after 2010. Areas in green have a low probability of deforestation (mostly in remote or protected areas) while those in red have a high probability (areas close to large cities, such as Douala or Yaoundé, or to roads, such as the network visible in the south) *(Source: JRC)*



From the tropical deforestation datasets of the JRC, the FAO and the Global Forest Watch, it appears that the deforestation intensity per country in Africa is negatively correlated with the remaining forest area, and positively correlated with the population size. Most African countries are expected to experience a drop in their deforestation rates after 2050 due to the demographic transition and reductions in available land area. Considering the world population prospects (UN, 2017) and related projections of deforestation intensities, many countries (such as Madagascar, Mozambique, Uganda and Tanzania) are likely to lose more than 50 % of their forests during the 21st century. Gabon, Cameroon and the Central African Republic are the only countries that will experience only a moderate (less than 25 %) fall in their forest cover.

> “Madagascar, Mozambique, Uganda and Tanzania are likely to lose more than half of their forests this century.”

Challenges and opportunities

‘Regional forest observatories’ provide decision-makers, researchers and civil society with coherent and comprehensive information on the state of forests, as well as relevant institutional and societal information. They promote regional integration and knowledge sharing among forest agencies and with other stakeholders, and provide a stable environment in which to bring together forestry information in a centralised database. The observatories aim to promote the development of methods, exchange of ideas, and standardised reporting of forest dynamics and forest parameters (e.g. field data, data-collection protocols and data-reporting structures). They provide a common repository for forest-related data (inventories, spatial data, forest codes and laws, information on concessions, etc.) with an open and regulated single entry point for partners, decision-makers, funding agencies, researchers and civil society (MacDicken et al., 2015). The observatories also publish research and findings relevant to the region’s forests in a regular report on the ‘State of Forests’.

Recent free and open sources of satellite imagery, such as the USA’s Landsat and the EU Sentinel imagery, provide new opportunities to map changes in tropical forests. Imagery from the Copernicus Sentinel-2 satellite is particularly valuable for the mapping of evergreen and semi-deciduous forests at finer spatial resolution (10 m). Dedicated geographic information systems, such as the Global Wildfire Information System, will soon provide fire monitoring at spatial and temporal scales suitable for use at national and regional levels. These systems should be brought to the attention of wildfire managers throughout Africa. Opportunities for such cooperation exist with African networks such as AfriGEOSS (an initiative to reinforce the Global Earth Observation System of Systems in Africa) and the regional networks of the Global Observation of Forest Cover Fire Implementation Team.

The use of modern technologies, such as satellite images and Geographic Information Systems, in the forestry sector and in biodiversity management – Agence Nationale des Aires protégées (ANPN), Gabon ©EU, by Stephen Peedell

Policy framework

The EU promotes sustainable forest management as a way of protecting biodiversity, fighting desertification and responding to climate change, while ensuring that forest ecosystems deliver goods and services. In this way, it contributes to sustainable development and to eradicating poverty. Through its Forest Strategy (European Commission, 2013), the Commission and the Member States are committed to: promoting sustainable forest management across Europe and globally, and the role of forests in the transition to a green economy in the context of EU development cooperation and external action; ensuring continued support for global efforts to fight illegal logging through the FLEGT (Forest Law Enforcement, Governance and Trade) Action Plan; and supporting developing countries in their efforts to improve forest policies and regulations, strengthen forest governance, value and monitor forest ecosystems, and address the drivers of deforestation and forest degradation through the REDD+ (Reducing Emissions from Deforestation and forest Degradation and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries) programme.

2) Gaps, future actions and priorities to be considered

Although the assessment and monitoring of deforestation is considered technically feasible, major challenges remain for the accurate assessment of forest degradation by national forestry services. These include access to satellite data of adequate spatial resolution and at required intervals to measure changes in forests; expertise on how to collect and process data to provide the required information; and access to suitable tools, particularly dedicated image-processing software.

Moreover, more robust maps of potential future deforestation can help decision-makers develop conservation policies and determine reference emission levels in the context of REDD+ activities under the UNFCCC. Models for tropical anthropogenic deforestation are also needed to better understand the processes and provide scenarios of future possible outcomes.

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6.2. Forests and climate change

Forests play an indisputable role in climate mitigation as they act as a carbon sink that captures and stores atmospheric carbon dioxide (CO_2). Land use, including agriculture and forestry, accounts for about 10 % of global GHG emissions of CO_2 and nearly a quarter of emissions when methane (CH_4) and nitrous oxide (N_2O) are included. Also, about one-third of the current anthropogenic CO_2 emissions are removed by terrestrial ecosystems, mainly forests. While deforestation (with forest degradation) is estimated to be the main GHG source in many tropical countries, forest sinks are important globally, with net sinks dominating in temperate and boreal countries. Africa accounts for approximately 20 % of the global GHG emissions occurring from tropical deforestation.

Tropical rainforest in Uganda ©EU, by Andreas Brink

Forest-based climate mitigation can occur through conserving and enhancing the carbon sink and by reducing GHG emissions from deforestation. Yet the inclusion of forests in international climate agreements has been complex, and often considered a secondary mitigation option. Starting in 2005, the (UNFCCC developed the REDD+ mechanism in recognition of the fact that deforestation and forest degradation threaten this carbon-sink function. In the context of the Paris Climate Agreement, countries submitted their (Intended) Nationally Determined Contributions ((I)NDCs), including climate mitigation targets. Assuming full implementation of (I)NDCs, land use, and forests in particular, will emerge as key components of the Paris Agreement: changing globally from a net anthropogenic source of carbon during 1990-2010 (1.3±1.1 $GtCO_2eq$ per year) to a net sink of carbon by 2030 (up to -1.1±0.5 $GtCO_2eq$ per year), and providing a quarter of the emission reductions planned by countries (Grassi et al., 2017). Realising and tracking this mitigation potential requires enhanced science-policy cooperation to increase confidence in numbers.

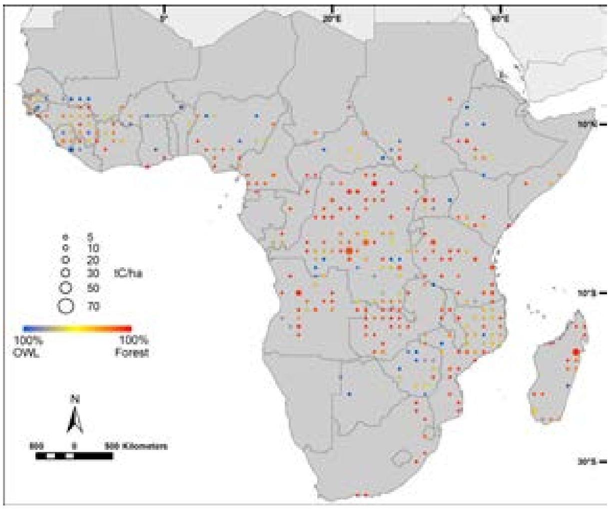
Moreover, it is increasingly understood that forests also regulate climate through biophysical interactions driven by water and energy fluxes, which have a strong influence on temperatures at local and regional scales.

1) Key findings

Deforestation and forest degradation as carbon sources

Most of the net flux of carbon into the atmosphere due to land-cover changes is attributable to deforestation in the tropics, with a smaller fraction is attributable to forest degradation. In the 2000s, gross annual carbon losses from changes in forest and other wooded-land cover are estimated at 148 million tonnes for sub-Saharan Africa (Achard et al., 2014). Also in the 2000s, gross carbon losses due to changes in forest and other wooded land in tropical Africa represented 17 % of losses from the global tropical belt. The majority (69 %) of such carbon losses in African tropical forests are in the tropical dry region (Figure 38).

FIGURE 38: Gross carbon losses due to changes in forest cover and other wooded land (OWL) at 1200 sample sites during the decade 2000-2010. Gross loss of forest cover appears in orange circles, and gross loss from other woodland losses appears in yellow circles *(Source: Achard et al, 2014)*



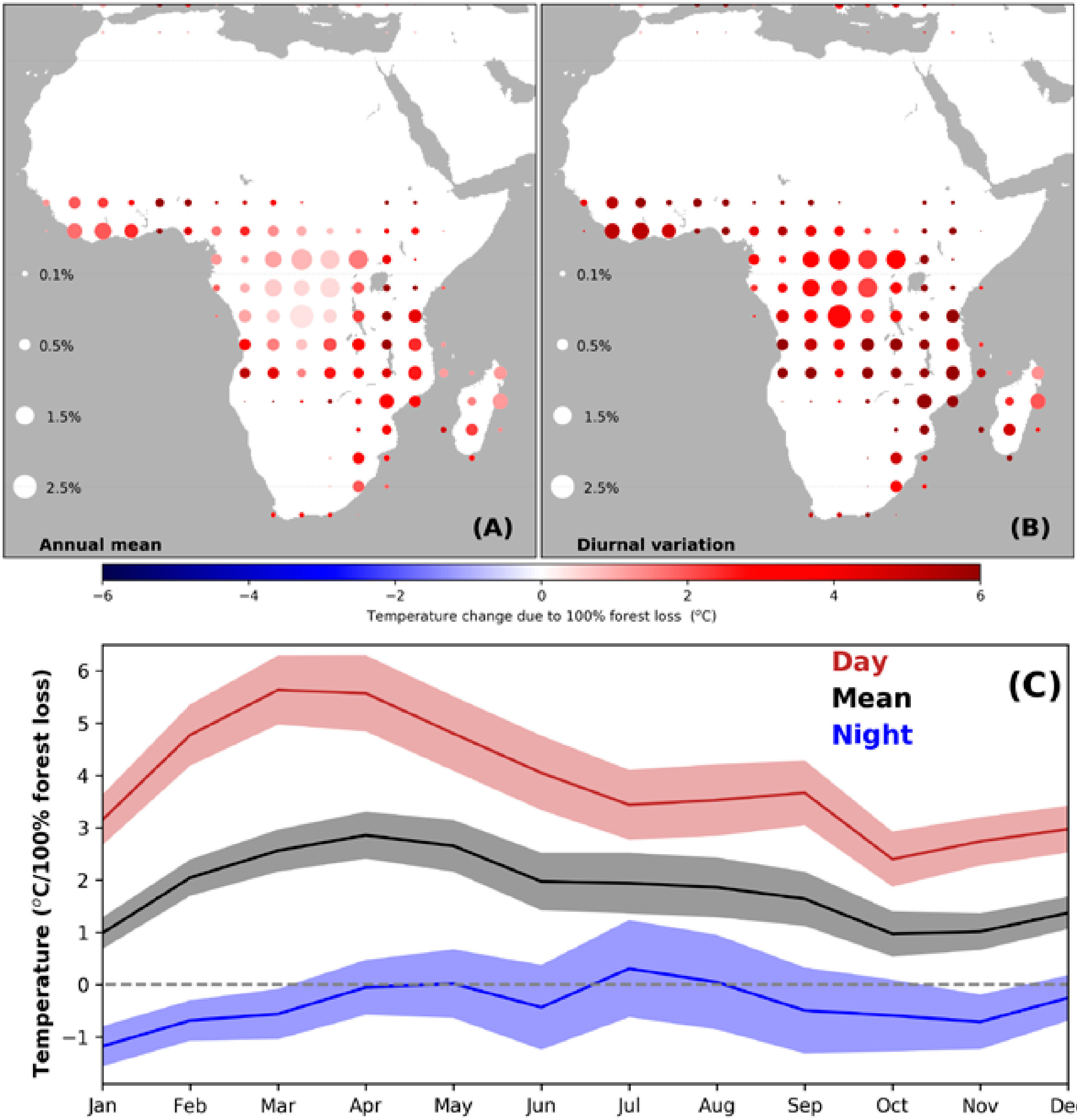
Biophysical impacts of deforestation on Africa's climate

Land-use change (particularly deforestation) can have a strong effect on local temperatures. In most of Africa, the conversion of forests into croplands or grasslands typically leads to a brighter surface (i.e. with a higher albedo/reflectivity), which will reflect more solar radiation back into the atmosphere and thus have a cooling effect on the land. However, such conversion also leads to surface heating due to a fall in evapotranspiration (the process whereby water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants). The reason for this decrease is that forests have deep roots (with access to groundwater) and uneven surfaces, which enable better dissipation of heat from the land surface. As the evapotranspiration effect is typically larger than the albedo effect in warm climates, the resulting impact of deforestation is therefore local warming of the climate. In contrast to carbon emissions (which have a global effect that is only felt over longer time spans), the biophysical consequences of deforestation are much more immediate and local. However, as these could also scale up and impact the climate at regional to global levels, their biogeochemical and biophysical effects should be addressed in a coordinated fashion.

“Deforestation has been found to lead to local warming of 1°C to 2°C in Africa.”

Although the theory behind these biophysical interactions is generally well understood, in practice, their complexity makes them very difficult to estimate accurately over large spatial scales using climate modelling. The use of satellite remote-sensing data can therefore significantly help to map these impacts at the global scale. Alkama and Cescatti (2016) estimated the effect of deforestation on land-surface temperature during the period 2003-2013. In Africa, the results show that deforestation causes significant local changes in the mean land temperature, with a 1 °C warming in tropical humid forests and more than 2 °C in semi-arid zones. In addition, forest losses produce a substantial increase in diurnal and annual temperature variation (Figure 39).

FIGURE 39: Changes in land surface temperature due to losses in forest cover, between 2003 and 2013. The upper maps show changes in mean annual temperature (A) and diurnal variations (B) due to forest losses. Symbol size indicates the magnitude of forest-cover losses, while the colour specifies the average temperature sensitivity to total deforestation. Points are spaced at 4 ° in both latitude and longitude, and statistics are computed in windows of 6 ° x 6 °. The graph (C) shows expected local changes in the monthly day, night, and mean land-surface temperatures due to total deforestation (mean ± STD error). To maintain a proper seasonality of the signal, the time series from the southern hemisphere were shifted by six months (i.e. January contains data from January in the northern hemisphere and from July in the southern hemisphere) *(Source: Alkama and Cescatti, 2016)*



Challenges and opportunities

With reference to carbon emissions from deforestation and forest degradation, the use of satellite data for measuring changes in tropical forests is essential for producing extensive estimates of forest changes (de Wasseige et al., 2015) which can then help calculate the fluxes of carbon into the atmosphere due to land-cover changes. Moreover, fine-resolution imagery and sophisticated image-analysis techniques are needed to assess the fall in carbon stocks due to forest degradation (Verhegghen et al., 2016). New remote-sensing techniques (such as extracting vegetation optical depth from passive microwave instruments) may provide new avenues to quantify forest degradation and related biomass loss, but these still need to be further explored.

Smoke from a nearby forest fire over an intact forest in Benin ©EU, by Andreas Brink

Regarding biophysical effects, current challenges involve moving beyond deforestation to characterise the effects of different land-cover transitions, including different types of forests, and to assess the effects of potential changes that have yet to be observed (Duveiller et al., 2017).

Policy framework

The Conference of the Parties (COP) of the UNFCCC agreed that Parties to the Convention should collectively aim to slow, halt and reverse the loss of forest cover and carbon, in accordance with national circumstances (from 2007 to 2013, Parties to the UNFCCC adopted 13 decisions on this issue). It encouraged developing country Parties to contribute to mitigation actions by reducing emissions from deforestation and forest degradation, and to promote the conservation and enhancement of forest carbon stocks and the sustainable management of forests.

The UNFCCC's mechanism for Reducing Emissions from Deforestation and forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (REDD+) can be implemented in phases, including actions that should be fully measured, reported and verified. Participating countries should demonstrate that emissions have been reduced with respect to an historical reference period (e.g. 2000-2012).

The biophysical effects of land-use change (the impacts of deforestation on the local and regional climate) are not covered in climate treaties.

A better understanding of the interactions between the climate and ecosystems can support policies and actions that contribute to SDG 13 on climate action through mitigation, as well as SDG 15 on protecting terrestrial ecosystems and managing forests, and SDG 6 on the role of forests in the water cycle.

2) Gaps, future actions and priorities to be considered

Despite substantial progress, there are still gaps in the evidence base on the interactions between climate and forest ecosystems, which are being addressed by current and planned activities within and outside of the JRC. Notably, a better understanding is needed of how the contrasting forces of albedo and evapotranspiration affect changes in land surface and air temperatures. Information at finer spatial resolution, along with *in situ* observations, are also necessary to support the development of optimal climate change mitigation and adaptation plans. This work should help develop tools for monitoring, reporting and verification of the biophysical effects of land-use change, similar to those currently used to track changes in carbon stocks. Ideally, a framework should be developed that combines biophysical with biogeochemical effects, in order to adequately evaluate the total climate effects of land-use change in Africa and the effectiveness of land-based mitigation and adaptation strategies.

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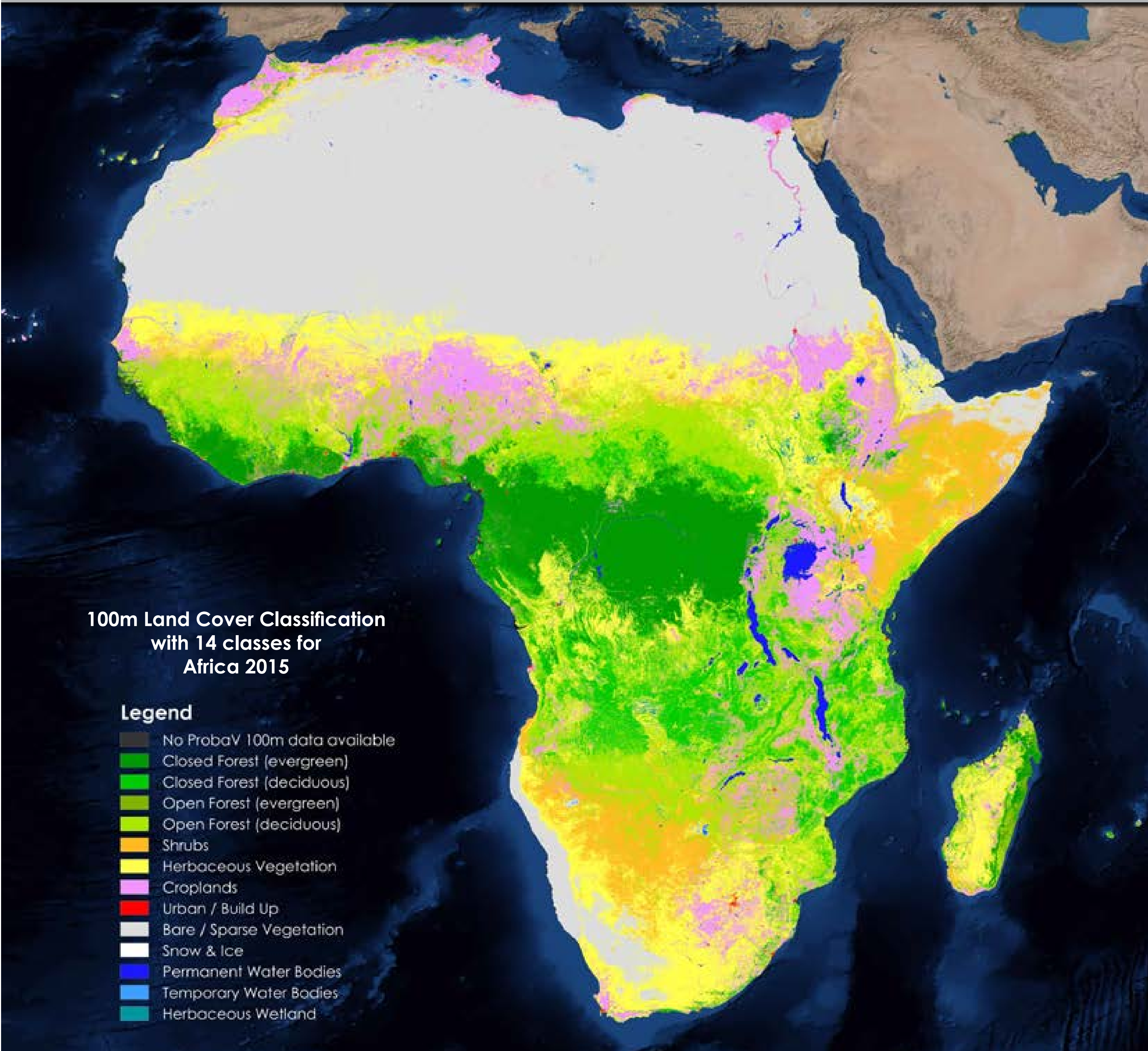
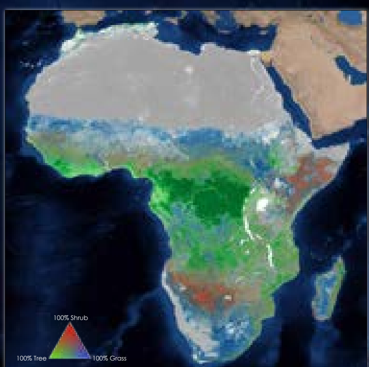
100m Global Land Cover Layer from Copernicus Global Land Service for Africa 2015





Cover Fraction Layer Composite of Forest, Shrubland and Grassland.

Cover Fractions for Evergreen and Deciduous Forests for Africa 2015.

Zoom in the Nile delta showing the natural mosaic for agriculture (black = 100 % crops).

This map was created by VITO Remote Sensing (Belgium), IIASA (Austria) and Wageningen University (the Netherlands) under assignment of the European Commission DG Joint Research Center (Italy) and in co-operation with DLR (Germany). The data used is PROBA-V 100 m for the reference year 2015. The bathymetry is derived from the Blue Marble next generation.

7. Land

7.1. Competition for land

1) Key findings

Firewood and charcoal transportation from the countryside to the city of Dar es Salaam ©EU, by Andreas Brink

Assessment of the situation

Natural land

From 1990 to 2010, 34.7 million hectares of natural vegetation (including forests and wood- and shrublands) was converted to agriculture or cleared for firewood and charcoal production in sub-Saharan Africa. To put this into context, this is the same as a forest area the size of the Republic of the Congo disappearing in 20 years. The predominant dynamics are occurring not in the humid tropics but in the dry tropics, which have far higher annual rates of net loss of natural vegetation (Achard et al., 2014) (see also Chapter I.6). Population growth (and hence competing demands for land) is also highest in the dry tropics. Although the driving force behind the clearing of natural vegetation has traditionally been attributed mainly to the expansion of new agricultural land areas (including investments in large-scale commercial agriculture), firewood extraction and charcoal production are also key factors in forest, woodland and shrubland degradation throughout the African region. This land-cover change dynamic is not just a by-product of greater forces such as logging for timber and agricultural expansion, but stems from a specific need to satisfy energy demand. While Africa is endowed with a huge diversity of energy sources (such as oil, gas, coal, uranium and hydropower), the local infrastructure and use of these commercial energy sources is very limited (see chapter I.13). Traditional sources of energy in the form of firewood and charcoal account for over 75 % of total energy use in the region (Kebede et al., 2010; IEA, 2014). These are mainly used for household cooking, but are also used in the agricultural and rural industry sector for brick-making, food processing, bakeries, tobacco-curing, etc. The clearing of forests for (often illegal and export-driven) wood and charcoal production has reached critical levels in fragile states which face difficulties in implementing environmental policies, such as the DRC and Somalia (Rembold et al., 2015).

> “Traditional sources of energy such as firewood and charcoal account for over 75 % of total energy use in Africa.”

Fire is often used to clear land for new agriculture fields ©EU, by Andreas Brink

Agricultural land

Scientists and international entities such as the Food and Agriculture Organization of the United Nations (FAO) and the International Food Policy Research Institute (IFPRI) agree that food production must grow substantially if it is to meet the world's future food security and sustainability needs. Past increases in crop production have occurred as a result of both extensification (clearing natural lands for agricultural and forestry use) and intensification (producing more products per unit area of land already used for agriculture or forestry). Agricultural land area increased by more than 50 % between 1975 to 2000 (Brink and Eva, 2009) and, according to projections, further extensification will contribute significantly to crop production in sub-Saharan Africa (according to Bruinsma, 2003), with cropland expansion alone accounting for almost 30 % of the increased food production required by 2030 (intensification having to provide the rest). By 2030, an additional 81 to 147 million hectares of cropland will be needed in Africa, compared to the cropland area in 2000 (Meyfroidt and Lambin, 2011). As explained by Lambin et al. (2013), land conversion for agricultural use is always associated with social and economic costs.

Despite the increase in crop area, agricultural area per capita is rapidly decreasing in most African countries due to high rates of population growth and growing competition for land for different uses (fuel production, mining, conservation, recreation, etc.). Estimates based on the analysis of satellite imagery suggest that the average amount of suitable land available for further exploitation in sub-Saharan Africa fell from 5.2 ha to 2.4 ha per person over the period 1975 to 2000 (Brink and Eva, 2009).

Pastoral land

Traditional pastoral areas face challenges posed by the combination of climate variability and change, limitations to nomadism and grazing patterns imposed by increasing pressure on land, and urbanisation. Reduced mobility combined with rising demands for livestock products have exposed pastoral areas in sub-Saharan Africa to greater levels of degradation. This has led to the displacement of large numbers of people and livestock, which has had a further impact on land-management practices. In pastoral areas, particularly where nomadic livelihoods are on the decline, private enclosures or the fencing of land (Nyberg et al., 2015) are becoming more common as a measure to protect and manage livestock, increase and protect fodder production, and demarcate and claim land rights. Land-tenure policies are often complex and some may be obsolete. It can be a struggle to introduce reforms that facilitate access to land by subsistence farmers and private investors. In some countries, the traditionally most fertile areas are shrinking due to climate change and land degradation. This leads to continued extensification, predominantly in marginal areas. Communal areas are also under pressure from private interests, and are being further fragmented and fenced off. Furthermore, investment in land has increased globally since the beginning of the 2008 economic crisis (see Box 5), and the value of farmland is soaring both in the developed and in the developing world.

> “In some countries, the traditionally most fertile areas are shrinking due to climate change and land degradation.”

BOX 5

Land grabbing – a highly sensitive issue

From the mid-2000s, interest in investing in large tracts of land in Africa, Asia and America has grown, fuelled by exporting countries concerned about the food security of their own populations. The 2008 food price crisis added momentum to this trend, bringing the total area across the globe subject to such deals up to 80 million ha between 2001 and 2010. This is more than the total farmland areas of Britain, France, Germany and Italy combined (*Economist*, 2009). This phenomenon, dubbed the “rush for land”, has captured the attention of policymakers, researchers, the media and the public. Despite the rapid increase, large-scale land acquisition or leasing in developing countries remains a highly sensitive issue, with significant economic and food security risks and impacts.

More intensive and productive agricultural practices are being implemented in large areas by private companies to grow produce for export, the idea being that the revenue and infrastructure improvements may increase labour opportunities and food security in these countries. However, local communities may not always benefit due to insufficient compensation schemes, and are often subject to negative impacts such as land-related conflicts and the loss of their main source of income (Nolte et al., 2016).

Due to the social, environmental and economic risks and controversies associated with large-scale land transfers, it is crucial to monitor land-use change and ensure, as far as possible, transparent, sustainable and inclusive implementation. The Land Matrix Initiative (LMI), a partnership of global and regional stakeholders supported by the European Commission, was established in 2009 with the aim of addressing the lack of robust data on land acquisitions. However, detailed monitoring data are often difficult to retrieve, especially in remote areas, and also because initial mechanised interventions can be perceived as the start of project implementation, but are often not followed by longer-term development.

Outlook

Population growth, agricultural expansion and energy demand all increase together. With the current state of development, population and economic growth, many people in Africa have to depend on the remaining natural vegetation to meet their needs for further agricultural expansion and energy (Brink et al., 2012).

Furthermore, land-tenure and land-distribution patterns between genders, races and socio-economic classes, as well as between private and state ownership, are not always equitable. In recent years, inequalities have been amplified by land grabbing and investments in large-scale commercial agriculture.

Large-scale tea and eucalyptus plantations in Uganda ©EU, by Andreas Brink

The sustainable use and management of land is particularly important in Africa because most people rely on natural resources and agriculture for food security. SDG 15 seeks to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss". Given globalisation and the population pressures on Africa's land, remedial action must be taken as a matter of urgency if this goal is to be achieved.

Challenges and opportunities

Sensitivity of land-tenure information and challenges in setting up efficient land-monitoring and registration systems lead to a situation whereby many African countries face strong competition for land. However, detailed data on the main dynamics are scarce, potentially available cropland is often not well assessed at the national scale, and the interactions between different drivers are unclear. Better information on potentially available cropland and the effect of competition drivers for land in different local contexts is particularly relevant for policymaking. Effective monitoring of land-use changes linked to land transfer and in line with the principles of the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forest (VGGT) is crucial, especially in remote areas where on-site monitoring is extremely costly.

The issue of forest degradation and the clearing of woods and shrubland areas for firewood and charcoal production is multifaceted in nature and complex to monitor. To distinguish legal from illegal clearing and harvesting of firewood, accurate and up-to-date land-tenure information and high-resolution satellite images are needed to identify small clearings and degradation patterns. Technological developments in the agricultural sector, energy-efficient technologies and a diversification in energy sources are required to meet the population and economic demands in Africa without over-exploiting natural vegetation and resources. Prerequisites for the sustainable use of natural vegetation in Africa include the use of modern technologies (such as mechanisation, fertilisation and irrigation) in the agricultural sector and the more efficient use of biomass energy sources as part of the development of a modern energy infrastructure.

The Copernicus Global Land Service presents one opportunity for such information gathering, especially through its High-Resolution Hot Spot Monitoring (C-HSM). This provides detailed land information on specific areas of interest. The service answers ad-hoc requests mainly within the domain of the sustainable management of natural resources, with an initial focus on Protected Areas and Key Landscapes for Conservation, although this could be expanded to address other dimensions of the competition for land.

Policy framework

The Joint Africa-EU Strategy (JAES) Roadmap 2014-2017 highlights joint priorities including 'Human Development', 'Sustainable and inclusive development and growth and continental integration' and 'Global and emerging issues'.

SDG 15 includes explicit reference to many land issues, notably the need for land degradation neutrality, and multilateral environmental agreements (such as the UN Convention to Combat Desertification and the Convention on Biological Diversity) include monitoring and reporting protocols that provide additional policy frameworks.

2) Gaps, future actions and priorities to be considered

Assessing and monitoring the dynamics of land-cover and land-use changes, focusing on natural vegetation, agriculture and infrastructure development and understanding its underlying causes, have not only been recognised as one of the key research domains in regional and global environmental change research, but are also a prerequisite for addressing the issue of degradation of and competition for land. However, the evaluation of competing land demands must go beyond simple observations and integrate several land-tenure and socio-economic aspects. This information is often fragmented, and is difficult to access and harmonise for the entire continent.

Within the JAES priority 'Sustainable and inclusive development and growth and continental integration', specific mention is made of the "establishment of a coherent framework for the development of Earth Observation activities in Africa", including the Monitoring of the Environment and Security in Africa (MESA) initiative, Global Monitoring for Environment and Security in Africa (GMES and Africa), and AfriGEOSS (Africa's contribution to the Intergovernmental Group on Earth Observations, GEO). Further specific future actions could include regional initiatives, such as the EU-funded project implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit's (GIZ) on 'Support to responsible agricultural investments in Ethiopia' and contributing spatial data to the Land Matrix Initiative (a global and independent land-monitoring initiative that promotes transparency and accountability in decisions about land and investment, also co-funded by the EU).

BOX 6

Case study: monitoring large-scale land transfers in the Gambella region (Ethiopia)

Ethiopia is an important case in the international debate on large-scale land acquisitions, where land deals for plantation agriculture are an important new element of the government's agricultural strategy, and where allocations have been subject to controversy in terms of impacts on rights and livelihoods at the local level (Keeley et al., 2014). Following a request from the European Union Delegation in Ethiopia, in 2016, the JRC issued a report on large-scale land transfers that focused in particular on the Gambella region of Ethiopia. This area is reported to have one of the highest concentrations of such transfers for which the least amount of information is available.

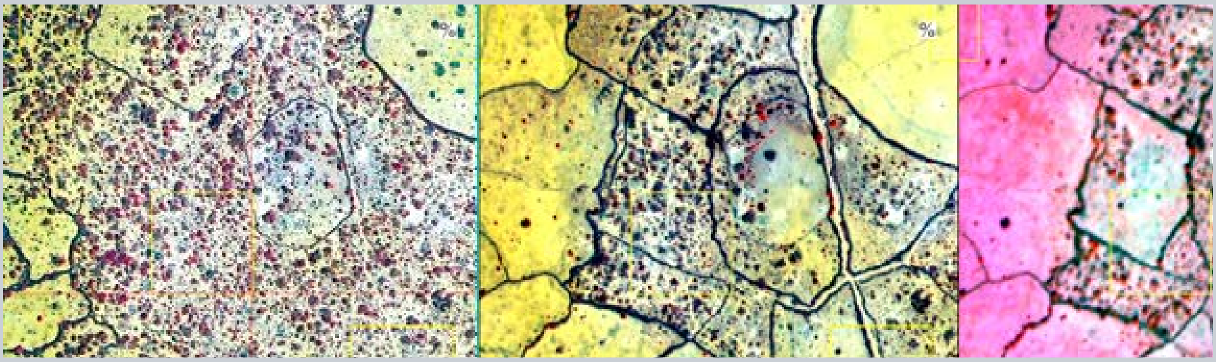
The report demonstrated that, with the new and continuous availability of sensor data from Copernicus satellites Sentinel-1 and Sentinel-2, it is now possible to monitor land conversion, even in areas where it is difficult to collect visual data due to persistent cloud cover. The total area calculated as being under mechanised cultivation in the Gambella region was in the order of 100 000 ha in 2016. This is a significant increase compared to 2010 (when the area of land under mechanised cultivation was around 20 000 ha). In 2011, the Oakland Institute reported that 170 000 ha were included in land deals known at the time. JRC figures show that only two-thirds of this area is under active agricultural use or under conversion.

FIGURE 40: Mechanised rice cultivation near the Abobo Dam in Gambella (Ethiopia) in June 2016 *(Source: European Space Agency)*. This area stands out in the Sentinel-1A synthetic aperture radar (SAR) composites due to its very regular structure (which is indicative of an extensive irrigation infrastructure) and its strong colours (reflecting different rice cultivars at various stages of growth). The project area is embedded in an area still characterised by natural vegetation, except towards the eastern edge, which is also cultivated. The westernmost edge appears to be a recent expansion. Farm buildings are visible on the eastern side of the project area (in white). The total delineated area is about 6500 ha.

BOX 7

New research on pastoral enclosures in the Dadaab refugee camp area, Kenya

FIGURE 41: Changes in pastoral enclosures (private fenced areas) from 2006 (left) to 2010 (middle) and 2013 (right) *(Source: European Commission, 2014).* The central shrub area is progressively divided into fenced plots used for pastoral fodder production. A reduction in vegetation density over time is clearly visible inside both old and new enclosures. (All images are false-colour composites with green vegetation shown in red; the colour differences are due to different sensor properties and different seasonality for the three dates.)



Pastoral areas in African drylands are subject to rapid environmental and social changes. With a progressive trend towards urbanisation and growing barriers to pastoral migration, communal grazing areas are often overexploited and cease to exist in their traditional forms. In many areas across the continent, an increasing number of formerly communal areas are being transformed into private forms of management called 'enclosures'. However, enclosure systems in drylands are disputed. In southern Ethiopia and Somaliland, for example, it is claimed that enclosures fragment the land, hinder mobility and access to other herders, and are used for land-tenure claims that erode traditional values and livelihoods (Ahmed et al., 2016). The immediate surroundings of refugee camps, for example, are among the areas facing the highest pressure on natural resources, including vegetation and soil. It is critical to understand the land-management patterns and dynamics of these areas in order to assess the sustainability of agriculture in the face of growing human pressures in dryland settings. The JRC studied the Dadaab area as part of activating the Copernicus Emergency Management Service in 2014, with the prime objective of analysing a reduction in woody biomass linked to firewood and charcoal production. Over a period of seven years (from 2006 to 2013), the construction of pastoral enclosures quickly emerged as the most noticeable land-use change in this particular environment. Preliminary results of mapping with very-high-resolution (VHR) imagery show an increase of 56 % in fenced areas over this period, with a clear trend towards fencing in the most densely vegetated areas. These changes show how quickly pastoral land tenure is changing in areas with high levels of human-induced pressure, and the need for a deeper analysis of the long-term social, economic and environmental sustainability of land-management practices.

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7.2. Land degradation and desertification

1) Key findings

Assessment of the situation

African drylands are the largest in the world, and cover 20 million km^2 (66 % of the continent). Around 75 % of Africa's croplands and nearly 80 % of its rangelands are located within dryland areas. Population growth, combined with low GDP, is of concern in 80-90 % of croplands, rangelands and forested areas located in drylands. Livestock densities are critically high in rangelands and crop-production areas. Around 70 % of crop-production areas are deficient in nitrogen and phosphorous. This can lead to nutrient depletion and land degradation, which is probably already the case in areas where land productivity has declined.

"Around 70% of Africa's crop-production areas are deficient in nitrogen and phosphorous."

A herder with his livestock in the northern drylands of Senegal ©EU, by Andreas Brink

With a population expected to nearly double by 2050 (see chapter I.1.1), land will come under increased pressure. The production and productivity of Africa's food sector will have to increase very quickly: the current agricultural growth rate is still below the 1.75 % required to feed Africa's rapidly growing population (Global Harvest Initiative, 2016; UNDESA, 2015).

Sustainable land-management strategies are critical to avoid land degradation. Land degradation is a multifaceted process in which the biological and economic productivity and the complexity of ecosystems are reduced due to a combination of natural and human-induced processes (UNCCD, 1994). Desertification is a specific case of land degradation in drylands with low rainfall and high potential evapotranspiration.

In Africa, up to 21 % of vegetated land showed signs of decline or stress in its productivity between 1999 and 2013 (see Figures 42 and 43 and Table 3). The map in Figure 42 shows five classes that indicate areas where land productivity has been or is declining, or is stressed, stable or improving. In southern Africa, in particular, large areas show declining productivity.

"Large land areas of Africa show declining productivity."

FIGURE 42: Assessment of land-productivity dynamics in Africa, combining productivity dynamics of standing biomass and relative productive capacity within ecosystem functioning types, using satellite-observed vegetation images from the Copernicus Global Land Service *(Source: Ivits et al., 2013a, 2013b and 2014)*

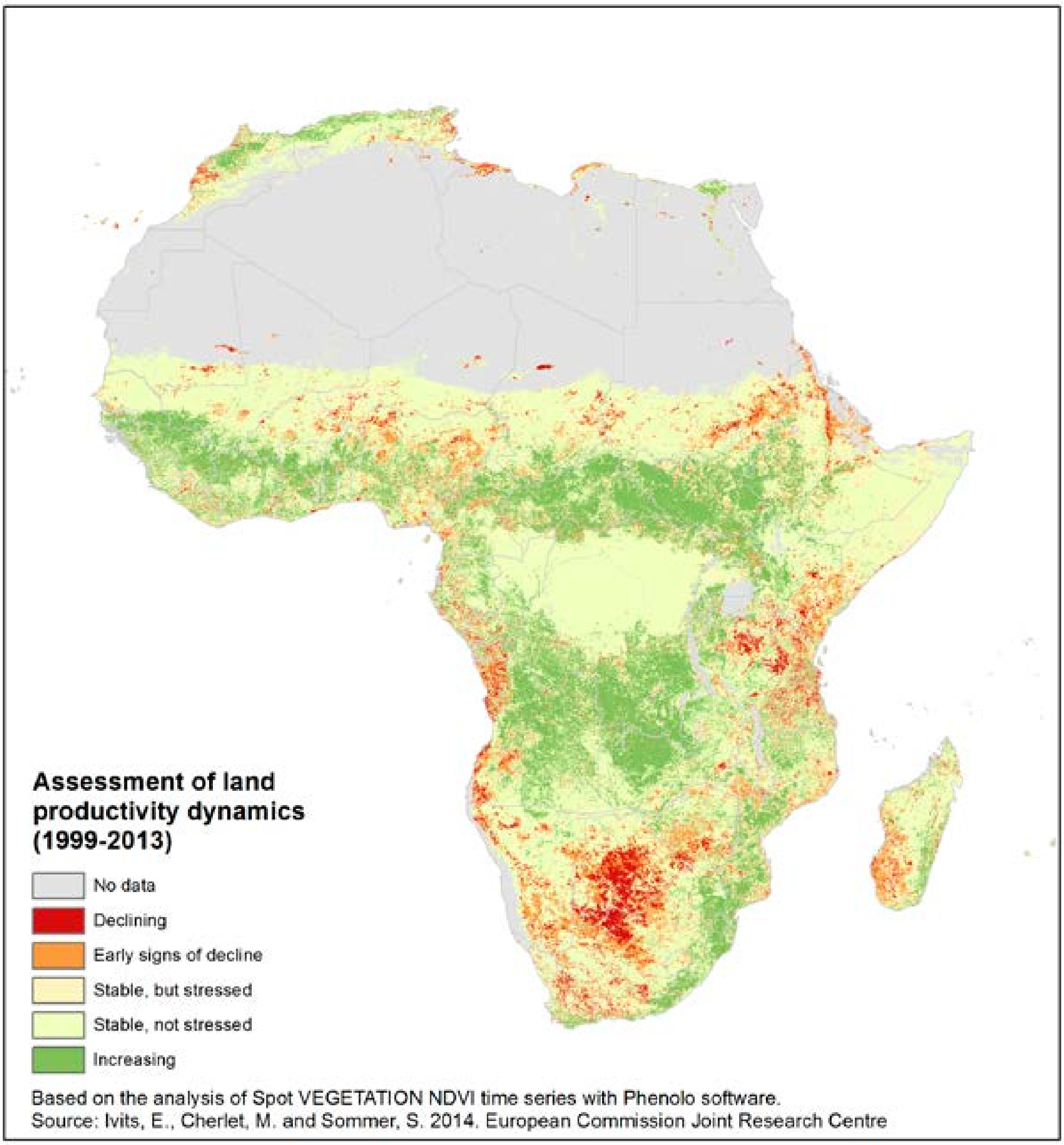


TABLE 3
Statistics from areas with declining or stressed land productivity

(based on map – Figure 42)	Area with land-productivity dynamics in decline or showing sign of stress (1999-2013)		Number of people living in these areas and therefore potentially affected (2015, in millions)
Land-cover type	Percentage of land covered	Million km2	
Cropland	24	1.0	94
Rangeland	25	1.7	54
Forest	17	1.1	52
Elsewhere (including expanding urban clusters)	19	0.6	131

Declining land productivity is not the only indicator of land degradation. Population increase, low income, livestock pressure, inadequate farming practices and the expansion of agriculture (in marginal areas and/or rangeland), water stress, fires, deforestation and droughts are some of the pressures that currently affect land resources in Africa. Local impacts are reflected in erosion, soil-nutrient depletion, soil-carbon losses and water shortages resulting in below-average crop yields, generating 'yield gaps' and a decline in land productivity. In large parts of Africa, e.g. northern Nigeria, fields are being expanded into rangelands to compensate for low productivity and poor management practices, putting further pressure on the remaining rangelands.

“Pressures on land resources lead to erosion, soil-nutrient depletion, soil-carbon losses and water shortages, resulting in below-average crop yields and a decline in land productivity.”

Figure 43 shows a map of African cropland areas in which 14 stress factors identified as being strongly associated with land degradation are combined. Of these 14 factors, six land-change processes relevant to land degradation are occurring concurrently in 42 % of vegetated lands across Africa, i.e. the forests, grass and savannah rangelands and croplands. The accumulated pressures coincided with and/or resulted in declining land-productivity dynamics over a vast surface of 2.7 million km^2. Based on 2015 populations in these regions, this means that some 83 million people living in cropland areas, 46 million in rangeland areas, 42 million in forest areas and 100 million elsewhere (updated from Ivits et al., 2013b) are potentially subject to distress due to land-degradation-affected areas.

Affected areas include northern Morocco, the Sahel (including Burkina Faso, northern Nigeria and eastern Sudan), Ethiopia, southern Kenya, northern Tanzania, Malawi, Zimbabwe and parts of South Africa. Three areas in particular stand out:

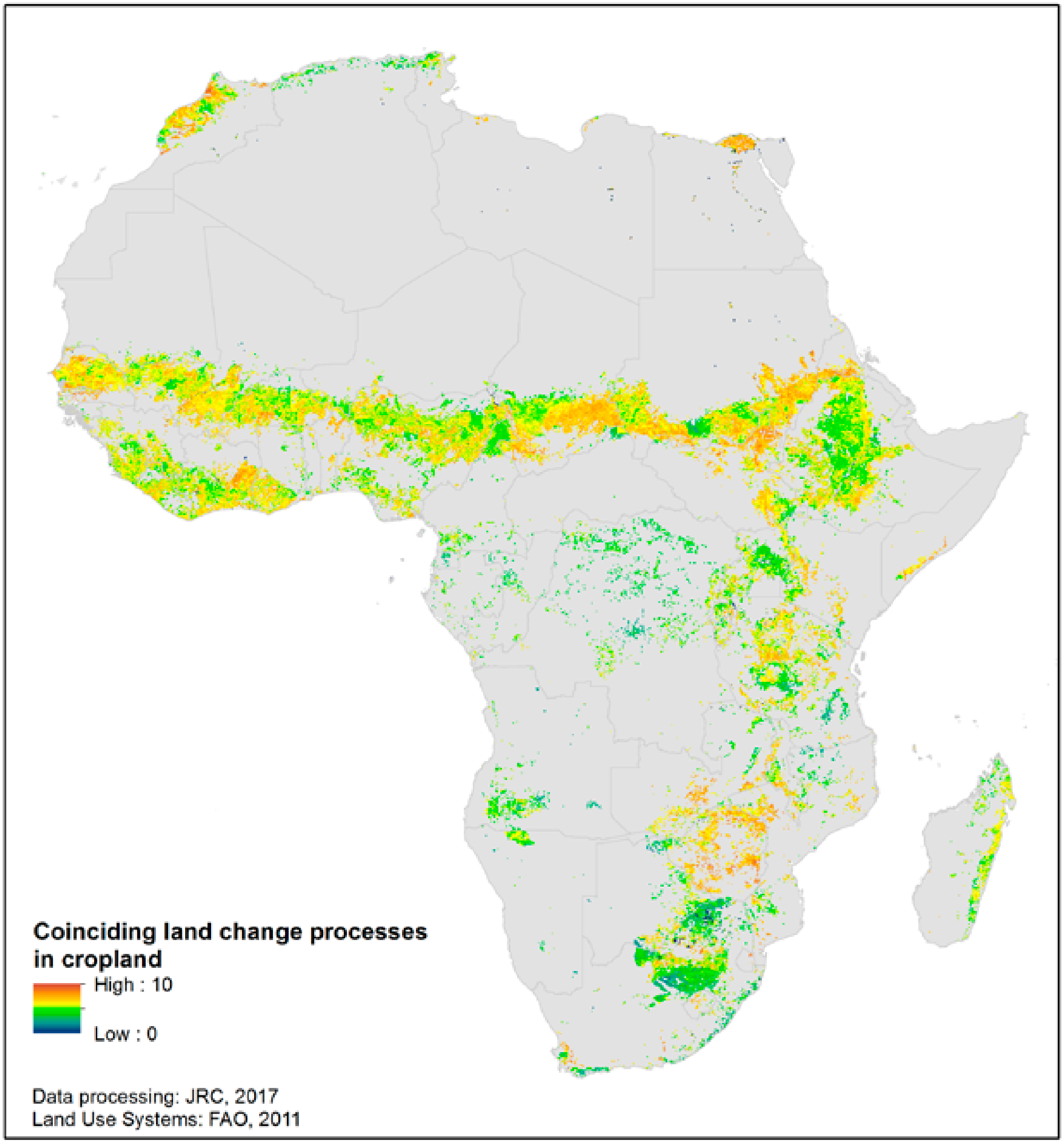
- **Sahel**: The accumulation of land-change processes in significant stretches of Sahel croplands merits specific attention, especially given that the population and related domestic food demands are growing, and croplands are scarce and managed by smallholders with limited means and income. As water resources are limited (Pekel and al., 2016), cultivation in the Sahel is mainly rain-fed (apart from some areas in Ethiopia), and is generally carried out on rather poor soils with medium or low levels of soil organic matter. Smallholder systems are mainly low-input farming systems with high densities of livestock and pressure from a growing settled population. In many cases, population pressure leads to small landholdings in areas of high-potential soils, while the traditional practice of fallowing is abandoned. High input costs, low product prices and market failures act as disincentives to invest in improved land-management practices. These processes put considerable stress on the land which, over time, leads to degradation. In these areas, pockets where biomass productivity decline has been observed over the past 15 years (while there is no widespread decrease in biomass productivity in the Sahel (Fensholt and al., 2012)) are the result of ongoing degradation processes. Frequent drought events, which are expected to intensify due to climate change, can further aggravate land-degradation conditions in stressed areas.

- **Kenya/Tanzania**: The expansion of croplands in southern Kenya and northern Tanzania has substantially reduced natural vegetation cover and biodiversity. Cultivation practices mainly involve low-input farming, which has led to a loss of soil nutrients, structure and organic carbon, thereby increasing the erodibility of soils (Maitima et al., 2009). The expansion of croplands leads to a reduction in rangelands, while livestock densities remain the same. Bare fields after cultivation and dense ranging have led to increased wind erosion in the Lake Victoria area in Tanzania (Dregne, 2002). Where these potential stress factors coincide, as reflected in the yellow and red pixels on the map, land degradation is certainly an issue.

Fencing is used to protect land from overgrazing by cattle, Kenya ©EU, by Andreas Brink

- **Zimbabwe**: Zimbabwe stands out as an example of coexisting pressures. Land degradation, which was previously already advanced, has accelerated in recent decades due to land-tenure issues. Colonial industrial farming reduced the amount of land available for the indigenous people, creating vast differences in land status and quality (Prince et al., 2009). In the 'common' lands, high population and livestock densities combined with low income, adverse government policies, insecure land tenure, agricultural expansion and drought events, and an observed reduction in land productivity, have created the right conditions for land degradation to occur. As land becomes scarcer, subsistence farmers are forced to engage in inappropriate land-use practices (Kamusoko et al., 2009). Rural households with insecure user rights to their farm plots, pastures and forest resources, are less inclined to invest in future productivity.

FIGURE 43: Number of concurring critical land-change processes in cropland areas *(Source: Cherlet et al., 2017)*



BOX 8

Ethiopia

Detailed stratified interpretations of land-productivity dynamics provide additional contextual information and are used to derive statistics for specific land uses. In this example, spatial analysis indicates that around half of the crop areas in the drylands are severely affected by declining land productivity, probably due to inadequate land-management practices that cause soil-nutrient depletion and wind erosion. As this is an important food-producing area, it should be the focus of conservation efforts.

FIGURE 44: Land-productivity dynamics across Ethiopia during the period 1999-2013 (Source: based on Cherlet et al., 2015)

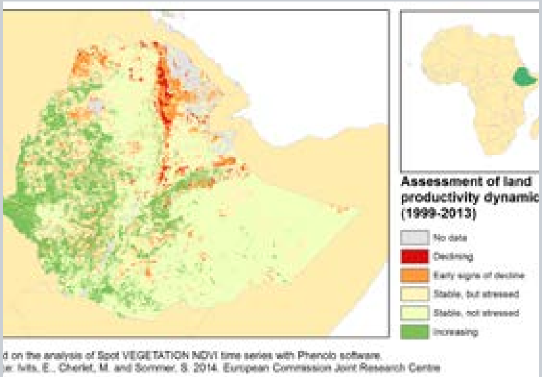
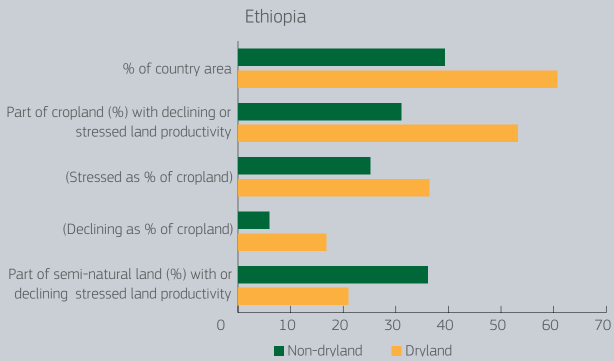


FIGURE 45: Area in percentage (x-axis) with declining or stressed land productivity in dryland and non-dryland zones in Ethiopia (Source: based on Cherlet et al., 2015)

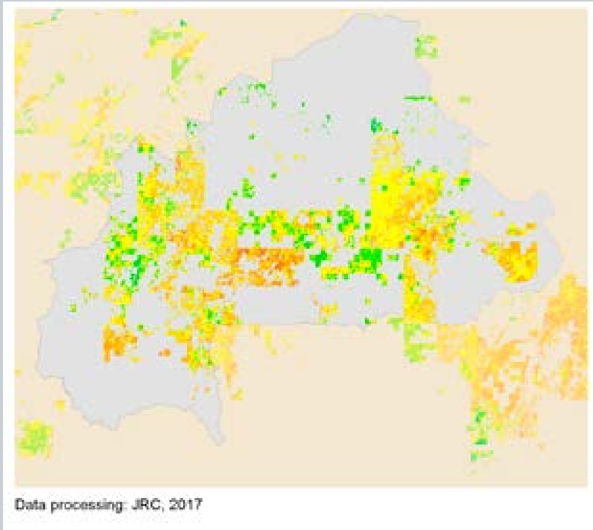


BOX 9

Burkina Faso

Burkina Faso has one of the fastest-growing populations in the world (UNDESA, 2017), and is one of the least-developed countries (UNDP Human Development Index). The economy depends on rain-fed agriculture. With poverty still prevailing in rural areas, productivity per hectare has not improved over the past decades. Farming is small-scale, extensive and low-input, which potentially leads to soil-nutrient deficiency. Recent land-tenure policies that ensure full land ownership and ease of access to land open up opportunities for investments in sustainable land management. Low productivity is therefore 'most easily' compensated by expanding the cultivated areas (Maitima et al., 2009) and reducing pastureland where stocking rates remain unchanged, both of which pose further threats to natural resources. More than eight or nine human-induced land-change processes occur in many of the low-input agricultural areas of Burkina Faso.

FIGURE 46: Number of land-degradation issues simultaneously active in low-input agricultural areas in Burkina Faso (coloured pixels represent low-input agricultural areas, i.e. where cropland makes up more than 10 % of the area, and where the nitrogen balance less than the global cropland average) (*Source: Cherlet et al., 2017*)



Outlook

In Africa, reliance on natural resources for direct subsistence will remain high, and the weak technological basis and widespread use of unsustainable production practices is expected to change only at a very slow pace, continuing to pose a threat to the condition of land resources (UNCCD, 1994). However, it has been estimated that if action to reduce nutrient depletion in African croplands was taken in the next 15 years, the average annual growth rate in agricultural production could rise by 5.3 % compared to 2010-2012 levels. Degraded land can be restored to some extent, but at higher costs than would be incurred in preventing degradation in the first place (ELD Initiative[17] and UNEP, 2015).

Three major constraints may further aggravate the situation: (a) reduced land availability per capita; (b) reduced fossil fuel availability per capita; and (c) the impacts of climate change (Riedacker, 2006). Climate change will exacerbate these stresses, as carbon fluxes from the land to the atmosphere will increase through loss of soil organic carbon and use of wood and fossil fuels. In addition, global warming increases the release (and loss) of soil organic carbon (Bradford et al., 2016).

> "If action to reduce nutrient depletion in African croplands is taken in the next 15 years, average annual growth in production could rise by 5.3 %."

Challenges and opportunities

The main challenge in balancing sustained and equitable economic growth with Africa's long-term food security for its large rural and growing city population will be to address land- degradation issues through sustainable management strategies that not only focus on the biophysical condition of the land but also on the socio-economic issues of the stakeholders who live on the land and from its resources.

17 The Economics of Land Degradation (ELD) Initiative is a global initiative on the economic benefits of land and land-based ecosystems.

Cotton plantation in northern Benin ©EU, by Andreas Brink

An important challenge is to locate those areas that are currently undergoing various aspects of land degradation. Understanding which specific land-change processes are concomitantly playing a role, and what their final impact will be, can help formulate targeted intervention strategies. To this end, the 'convergence of evidence' concept can be applied: when multiple sources of evidence are in agreement, significant conclusions can be drawn even when none of the individual sources is significant on its own. This concept, presented at the global level in the JRC's World Atlas of Desertification (to be published in 2017), can be implemented at regional and local scales using more detailed contextual information.

Methodologies to assess medium- to long-term land productivity dynamics are being developed, and have already been widely adopted. For example, the land-productivity dynamics metric has been part of the core datasets used to set standards for country reporting on land degradation neutrality. It is one of the three indicators used for SDG 15.3[18]. The Copernicus Land Service provides a mechanism to take such monitoring forward on a sustained basis. Increased access to free and open archives of satellite imagery will also support the development of methodologies for the production of higher-resolution (10 to 30 m) global datasets of the land-productivity indicator and for monitoring land-cover change.

Policy framework

The JRC's work on land-productivity dynamics was implemented in the framework of the Copernicus Land Service (Copernicus Regulation: (EU) No 377/2014). Work on the World Atlas of Desertification is in response to the EU's contribution and support as a signatory to the United Nations Convention to Combat Desertification (UNCCD), and is being carried out to support SDG 15.3.

2) Gaps, future actions and priorities to be considered

The processing of higher-resolution global datasets to improve the indicator of land-productivity dynamics remains a challenge, particularly given the lack of interactive processing capacity available. Econometric expertise is needed to link the current findings to more precise economic evaluations (e.g. from the Economics of Land Degradation Initiative).

A global or Africa-oriented land-degradation evaluation tool should be developed based on the 'convergence of evidence' concept, and linked to an African network of stakeholders.

18 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.

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8. Soils

1) Key findings

Assessment of the situation

A general perception of equatorial Africa is one of lush rainforests or savannah grasslands growing on red soils. In fact, as shown by this striking photograph from Tanzania, many soils across Africa are deeply weathered (which indicates that they are very old), highly acidic and largely devoid of essential nutrients, which have been leached out over time and often contain high levels of iron or aluminium oxides that give rise to their distinctive reddish or yellowish colour. Natural ecosystems have evolved to survive in such conditions by maintaining fragile nutrient cycles. Land-use change destroys this balance, causing soils to become increasingly infertile and more vulnerable to degradation processes, such as erosion.

High levels of iron or aluminium oxides give a characteristic reddish colour to many African soils ©Erika Micheli

A small banana farm in Cameroon, with an under-planting of secondary crops. This is an example of sustainable soil-management practices which, in addition to strengthening the resilience of the local community through additional food and income, reduce soil degradation, increase carbon accumulation, maintain moisture, improve soil structure and provide a better habitat for soil organisms ©Erika Micheli

Ignored or largely overlooked in most policy contexts, healthy and fertile soils are at the core of food security, sustainable rural development, climate resilience, poverty reduction and societal stability in Africa. The sustainable management of soil resources is therefore a key challenge. Neglecting this issue will have critical implications for the well-being, and even the survival, of over 1 billion people and the continent's above-ground ecosystems, which depend on the public services provided by soil.

More than 95 % of the food consumed in Africa, and 100 % of the firewood used for cooking and heating, come from the land. Healthy functioning soils are the backbone of agriculture, which in turn accounts for approximately 25 % of sub-Saharan Africa's GDP, 40 to 65 % of its labour force (where women play a major role) (AGRA, 2016), and 15 % of its total exports (WTO, 2015), and is the main source of income for Africa's rural population. In addition, soils regulate nutrient cycles (including organic carbon), store, transform and filter pollutants to ensure clean drinking water and, in many regions, have significant cultural and landscape connotations.

Soils on the African continent are very diverse (see Box 10). More than half of the land surface is characterised by a combination of sandy soils (22 %), shallow stony soils (17 %) and young, weakly developed soils (11 %), which place severe natural constraints on their use (Jones et al., 2013). In the remaining portion, large areas are characterised by soils that are inherently fragile (as they are low in nutrients and organic matter), often containing high levels of iron and aluminium oxides and salts, exhibiting extremes in pH values19. These soils can be improved by the addition of fertilisers and by irrigation.

The JRC has calculated that only about 8 % to 13 % of the total African land mass is relatively free of natural constraints to agriculture. In these areas, there are highly fertile and productive soils which have a good structure and rootability, possess adequate levels of organic matter and primary minerals, and have good water-holding capacity.

“Only on about 8 % to 13 % of total Africa's land mass are soils naturally suited to intensive agriculture.”

BOX 10

Understanding the soil types of Africa

The central, most humid part of the continent is dominated by deeply weathered, acidic soils with high levels of iron oxides and lacking in essential plant nutrients. In drier conditions, the less-intense weathering processes, together with inputs of wind-blown dust, give rise to soils with increased clay content and slightly higher pH levels.

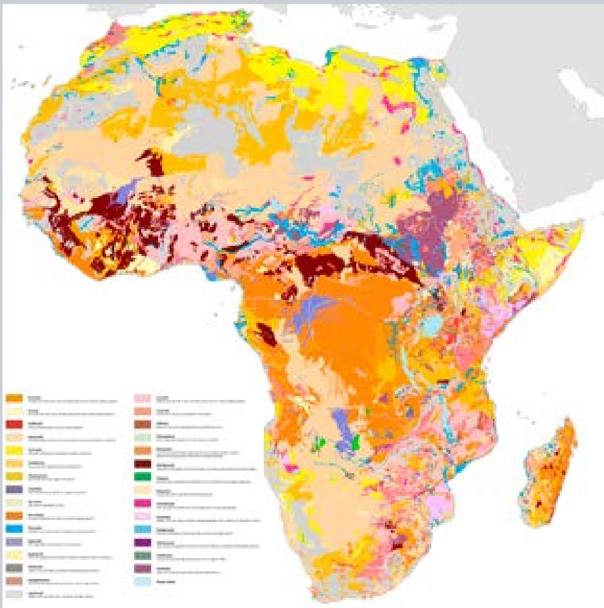
In west Africa, large areas are characterised by soils with surface layers hardened by iron and clay compounds.

The desert regions in the north and the south are dominated by soils that range from lime or gypsum-rich to shallow, weakly developed and sandy.

In the dry part of southern Africa, soils with a significant accumulation of silica and an associated ‘hardpan’ can be found. The dark purple colour on the map, notably in Sudan and Ethiopia, indicates soils containing high levels of swelling and shrinking clays, whereas the bright red colours depict soils associated with volcanic deposits, which are particularly evident along the African Rift Valley, where Africa’s most fertile soils are found.

In the Mediterranean region, the pale brown and light green colours indicate soils that have developed under permanent grasslands. Soils that have been strongly influenced by water can be identified throughout the map, and indicate wet conditions caused by high groundwater levels, stagnant water or sediments associated with Africa’s river systems, deltas or mangroves. Saline and sodium-rich soils are mainly associated with ephemeral lakes in arid climates and coastal plains.

FIGURE 47: Africa’s main soil groups (Source Jones et al., 2013)



19 The pH (potential of hydrogen) scale is a measure of the degree of acidity or basicity of an aqueous solution. The pH scale ranges from 0 to 14. A pH value of less than 7 denotes an acidic solution.

The low nutrient status of most soils in sub-Saharan Africa is exacerbated by insufficient use of inorganic fertilisers and manure (partly related to rural poverty as well as inadequate infrastructure and high transport costs), and by the practice of monocropping. Overall use of inorganic fertilisers in sub-Saharan Africa is just 12 kg/ha, the lowest in the world, while soil-nutrient depletion is widespread in croplands. Average applications of inorganic fertilisers are less than 9 kg of nitrogen and 6 kg of phosphorus per ha, compared with typical crop requirements of 60 kg of nitrogen and 30 kg of phosphorus per ha. The natural replenishment of nutrients in land with poor-to-moderate potential during fallow periods is insufficient to maintain soil productivity in the long term and will diminish the capacity of ecosystems to provide services.

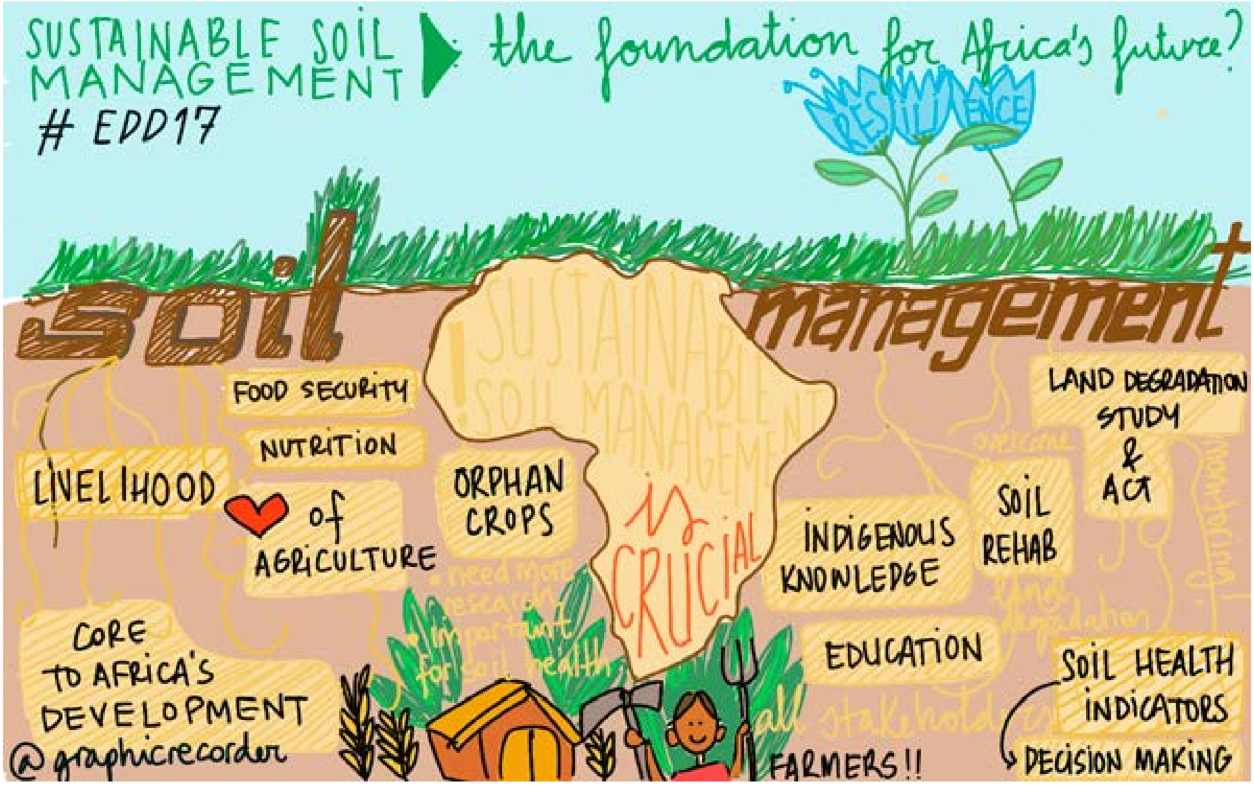
> "Overall use of inorganic fertilisers in sub-Saharan Africa is the lowest in the world."

While highly visible on the ground, data on the extent of soil degradation in Africa is unreliable. It is estimated that 77 % of sub-Saharan Africa is affected by erosion, with the most badly affected areas in South Africa, Sierra Leone, Guinea, Ghana, Liberia, Kenya, the DRC, the Central African Republic, Ethiopia, Senegal, Mauritania, Nigeria, Niger, Sudan and Somalia (FAO, 2015). Despite limitations in methodology, the Global Assessment of Human-induced Soil Degradation (GLASOD) study (Oldeman et al., 1990) is still the only published estimate of soil degradation for the entire continent. The study, carried out in the late 1980s, reported that around 65 % of agricultural soils in sub-Saharan Africa have become degraded since the middle of the 20th century as a result water and wind erosion, pollution, salinisation, nutrient loss and structural collapse due to compaction (Oldeman, 1991). In addition, 31 % of permanent pastures and 19 % of woodlands and forests exhibited soil degradation, many irreversibly so in terms of human lifespans. While the GLASOD methodology is considered unrefined and subjective, Earth observation data can provide indirect proxies for the condition of the land (see chapter I.7.2). However, contemporary data-collection programmes are currently unable to provide precise assessments of soil condition.

Planners, decision-makers and users of the land need to be more aware that agricultural production depends on the productivity of soils, and that the sustainability of production depends on proper utilisation of the resource. In recent years, competition for land for different uses (see chapter I.7.1) has also overtaxed the resilience of natural processes, thereby causing land degradation and a decline in soil productivity.

In the Status of World Soil Resources Report (FAO and ITPS, 2015), the Intergovernmental Technical Panel on Soils noted that the most critical threats to soils and the related ecosystem functions in sub-Saharan Africa are soil erosion, loss of organic matter and nutrient depletion. These are driven by greater use of land for agriculture, overgrazing (both of which are compounded by population expansion), poverty and climate change.

FIGURE 48: Sustainable soil management is crucial for Africa's future development. Healthy functioning soils will help address key societal challenges, such as food security, rural development, poverty and migrational pressures, while providing increased resilience to climate change. This image is a graphical summary of the key issues raised during a recent JRC workshop on soils in Africa, held at the 2017 European Development Days Conference ©Nick Payne/@graphicrecorder



Outlook

While many African countries have experienced a recent slowdown in economic growth, others (such as Ethiopia, Rwanda and Tanzania) are continuing to develop with annual average growth rates of over 6 % (World Bank, 2016). In parallel, a growing population and rapid urbanisation are putting greater pressures on farmers to boost productivity to satisfy the increasing demand for both food (including feed for animals) and cash or energy crops.

Initiatives such as the 2014 Malabo Declaration (which commits African countries to double agricultural productivity in order to end hunger by 2025) raise the question of whether such targets can be satisfied by more intensive use of soil resources or by an expansion of the agricultural area, both of which have significant secondary consequences.

Soils and climate are inextricably linked, as climate is a soil-forming factor and soils are a key component of the global climate system. As climate changes, so will the range and intensity of soil processes. This will affect the role of soil in the hydrological cycle and its ability to support existing ecosystems, leading to changes in vegetation. Climate change scenarios for Africa run by the Intergovernmental Panel on Climate Change (IPCC) note that temperatures in much of the continent are likely to increase by more than 2 °C in the coming decades (Niang et al., 2014), and climate models project that a warming of more than 3.5 °C will occur across most of the African continent in the northern hemisphere winter by the end of this century, which will lead to increased evaporation from soils and plants (see chapter I.5.1). While rainfall projections are uncertain for much of the continent, both a reduction in the quantity and an increase in the volume and intensity of rainfall may exacerbate soil erosion. In parallel, increased use of soil for carbon sequestration to mitigate climate change may give rise to opportunities for the application of more 'soil-friendly' land-management practices.

Challenges and opportunities

Conspicuously absent as a topic in the Joint Africa-EU Strategy (JAES) Roadmap for 2014-2017, soils have the potential to make a substantial contribution to sustainable economic activities, job creation, peace and security, disaster risk reduction and climate change adaptation and mitigation. However, there are major challenges.

> “Africa’s soils can contribute to sustainable economic activities, job creation, peace and security, disaster risk reduction and climate change adaptation and mitigation.”

Many social crises in Africa are triggered by inadequate soil- and water-management policies and practices. There is a need for land-use policies that reflect the importance of soil and create incentives for people to adopt sustainable and integrated soil-management solutions. For example, the ‘4 per 1 000’ initiative aims to offset carbon emissions, and thus mitigate climate change, by increasing soil carbon levels in agricultural land by 0.4 % per year, while at the same time creating more fertile and resilient soils.

Fertile land in the Kenyan highlands ©EU, by Andreas Brink

Greater attention must be given to soils in Africa. The first-ever Soil Atlas of Africa was produced as recently as 2013 (French version in 2015).

Policy framework

At present, no EU policy documents specifically target the sustainable use of soil or the restoration of degraded soils in Africa. In 2015, the FAO (with EU support) approved a revised World Soil Charter with the overarching goals that soils are managed sustainably, degraded soils are rehabilitated or restored, and that good soil governance is practiced at all levels. In particular, the charter calls for the compilation of reports on the state of soil resources and sustainable soil-management protocols, development of a global soil information system integrated with Earth observation systems, and the provision of assistance to governments to establish appropriate soil-management legislation. As a member of the FAO, the EU could react to these challenges, particularly in the context of the JAES.

Viable soil management is essential to achieve the SDGs in Africa. SDG 2 recognises that hunger abatement requires efficient and sustainable agricultural production, which can only be achieved if soil functions are maintained and sustainable and climate-friendly soil-management practices are put in place. These are equally relevant for combating soil degradation, contamination and climate change, as outlined by SDGs 3, 12, 13 and 15.

2) Gaps, future actions and priorities to be considered

At present, there is a lack of contemporary, consistent and comparable data on the state of and trends in soil resources, associated ecosystem services and threats to soils across Africa. Initiatives such as the African Soil Information System (AfSIS) use remote-sensing and legacy soil profile data to provide new continent-wide soil property maps. However, the associated field programme should be supplemented by an extensive and dense network of primary data collection that can deliver accurate policy-relevant assessments (as a comparison, the Land use/cover area frame statistical survey (LUCAS) collects samples from approximately 27 000 locations across the EU, compared to the 10 000 samples collected in Africa by AfSIS, for an area that is almost seven times smaller).

With the explosion of mobile communications across Africa, there is tremendous scope for ‘citizen science’ initiatives in this area. In combination with socio-economic data, soil data can be analysed to indicate the suitability of land for various uses. Such information can also be used for monitoring the effects of land uses and policies on soil resources. It is essential to develop a harmonised soil-monitoring programme for Africa, by reinvigorating national/regional soil survey programmes. Education, including farm-level advisory services, should also be a priority. Without a trained scientific base, it will be impossible to collect relevant soil information and provide guidance for its sustainable management.

It is vital to raise awareness among politicians, policymakers, farmers and landowners, the private sector, donors and investors of the need for a paradigm shift in the way that Africa’s soils are being managed and used.

Strategies for intensification of agricultural production should aim to achieve high yields per unit area, while at the same time improving soil health and conserving water resources and environmental vitality. This can be achieved when land users are informed of the potential and management requirements of a given area of land identified for a specific purpose. Measures are also needed to reduce food waste.

A key solution is for guidelines on sustainable soil management to be adopted by all countries. Long-term and large-scale measures are also necessary to build greater resilience to soil degradation and reduce human vulnerability to disaster events. The concepts of sustainable soil management should be part of the land-management policy cycle, supplemented by investment in technical training and education (at all levels, for all stakeholders). Metrics to assess progress towards soil-related SDG targets (in particular, those relating to land degradation and the implications for human health from soil contamination) are under way, and such work should continue. Scientific and technical training in the making and use of such metrics should also be developed and delivered. Quantification of the value of the public services provided by soil, the benefits of sustainable management practices, and the costs of land degradation can increase awareness of the need to address soil as part of Africa's natural capital. The JRC's expertise in mapping and assessing land-management practices and soil-based services could help quantify these aspects.

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9. Biodiversity and protected areas

Rich biodiversity in the tropical rain forest of Gabon ©EU, by Grégoire Dubois

1) Key findings

Assessment of the situation

Biodiversity underpins the livelihoods and well-being of much of Africa's population, especially in those rural communities that depend directly on healthy ecosystems for water, food, fodder, fuel, shelter, medicines, and cultural and spiritual needs. Africa's terrestrial, freshwater and marine ecosystems are home to rich and unique biodiversity – a tremendous natural, cultural and economic asset. For example, the continent supports the world's second-largest rainforest area (in the Congo Basin), vast savannah areas with exceptional megafauna communities, and eight global biodiversity hot spots, each with at least 1500 endemic vascular plant species (Figure 49a).

> “The rich and unique biodiversity of Africa's ecosystems is under serious pressure from human activities.”

African biodiversity is, however, under ever-increasing pressure, mainly driven by habitat loss and unsustainable and intensifying human use (Figure 49b). Over 3 million hectares of natural habitat are lost each year in Africa

BOX 11

Wildlife crime – a serious threat to Africa's biodiversity, security and economy

In the past few years, wildlife crime has once again emerged as a serious issue for Africa, largely driven by increased demand in a few Asian countries (Nellemann et al., 2014). Often perpetrated by heavily armed groups, it has reached a level that is not only creating a critical risk to many wildlife populations, but also poses security problems and jeopardises tourism and local livelihoods (UNEP, 2016). Wildlife crime helps finance militia and terrorist groups, and thus fuels terrorism and civil conflict in Africa. Large regions in Central Africa are destabilised by the presence of these well-organised armed groups.

> “Over 3 million hectares of natural habitat are lost each year in Africa.”

At present, elephants, rhinoceroses, pangolins and prized hardwoods are the primary target species for wildlife trafficking. Rhinoceroses have been wiped out in several African countries (Mallon et al., 2015), and well over 1 000 are still killed each year in southern Africa. Over 20 000 African elephants are killed each year (i.e. up to 5 % of the remaining population), and the African forest elephant population has declined by over 60 % since 2002 (Nellemann et al., 2014).

The aftermath of bushmeat poaching in Zambia ©EU, by Grégoire Dubois

To help tackle this complex issue, the EU has recently adopted an Action Plan against Wildlife Trafficking which includes 32 measures applicable within the EU and globally.

(FAO, 2015; UNEP, 2012). Deforestation and forest degradation have heavily affected the continent's tropical dry forests and some of the rainforests in Madagascar, West Africa and the DRC, while mangroves and wetlands have also declined significantly over the past 20 years (see chapter I.6.1 and UNEP-WCMC, 2016). For many species, the problem is exacerbated by intense wildlife poaching and trafficking (see Box 11). Invasive alien species, pollution and climate change add further pressure. As a result, more than 6400 animal species, 3100 plant species, and 21 % of all freshwater species in Africa are threatened with extinction (UNEP-WCMC, 2016), with particularly dramatic declines in the Saharan and West African megafauna (Durant et al., 2014; Mallon et al., 2015). This ongoing erosion of biodiversity, ecosystems and ecosystem services – often propelled by global drivers and pressures – threatens the economic, social and cultural well-being of many Africans.

Recent studies have shown that effectively managed protected areas can significantly help counter biodiversity loss and provide multiple benefits to people (e.g. Beresford et al., 2013; UNEP-WCMC and IUCN, 2016). Tourism linked to protected areas also contributes substantially to the national economies in many African countries (UNWTO, 2014).

> “Only 14.4 % of Africa's land area and 5.3 % of the continent's marine areas are protected.”

However, protected areas only cover 14.4 % of Africa's land area and only 5.3 % of the continent's marine areas under national jurisdiction (IUCN and UNEP-WCMC, 2017), thus falling short of the global targets set by the United Nations Convention on Biological Diversity (CBD) of having 17 % terrestrial protection and 10 % marine protection by the year 2020. Moreover, protection is highly uneven across Africa (Figures 49c and 49d) and is still ineffective in many protected areas, mainly because of inadequate resources.

Since 1985, EU development funding has supported many African protected areas of high biodiversity value yet often face significant anthropogenic pressures that threaten their performance (Hartley et al., 2007). Continued EU support for the long-term improvement of the governance, management and enforcement of protected areas is urgently needed to effectively address multiple threats and challenges (European Commission, 2015).

Outlook

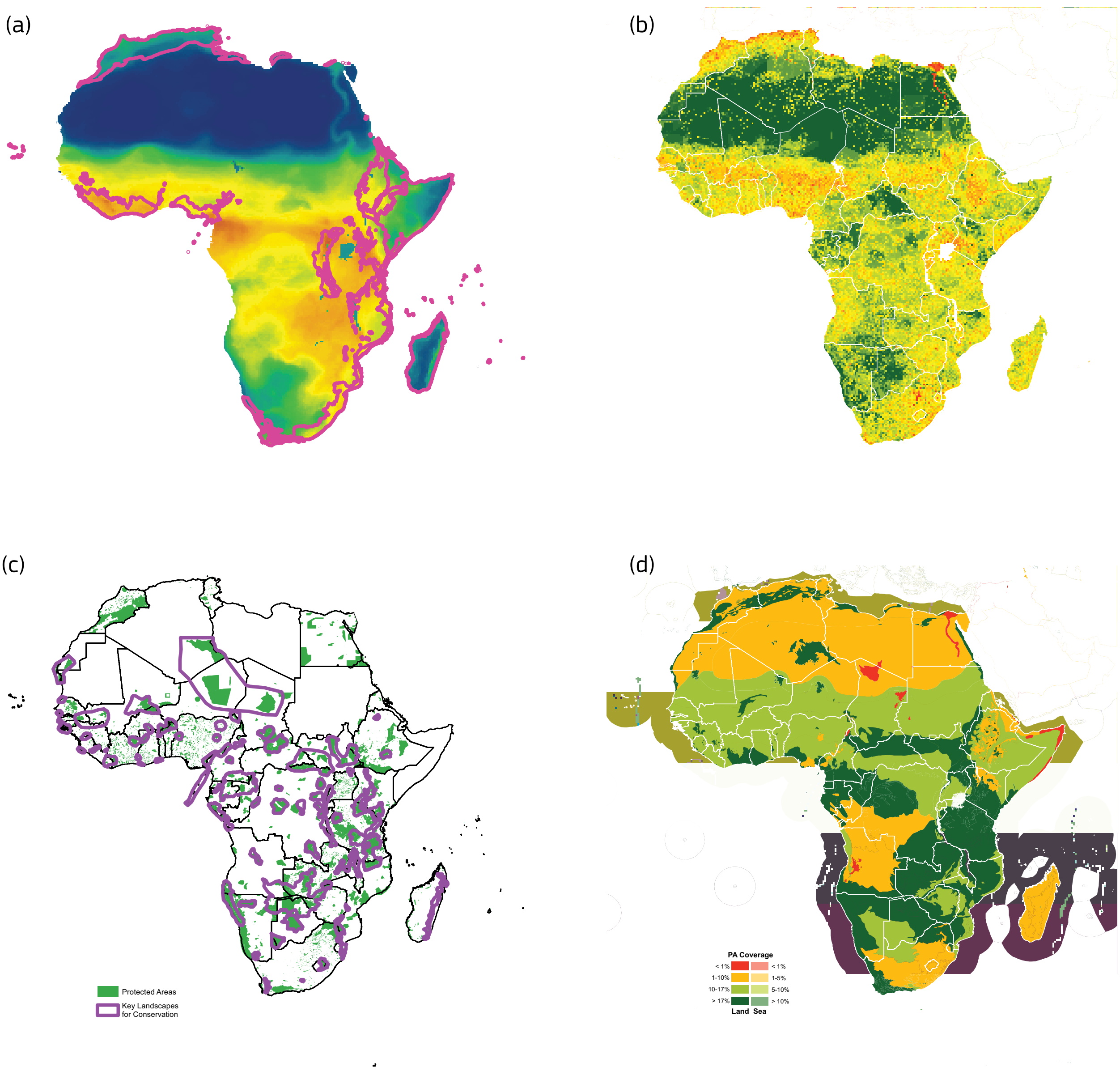
Rapid growth in human population and per-capita consumption are expected to put further pressure on Africa's biodiversity (UNEP, 2016). Large-scale expansion of agriculture, urbanisation, extractive industries (logging and mining) and infrastructure such as roads, railroads and pipelines, including in Africa's major 'development corridors', will affect many species, ecosystems, protected areas and associated ecosystem services (Laurance et al., 2015; UNEP, 2016). Africa's biodiversity will also be impacted by climate change, which will trigger changes in species distribution and interaction, and increase the risk of extinction. Well-designed protected-area systems can, however, play a key role in enabling species to adapt to climate change.

There are concerns that Africa will not be able to achieve many of the CBD's targets for 2020; a recent review showed insufficient or no progress on 18 of the 20 targets (UNEP-WCMC, 2016). In fact, prospects for meeting the critical Target 12[20] on species conservation have deteriorated, and there is still insufficient progress on key elements of Target 11[21], such as effective and equitable management, representativeness and the connectivity of protected areas.

20 Target 12 of the CBD: By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.

21 Target 11 of the CBD: By 2020, at least 17 % of terrestrial and inland water, and 10 % of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

FIGURE 49: Maps of Africa showing: (a) species richness in amphibians, birds and mammals (IUCN, 2016; BirdLife International and NatureServe, 2014), plus biodiversity hot spots identified based on endemic plants (Conservation International, 2011); (b) human footprint on land, a cumulative measure of eight human pressures, in 2009 (Venter et al., 2016); (c) terrestrial and marine protected areas in 2017 (IUCN and UNEP-WCMC, 2017), plus the Key Landscapes for Conservation (KLCs) identified in the EU strategic approach to wildlife conservation in Africa (European Commission, 2015); and (d) degree of coverage of marine and terrestrial ecoregions by protected areas in 2016 (UNEP-WCMC and IUCN, 2016). The biodiversity hot spots and KLCs highlight some of the critical areas for biodiversity conservation on the continent.



Challenges and opportunities

Africa is at a crossroads – if it does not move towards green development, for example by strengthening the governance and management of its rich natural resources, there is a high risk that its natural capital will be irreparably damaged. Africa's biodiversity and protected areas clearly have the potential to make a substantial contribution to sustainable economic activities, job creation, peace and security (e.g. through cross-border conservation areas or 'peace parks'), disaster risk reduction and climate change adaptation. Africa's protected areas provide thousands of jobs, support millions of livelihoods, and generate tourism revenues worth several billion US dollars each year. They attract an estimated 69 million recreational visitors annually (mainly international tourists), generating about US$ 48 billion direct in-country expenditure (EUR 39.8 billion, at 2017 exchange rates), which contributes substantially to local incomes and employment (UNWTO, 2014; Balmford et al., 2015).

> “Africa’s protected areas attract an estimated 69 million recreational visitors annually, generating about US$ 48 billion direct in-country expenditure.”

However, more effective protected area systems are needed to maintain biodiversity and the essential ecosystem services on which most rural communities depend, and which can form the basis for sustainable livelihoods and green development.

The Joint Africa-EU Strategy (JAES) Roadmap 2014-2017 contains a clear commitment to cooperate financially and technically on “the preservation and the restoration of healthy, resilient ecosystems within and outside protected areas, considering them as a critical natural asset to ensure sustainable livelihood for the people and development of the region”. This explicitly includes the fight against wildlife crime, the involvement of local communities in the sustainable use of biodiversity for economic development, and the integration of biodiversity into national policies, plans and budgets.

Data, indicators, maps, analytical tools, web-based information systems, and capacity-building all help to generate the knowledge required for improved policy- and decision-making on biodiversity conservation in Africa. The Digital Observatory for Protected Areas (DOPA) and the Biodiversity and Protected Areas Management Programme (BIOPAMA) are recent examples of initiatives that demonstrate the power of geospatial tools. DOPA is a global information system that delivers indicators and analytical tools for assessing the biodiversity of, and threats to, protected areas. This informs policy- and decision-makers involved in spatial planning, resource allocation, and protected-area development and management (Dubois et al., 2016). BIOPAMA is an initiative by the African, Caribbean and Pacific (ACP) Group of States that aims to improve the long-term conservation of biodiversity and reduce the poverty of populations in and around protected areas by helping institutions in the ACP regions to access critical data, information and knowledge. To facilitate this, the JRC is developing and deploying Regional Reference Information Systems (RRIS) across the ACP regions to gather, manage and provide access to information on training, best practices, funding, literature, expertise, maps and other geographic data on biodiversity and protected areas.

> “The Digital Observatory for Protected Areas (DOPA) and the Biodiversity and Protected Areas Management Programme (BIOPAMA) provide access to critical data and information to support biodiversity conservation and management.”

The range and quality of indicators provided by systems such as DOPA will continue to evolve, as will web-based tools that facilitate the monitoring and reporting of critical information on biodiversity and protected areas, including conservation projects funded by large public donors. In addition to continent-wide/global systems, regional observatories and their RRIS will also present new monitoring opportunities and ensure that information directly supports decision-making by all stakeholders. Other opportunities include the preparation of regional ‘State of protected areas’ reports and further deployment of the Integrated Management Effectiveness Toolkit (IMET), which helps plan, monitor and evaluate protected areas. The Copernicus Global Land Service will also become increasingly relevant as higher-resolution free satellite imagery is used to create maps of contemporary land cover and how this is changing in Africa’s protected areas and KLCs (Figure 49c).

Policy framework

A number of policy documents currently aim to enhance and promote biodiversity conservation and protected areas in Africa. Examples of relevant European policies and strategies include Target 6 of the EU Biodiversity Strategy to 2020 to “help avert global biodiversity loss”, the EU Biodiversity for Life (B4Life) Flagship Initiative, the EU Action Plan against Wildlife Trafficking, and the EU Strategic Approach to Wildlife Conservation in Africa (‘Larger than Elephants’). The CBD and other biodiversity-related conventions, including the World Heritage Convention, the Ramsar Convention on Wetlands of International Importance, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and the Convention on the Conservation of Migratory Species (CMS), provide an international framework. Relevant regional instruments include the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) and the Lusaka Agreement on Co-operative Enforcement Operations Directed at Illegal Trade in Wild Fauna and Flora (for East, Central and Southern African countries). Ultimately, all these policies contribute to the achievement of multiple SDGs, in particular SDG 14 (marine life) and SDG 15 (life on land).

Elephant in Gabon ©EU, by Grégoire Dubois

2) Gaps, future actions and priorities to be considered

More information is needed to answer critical policy questions such as: how to reconcile biodiversity conservation and sustainable development in Africa? What are the best strategies for establishing, governing, managing and enforcing effective protected areas? How to ensure that the costs and benefits of protected areas are shared fairly and equitably? The information required needs to include better spatial data on the values, status and trends, threats and conservation needs of African biodiversity (e.g. more detailed, frequently updated and easily accessible information); tenure and resource-use rights; and the social, economic and conservation outcomes of protected areas vis-à-vis their management effectiveness and governance quality.

By targeting multiple stakeholders from different sectors (tourism, agriculture and fisheries, forestry, transport, energy, etc.), the pan-African network of BIOPAMA Regional Observatories provides a new opportunity to fill knowledge gaps, and support biodiversity conservation and mainstream biodiversity into decision-making by relevant actors and sectors. Knowledge products, such as regional 'State of protected areas' reports, provide further regular updates on African protected areas, and highlight how they can act as models of sustainable development for Africa's local communities and national economies.

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10. Water-resource management

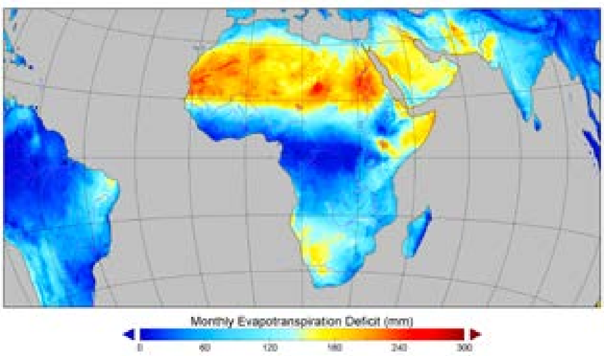
1) Key findings

Assessment of the situation

Africa contains three extremely dry regions: northern Africa (with the Sahara Desert at its heart), south-western Africa (around the Kalahari and Namib deserts), and the Horn of Africa. The continent also covers several regions with abundant water resources, which are often called water towers. Africa's water towers include the Ethiopian Highlands, the Congo Basin, the East African mountain region, the Angolan water plateau, the Lesotho Highlands, the Jos Plateau in central Nigeria and the Fouta Djallon mountains in Guinea (UNEP, 2010).

Crater lake in the East African mountain region of Uganda ©EU, by Andreas Brink

FIGURE 50: Average monthly evapotranspiration deficit 1979-2012 (Source: JRC, 2017)



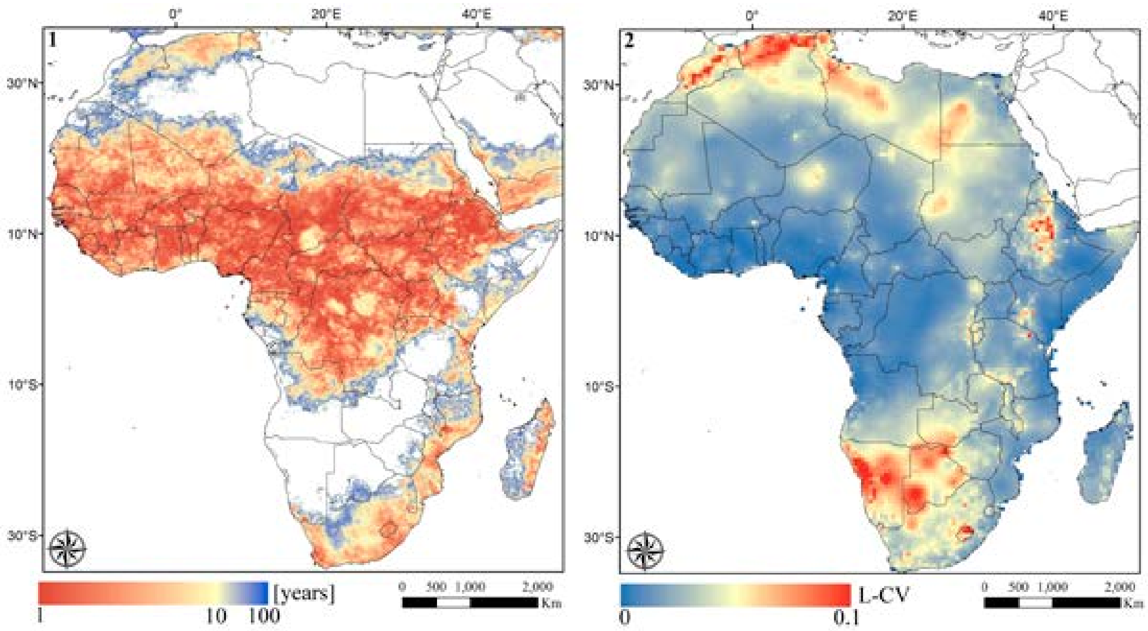
In the dry regions, mean annual evapotranspiration (evaporation from the land surface plus transpiration from plants) is significantly lower than that required for unstressed vegetation growth (Figure 50), and the growth of natural vegetation and rain-fed crops is often water-limited. In these areas, agriculture may only be possible through irrigation.

However, water shortages are more often caused by inter- and intra-annual fluctuations of rainfall at the fringes of the dry and wet areas (particularly in the Sahel and southern Africa), resulting in droughts and crop failure. Growing seasons where the actual precipitation is 30 % less than the amount expected (precipitation deficits) occur with a return frequency (an estimate of the likelihood an event will be repeated) of four to six years across the Sahel, sub-Sahel and Central Africa (Figure 51, left). Mean annual temperatures throughout the region are far more stable, although they are high enough for the reduced precipitation to be associated with drought (Figure 51, right).

Although after Australia, Africa is the driest continent in the world, it currently abstracts relatively little of its renewable water resources (surface and groundwater): only 5.5 % is used, of which 81 % serves the agricultural sector, followed by urban use at 15 % and industrial use at 4 % (reference year 2010; FAO, Aquastat, 2016). This figure falls to below 3 % of renewable water resources when sub-Saharan Africa alone is considered. The Near East and North Africa use well over half their renewable water, at 62.5 %, while Asia uses 20.4 %. Sub-Saharan Africa is also the region where irrigated agriculture is least developed. Only 3.5 % of its cultivated area is irrigated, compared to 42.2 % in South Asia and 33.6 % in the Near East and North Africa (FAO, Aquastat, 2016).

> “Only 3.5 % of the cultivated area in sub-Saharan Africa is irrigated.”

FIGURE 51: Return periods for precipitation deficits of 30 % in August (white corresponds to areas with negligible rainfall (dry season), for which the indicator is not representative) (left) and yearly temperature variability from 1948 to 2008 calculated using the University of Delaware Air Temperature and Precipitation dataset[12] (right) *(Source: JRC)*



In 2015, Africa housed about 8 % of the Earth's permanent surface water and roughly 16 % of the world's total population. At the same time, the water-rich North American region held slightly more than half of Earth's permanent surface water, but was home to less than 5 % of the global population (Pekel, 2016). Moreover, the volume of groundwater in Africa is estimated to be more than 100 times the annual renewable freshwater resources (in total, about 0.66 million km3), and 20 times the freshwater stored in African lakes (MacDonald, 2012).

Satellite analysis of global surface-water occurrence for the period 1984-2015 revealed that there has been a small net increase of almost 3 % in surface-water extent in Africa. This is the result of an increase in irrigated agricultural areas and more artificial (typically hydropower) reservoirs. However, localised losses in surface-water area also occur (e.g. Tanzania's Lake Sagara – see Box 12), often due to sustained abstraction combined with reduced rates of recharge.

Changing groundwater resources in Africa are equally important. Groundwater is the source of drinking water for three-quarters of Africa's population (UNECA, 2000). Africa's important aquifers (such as the Nubian Sandstone Aquifer System – the world's largest fossil-water aquifer system – and the Lake Chad aquifer) are losing more water than their rates of recharge (UNEP, 2010). Wada et al. (2016) estimate that several aquifers in Africa lose 20 to 100 million m^3 of water per year (calculated on a 50 x 50 km grid), which translates into a loss of 2 to 10 cm water depth per year. Some of the largest aquifers undergoing groundwater depletion are situated in Libya, Algeria, Mauritania and South Africa.

> “Groundwater is the source of drinking water for three-quarters of Africa's population, but groundwater resources are depleting.”

For Africa, the largest net area loss in surface-water occurrence over the 30-year review period (1984-2015) was found in the DRC, Tanzania and Uganda. These countries belong to Africa's 'water towers', but they are also among the nine countries in which half of the world's population growth is expected to be concentrated during 2015-2050, which will lead to greater demands for water.

> “Africa covers 20.4 % of Earth's land area, but only has about 8 % of global surface water.”

22 Willmott, C. J. and K. Matsuura (2001), Terrestrial Air Temperature and Precipitation: Monthly and Annual Time Series (1950 - 1999), http://climate.geog.udel.edu/~climate/html_pages/README.ghcn_ts2.html. Source: https://www.esrl.noaa.gov/psd/data/gridded/data.UDel_AirT_Precip.html

FIGURE 52: Net change in surface-water area (km2) in orange, with the percentage change in blue *(Source: Pekel et al., 2016)*

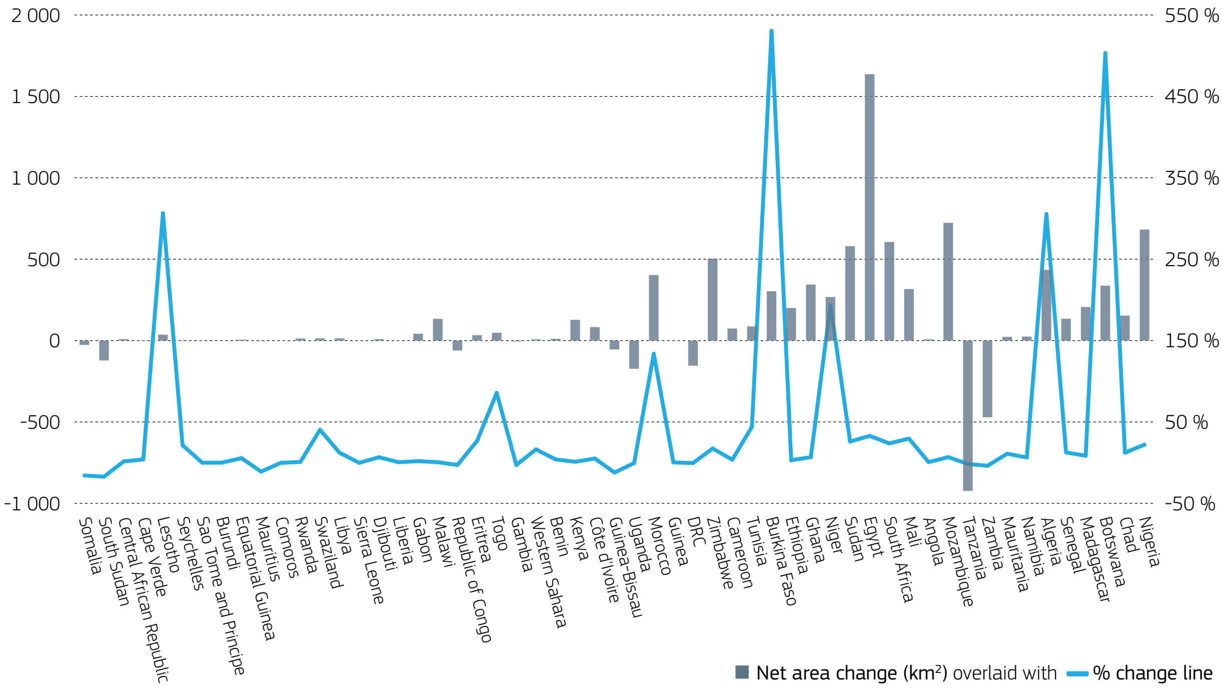
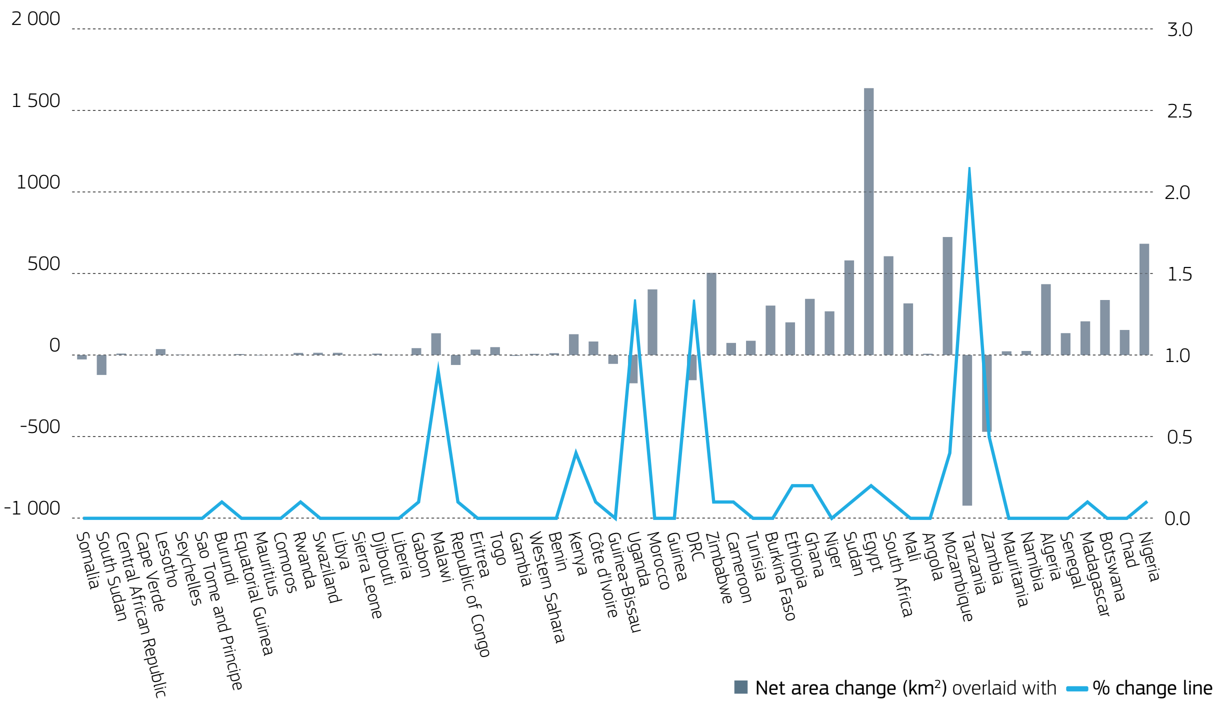


FIGURE 53: Net change in surface-water area (km2) in green, with the percentage of the country's contribution to the total in blue *(Source: Pekel et al., 2016)*



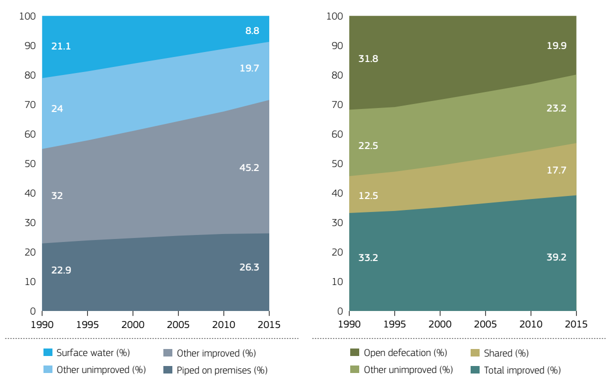
The amount of renewable freshwater (surface and aquifers that are recharged, not ancient hitherto undisturbed fossil-water aquifers) available per capita per year is commonly used as an indicator to express water availability (Falkenmark, 1989). Water availability of more than 1 700 m³ per capita per year is considered as the threshold above which water shortage occurs only irregularly or locally. At less than 1 700 m³ per capita per year, water stress appears regularly; at less than 1 000 m³ per capita per year, water scarcity limits economic development, human health and well-being; and at less than 500 m³ per capita per year, water availability is a major constraint on life. Calculating the Falkenmark Indicator at the level of sub-river basins within a given country accounts for regional effects. Upstream inflowing water can also be included in the calculations (e.g. the Nile in Egypt).

In many regions of northern Africa and the Horn of Africa, freshwater availability is less than 750 m^3 per capita per year and thus very critical. In sub-regions in Kenya and southern Africa, freshwater availability is just above the critical level, with values around 2 000 m^3 per capita per year (De Roo et al., 2017). Fossil groundwater may be used to meet local needs that cannot be met by surface freshwater, but this leads to rapidly decreasing groundwater levels, as confirmed by recent calculations by Wada (2016) for several aquifers in Africa.

Access to improved water supply and sanitation has been increasing in Africa since 1990 (Figure 54), in particular in North Africa, although 32 % of sub-Saharan Africa's communities were still without access in 2015. Supply is improving, but sanitation is still lagging: 70 % of people in Africa had no improved sanitation facilities in 2015, leading to the general practice of open defecation (Joint Monitoring Programme of the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF). Urban areas are better served than rural ones.

> “In 2015, 32 % of sub-Saharan Africa still had no access to water supply and sanitation, and 70 % had no improved sanitation facilities.”

FIGURE 54: Trends in access to water supply 1990-2015 (left) and sanitation 1990-2015 (right) in Africa *(Source: Joint Monitoring Programme of the World Health Organization and the United Nations Children's Fund)*



Outlook

With climate, population and economic activities all changing, Africa's water resources are under mounting pressure. More people means greater drinking and sanitation water demand, as well as increased indirect-water needs for food production. Higher energy demand means that the needs will grow for cooling water for thermoelectric power production as well as direct hydroelectric power generation. Although changes to precipitation amounts in African climate projections are uncertain, patterns of availability are likely to change.

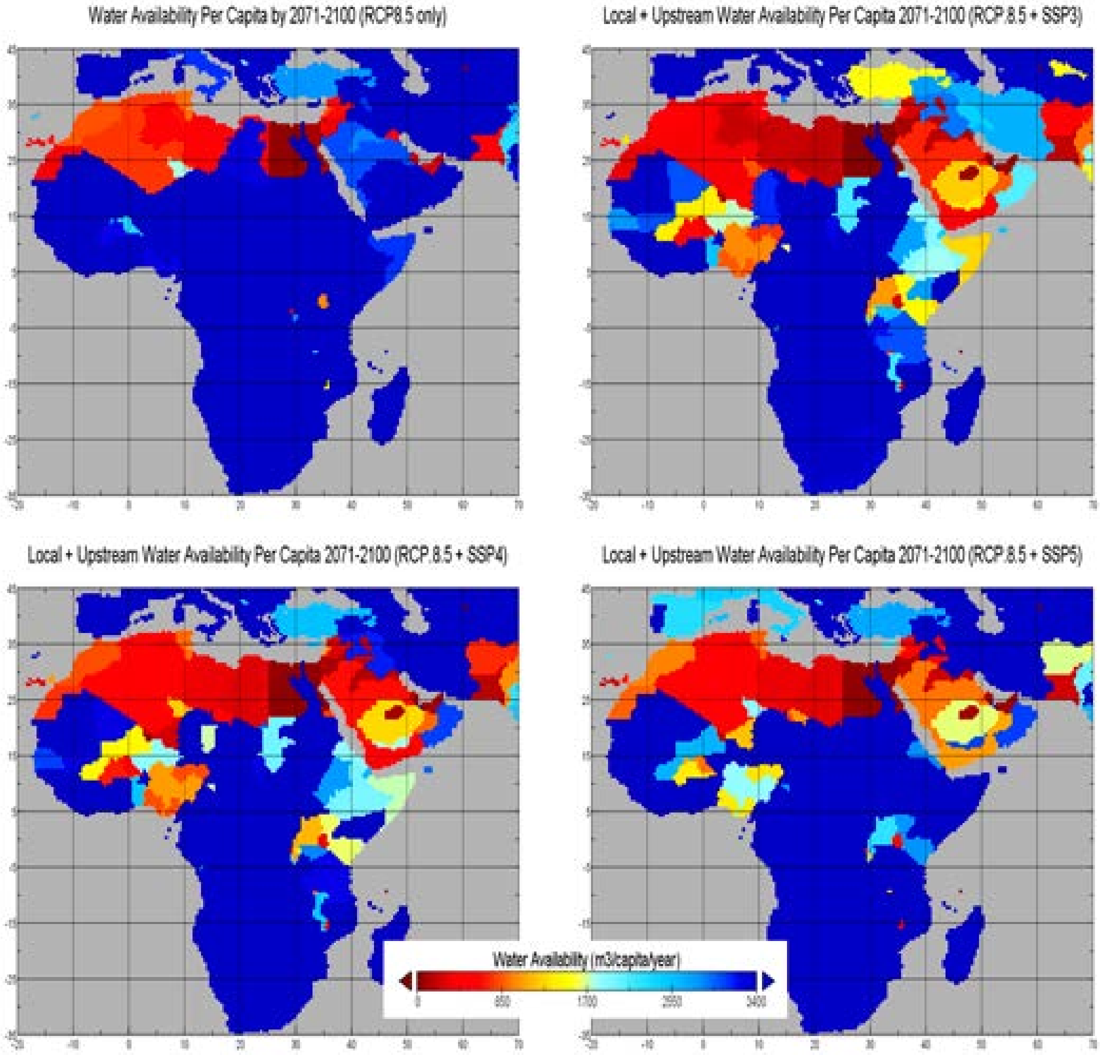
> “With the climate, population numbers and economic activities all changing, Africa's water resources are under mounting pressure.”

The uneven distribution of water resources across Africa and competing water uses are already putting great pressure on existing resources. For example, water is abundant near the water towers where there is little or no need for irrigation, yet where there is a need for irrigation, surface water is often scarce and groundwater sources are at risk of depletion. Africa's current modest abstraction rate of 5.5 % is expected to grow threefold in the coming decades. However, opportunities for improved management arise from the knowledge that recent mapping and modelling assessments provide data concerning where and when water occurs. Notwithstanding the increasing knowledge concerning water availability, where water abstraction depends on cross-border water supply, growing water dependencies could lead to water conflicts, unless sufficient water cooperation agreements are in place.

> “As most of Africa's agriculture is rain-fed, it is very sensitive to fluctuations in precipitation.”

As most of Africa's agriculture is rain-fed, it is sensitive to fluctuations in precipitation. Droughts and heatwaves that negatively impact rain-fed agriculture and livestock are projected to become more frequent (Ceccherini et al., 2017; see also chapters I.3, I.5.1 and I.12 in this report). It is also projected that the changing climate will cause increased flooding which, given the growing population and increasing levels of vulnerability (in part, because the growing economy and new buildings, bridges and roads mean there is more to lose), will affect more people and cause widespread damage.

FIGURE 55: Scenarios of future climate change, population growth and expected GDP growth until 2100, showing changing water availability per capita *(Source: De Roo et al., 2017)*



Scenarios of future climate change, population growth and expected growth in GDP until 2100 estimate that water availability per capita will change. Climate change is projected to negatively impact water availability, especially in northern Africa. Socio-economic changes, in particular population growth, and the consequent increase in the demand for water, are projected to further negatively impact water availability per capita, in particular in western Africa, Nigeria, and East Africa.

The Water Exploitation Index (WEI+), which can be simulated using the JRC's LISFLOOD water resources model, is an indicator of daily water availability and water demand (irrigation, livestock, industry, energy and household water use) at a resolution of 0.1 degree (11 x 11 km at the equator). Basically, this is net water consumption as a ratio of water availability. Water availability in this index is the sum of local annual renewable freshwater resources and water flowing into a country from transboundary rivers (e.g. the Nile in Egypt and Sudan). A WEI+ value of 1 indicates that 100 % of the available water is consumed; WEI+ values of 0.4 to 1 indicate severe water stress; WEI+ values of between 0.2 and 0.4 indicate water-stressed areas; and values of between 0.1 and 0.2 indicate low water-stress areas[23].

The WEI+ under current climate (1979-2012) and socio-economic conditions (GDP, population, and water demands from various sectors) can be compared with how WEI+ might change due to climate change and various socio-economic and population growth scenarios. Under extreme scenarios (e.g. the Representative Concentration Pathway[24] (RCP) 8.5 (high) emission scenario in combination with the Shared Socio-economic Pathways[25] SSP3 (fragmentation), SSP4 (deepening inequality) and SSP5 (conventional development) until

23 http://www.eea.europa.eu/data-and-maps/indicators/water-exploitation-index
24 Representative Concentration Pathways (RCPs) are a set of scenarios used by the IPCC, which provide trajectories over time of atmospheric GHG concentrations.
25 Shared Socio-economic Pathways (SSPs) are scenarios adopted by the climate change research community to facilitate the integrated analysis of future climate impacts.

2100), climate change will negatively impact water availability significantly and the WEI+ in the northern part of Africa, the Mediterranean and the Middle East. Southern Africa and Madagascar are also projected to suffer from deteriorating water availability. Projected socio-economic changes exacerbate this deterioration in northern Africa and have a negative effect on the WEI+ in West Africa, too.

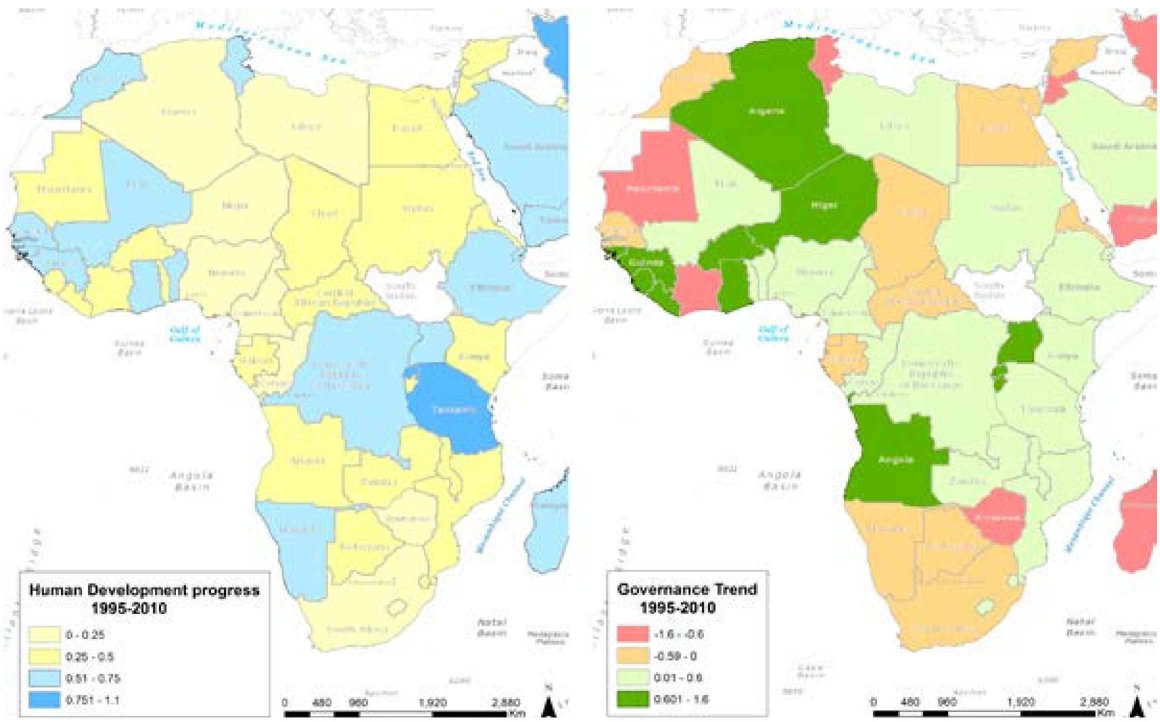
Another issue is a region's dependency on upstream transboundary inflowing river water to fulfil its local water demands, expressed as the Water Dependency Index (De Roo et al., 2017). In Africa, this is especially the case for the Nile, Niger and Zambezi river basins. The Nile area in Egypt is a classic case as it depends almost entirely on upstream water inflowing from Sudan and Ethiopia, resulting in a water dependency index of close to 1. Identifying areas with high water dependency can indicate where water diplomacy and cooperation are crucial to prevent the emergence of water conflicts. Analyses carried out at the JRC suggest that, under projected climate and socio-economic changes until 2100, regions that are currently water dependent will remain dependent in the future, while no new areas of dependency are expected to emerge.

> “Diplomacy and cooperation are crucial in areas with a high dependency on upstream transboundary waters.”

Challenges and opportunities

The devastating drought affecting Africa in 2017, with more than 20 million people affected by food crises (Africa News, 2017), demonstrates the need to improve communities' resilience by addressing drivers of change. Research can support these processes by means of effective cooperative frameworks with key stakeholders on the ground. Features of the water-energy-food-ecosystems (WEFE) resources are key drivers of the SDGs, as demonstrated by the human development progress composite indicator (HDP) and the governance trends composite indicator (Dondeynaz et al., 2012, Rivas et al., 2016; Dondeynaz and Carmona, 2017). These indicators cover many of Africa's greatest challenges, such as livelihood conditions (access to water and sanitation, primary education, basic medical services, urbanisation, housing conditions and economic level) as well as the level of governance and political stability, contributing substantially to achieving the SDGs. Their spatial pattern (Figure 56) reveals that living conditions improved in all African countries in the 15-year period from 1995 to 2010 (HDP on the left), particularly in the poorest ones, while governance, as a prerequisite for effective and sustainable development, has worsened in some cases. Therefore, the ultimate challenge is to develop methods and tools to effectively assess and address WEFE interdependencies, including the identification of potential synergies and of cascade effects of resource constraints on the livelihood conditions of the poor in order to improve communities' resilience.

FIGURE 56: Patterns of the human development progress indicator (left) and the governance trend indicator (right) between 1995 and 2010 (*Source: Rivas et al., 2016*). In both panels, a positive indicator value shows improved conditions (the higher the value, the greater the improvement).



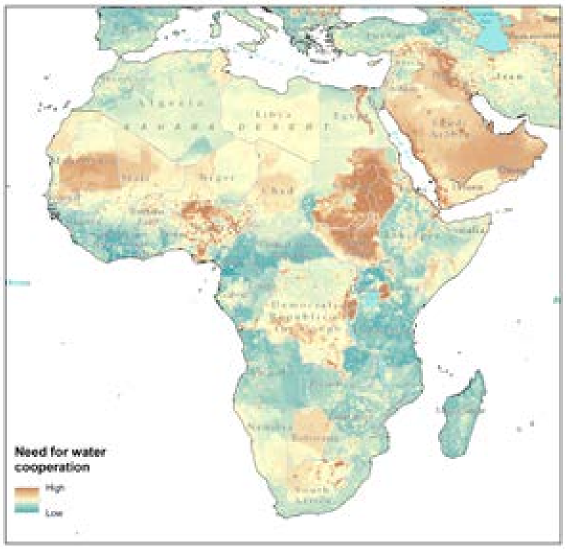
The WEFE nexus approach does not give precedence to water over other sectors, but explicitly addresses trade-offs and synergies between the major water-using sectors (including ecosystems, which need water for their sustained functioning), and strongly promotes sustainability and security. Such an integrated approach allows for a more thorough analysis of the constraints and impacts of policy options on water quantity and quality, food production, energy production and ecosystem condition. It can help identify more efficient, fair and sustainable solutions, with the objective of lowering costs and raising benefits for humans and nature, without compromising the resource basis upon which humanity relies (Bhaduri et al., 2015). Under the WEFE nexus approach, current scientific and technical analyses and tools need to be adapted and integrated to deliver support to decision-making across relevant sectors, which requires interdisciplinary analyses. Beyond the adaptation of analytical tools, addressing WEFE challenges at the (transboundary) river-basin scale also implies developing cooperative frameworks with key stakeholders.

Substantial archives of digital satellite imagery from the USA (Landsat26) and Europe (Copernicus Sentinels27) are now freely available. Among different aspects of water monitoring, these can be used to produce maps and statistics, such as in the Global Surface Water Explorer (GSWE), which describes when and where Africa's land surface has been covered by water. GSWE maps are freely available online, and can be used to determine when (month and year) and where surface water was found between 1984 and 2015. They are very detailed, showing surface-water bodies as small as 30 m x 30 m, but are consistent across the continent (indeed, the world). They provide a surface-water history that can be used at local, national, regional and continental scales, allowing for national planning, transboundary resource planning (and monitoring the effects of water-management infrastructure with transboundary implications) and reporting at a continental and global scale. Statistics on water area and changes since the 1980s are also available – these can be generated for any desired geographic region (country, subregion, watershed, protected area, etc.).

Water-resource modelling is also advancing28, with a range of models now capable of linking water demand with water-cycle information and supply to better forecast water-management factors, such as water scarcity, at different times in different places. Flood- and drought- forecasting systems covering Africa provide new opportunities to develop evidence-based water-management policies. The African Drought Observatory provides specific drought monitoring and seasonal forecasts, as well as information on vulnerability.

The cross-sectoral nature of many water-management issues is particularly challenging, although nexus approaches provide a starting point for the analysis of interactions between water availability, water demand from the various sectors (energy production, rain-fed and irrigated agriculture) and their feedback mechanisms. Composite indicators are being developed to analyse the interactions between the biophysical and socio-economic factors that determine the need for water cooperation in transboundary river basins. The geographical areas most in need of cooperation to prevent or address water-related issues in a timely manner are shown in Figure 57. These include the river basins of the Nile Delta, the upper Nile River, the Senegal River, the lower Niger River, the Orange River, the Congo River and the Zambezi River.

FIGURE 57: The need for water cooperation under current climatic and socio-economic conditions *(Source: Farinosi et al., in preparation)*



Policy framework

The 2030 Agenda for Sustainable Development and the SDGs, and the Joint Africa-EU Strategy (JAES) Roadmap for 2014-2017 provide the overall strategic framework for much of the research cooperation outlined above.

The Joint Consultation Paper (2015) 'Towards a new European Neighbourhood Policy', the Joint Staff Working Document (2015) 'Implementation of the European

26 The Landsat series of satellites provides the longest temporal record of moderate resolution multispectral data of the Earth's surface (extending back to 1982 at 30 m resolution, and to 1972 at 79 m resolution).

27 The Sentinels are a family of satellites that address the specific needs of the Copernicus programme.

28 GLOWASIS, DEWFORA, HELIX, and EARTH2OBSERVE are all examples of new-generation water models that support water-resource management.

Neighbourhood Policy Partnership for Democracy and Shared Prosperity with the Southern Mediterranean Partners Report', the Joint Declaration of the 7th College-to-College meeting between the European Commission and the African Union Commission (Brussels, 22 April 2015) and the Council conclusion (CL13-072EN) on EU water diplomacy (22 July 2013) all support the development of science-based decision-making processes.

2) Gaps, future actions and priorities to be considered

Water-resource mapping and monitoring tools must be up to date if they are to reach their full potential. The Copernicus Global Land Service has tentative plans in place to update Africa's surface-water history, and to continue this routinely. Advances in seasonal meteorological and hydrological forecasts are promising for most regions across Africa, and efforts to improve these will continue.

Flood- and drought-risk models should focus more on human and welfare losses. A multi-model approach to better characterise the uncertainty of hydrological modelling should also be developed, as should decision-support tools that integrate hydrological, agricultural, climate variability and socio-economic data.

Systematic observations, notably of river-discharge rates, groundwater-resource availability (and consumption), and even surface-water volumes are often lacking. Improving such observation frameworks would not only enhance water security and management, but would also have collateral benefits, such as improved climate models and climate change adaptation strategies. The lack of reliable, accurate, harmonised and up-to-date data and information on the socio-economic (spatial) dimensions of water access, demand and management (particularly in rural areas), in addition to classical hydrological information, is also an issue.

Not only should information on the observations outlined above be provided, it is also important that it is accessible. Uneven access to information between countries that share transboundary river basins and between national institutions, as well as the wide disparity of data in terms of level of aggregation, scale, accuracy and reliability at the transboundary river-basin level, significantly hamper any integrated approach to water-resource management.

Along with hydrological observations, drought forecasts and warnings should be targeted to provide key information to users. Traditional knowledge can be integrated to supplement drought forecasts and early-warning systems.

The uncertainty in climatic and population projections also increases the uncertainty in future water projections and in assessing which solutions might be feasible. Therefore, efforts must be made to reduce the uncertainty in these projections, too.

Various sources of uncertainty within the modelling framework must be accurately defined: uncertainty in climate scenarios, in modelling conceptual assumptions and parameterisations, extreme value fitting for extreme events, digital elevation data accuracy and hydraulic modelling, and damage impact modelling.

Capacity is required at all levels (policy- and decision-makers, researchers, meteorologists, farmers, communities, etc.) for the effective interpretation and use of forecasting and early-warning tools. Currently, the low level of technical and managerial personnel's applied knowledge in most organisations that issue early-warning tools is a major constraint.

Key features of the WEFE nexus, such as access to water and sanitation, governance, sustainable development and cooperation, are closely linked to the SDGs. In addition to the planned activities outlined above, there is a growing need to monitor progress towards SDG 6 (to ensure availability and sustainable management of water and sanitation for all). A number of the modelling and monitoring tools introduced above could be combined to provide national and even local measurements of some indicators linked to this, in particular the percentage of total available water resources used, taking environmental water requirements into account (level of water stress), the percentage of change in the extent of wetlands over time, the percentage of receiving water bodies with ambient water quality that do not present a risk to the environment or human health, and the rate of access to (fresh and safe) water.

Children playing with water in Maputo, Mozambique ©EU, by Paolo Ronco

The river basin would seem to be the most appropriate scale for an integrated approach to water management. Such an approach should be combined with enhanced multilateral and multinational cooperative dialogues with stakeholders and policymakers, such as river basin organisations, regional economic communities and local academics, who can provide local and regional knowledge. Essential actions include: developing regional-knowledge management systems to support African institutions and policymakers, based on harmonised and shared information and decision-support tools; encouraging collaborative research to understand and quantify the interlinkages between water, energy, food security and ecosystems; and building the capacity of existing institutions and decision-makers to implement such an integrated approach.

BOX 12

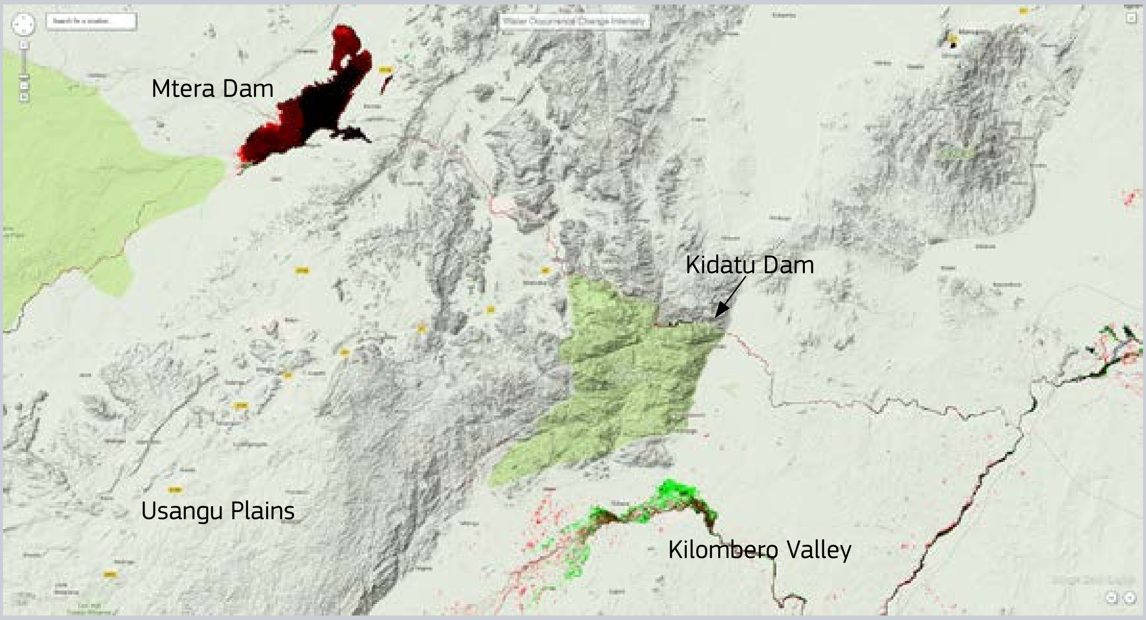
The Southern Agricultural Growth Corridor of Tanzania (SAGCOT)

The SAGCOT initiative aims to sustainably intensify agriculture while simultaneously conserving natural resources to reduce pressures on forest, water and biodiversity ('Agricultural Green Growth'). Along with the Tanzania government, the main partners are private-sector companies, including multinationals such as Bayer Crop Science, Nestlé and Syngenta. Other partners include the United States Agency for International Development (USAID), the African Wildlife Foundation, the IUCN, the UNDP and the United Kingdom's Department for International Development (DfID). However, in terms of area, Tanzania currently suffers from the greatest water loss in Africa (-924 km2, which is over 2 % of the African total). Possible causes are increased irrigated agricultural areas, which require greater water abstraction from rivers upstream (e.g. the Kilombero Valley Ramsar Site29 and the Usangu wetlands catchment area). Irrigation in Usangu has an impact on the Ruaha National Park, as park authorities fear that tourist revenue will fall as a result of the dry river.

Wet season inflows to the Mtera hydropower reservoir (51 % of Tanzania's hydropower generation) may have fallen by 5 % over the period 1980 (when the Mtera Dam was constructed) to 2000 as a result of irrigation. The flow of the Great Ruaha River, historically a perennial river downstream of the Usangu river basin, ceased in 1994 and most years since then. The Kidatu hydropower reservoir downstream of the Mtera reservoir (bordering the Udzungwa National Park) also shows decreased water occurrence. On the one hand, the Kilombero valley region has seen a large rise in water occurrence due to an increase in irrigated agriculture (21.6 % of land under natural vegetation was converted to agricultural use between 1990-2010, corresponding to a total area of over 1091 km2 (Brink et al., 2016)), and on the other hand, lower river flow and less natural wetland areas. This development pattern may increase the potential for conflicts between irrigated agricultural farming, hydropower generation and protected areas in Tanzania.

> "Tanzania suffers from the greatest area of water loss in Africa, mainly due to increased irrigation."

FIGURE 58: Change in the intensity of water occurrence in Tanzania: areas with falling water occurrence are shown in red, while those with rising water occurrence are shown in green (Source: JRC/Google, Global Surface Water Explorer)



29 Ramsar sites are those designated as 'wetlands of international importance'.

BOX 13

Burkina Faso

Every year, Ouagadougou receives more rainfall than London (700 mm rainfall per year on average in Ouagadougou vs. 585 mm for London (World Meteorological Organization). However, much of this rainfall is not available for consumption due to rapid run-off and deep infiltration.

In 1999, the Ministry of Agriculture, Hydraulics and Fishing Resources launched an Integrated Water Resources Management (IWRM) programme (with the technical and financial assistance of the Danish International Development Agency, DANIDA), followed by the Action Plan for the Integrated Water Resources Management in Burkina Faso (PAGIRE) in 2003. Phase 1 of PAGIRE (2003-2008) cost about EUR 20 million. A substantial contribution was provided by international donors such as the World Bank, the EU, the EDF, the Asian Development Bank (ADB) and EU national donor agencies (including DANIDA, the Swedish International Development Cooperation Agency (SIDA) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)).

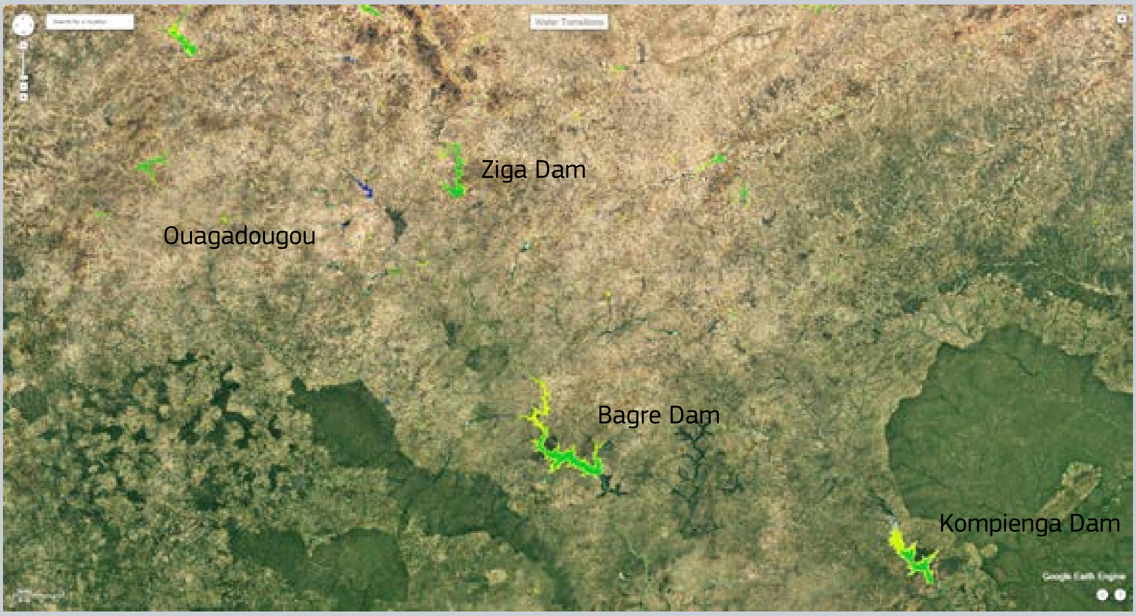
Government and donor agencies alike consider urban water supply in Burkina Faso to be one of the rare development success stories of sub-Saharan Africa. Access to improved water sources in urban areas increased from 73 % in 1990 to 95 % in 2008 (World Bank).

However, irrigation and livestock watering are the main water uses30. Small-scale water reservoirs and small dam projects, such as those implemented by WaterAid and SIDA, supply some of this water.

The water-occurrence table for Burkina Faso shows that, over the period 1980-2015, the area of permanent water rose by 303 km2 (from 57 to 360 km2), with only minimal loss of permanent water (0.42 km2). This represents an area increase of 530 %. The area of seasonal water increased by 605 km2 (mainly located at the borders of permanent water bodies).

Dam construction has led to competing water demands between hydropower, irrigation, drinking water supply, livestock, etc.

FIGURE 59: Burkina Faso water transitions: dark green represents new areas of permanent water, while light green characterises new areas of seasonal water *(Source: JRC/Google, Global Surface Water Explorer)*



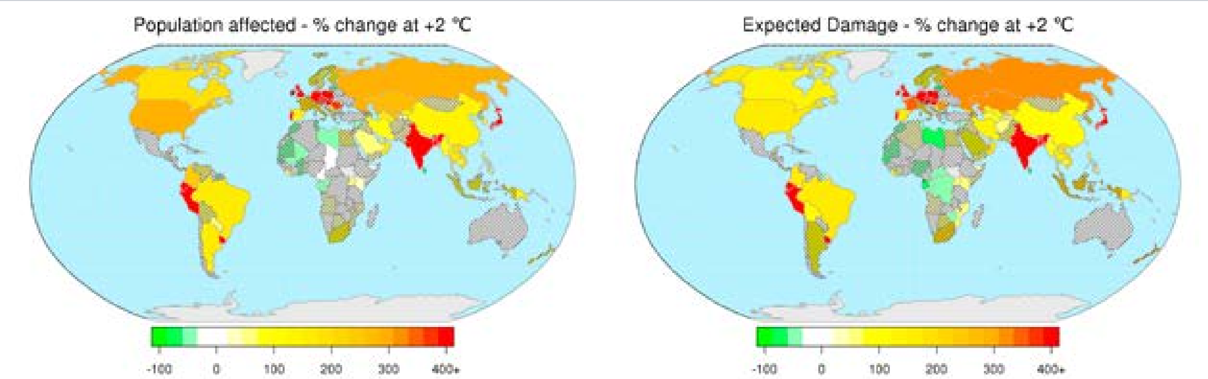
30 FAO, AQUASTAT: http://www.fao.org/nr/water/aquastat/main/index.stm (accessed 2017).

BOX 14

Outlook on flood risk

The JRC assessed changes in the risk of river floods under different global warming scenarios (1.5 °C, 2 °C, and 4 °C), using seven high-resolution climate projections in a socio-economic impact model coupled with a hydrological-hydraulic modelling framework (Alfieri et al., 2017). These assessments were made against a baseline scenario (1976-2005), for which overall mean river flood damages in Africa were estimated at US$ 8.5 billion per year (2010 US$ values, EUR 6.3 billion, at 2010 exchange rates), with 16.5 million people being affected every year. Findings show that global warming is significantly correlated to greater flood risk in most world regions. However, the multi-model projections did not agree on a significant change in flood impacts in most countries in Africa at all warming levels. Most climate models predict a northern hemisphere winter temperature increase of 3.5 °C by the end of this century (see chapter I.5.1). Figure 60 shows the expected damage and population affected by a more modest 2 °C increase, and if warming reaches 4 °C, it is projected that some African countries will undergo a significant increase in flood risk compared to present levels. Under a 4 °C scenario, flood damages are projected to increase by 200 % in Liberia, Angola and South Africa, and the population affected will grow by 200 % in Liberia and Angola. Furthermore, socio-economic drivers are likely to exacerbate the impacts of floods in countries with significant population growth and economic development.

FIGURE 60: Average change in population affected and expected damage per country at 2 °C global warming. Hatching indicates countries where the confidence level of the average change is less than 90 %. The maps show that some countries, mainly in central and northern Africa, are likely to experience a reduction in flood risk, while moderate increases in flood risk (less than 100 %) are projected for Liberia, Mozambique, Kenya and Uganda. In most countries, agreement between multi-model projections is relatively low, hence the projected average changes are not significant (*Source: Alfieri et al., 2017)*



BOX 15

Outlook on drought risk

Large parts of Africa are drought-prone and are regularly subjected to substantial economic losses and humanitarian suffering as a result. The 2011 drought in the Horn of Africa is estimated to have caused up to a quarter of a million deaths, and to have left over 13 million people in the region dependent on humanitarian aid. Over US$ 1.3 billion (c.a. EUR 1 billion at 2011 exchange rates) was spent on drought-relief measures (UNOCHA, 2011).

Drought risk is a tangible threat in Africa. More than 400 million people are reported to have been negatively affected by droughts over the past 30 years, with estimated damages of more than US$ 6 billion31 (Guha-Sapir et al., 2017). To aggravate the situation, most climate scenarios project further water limitations (Veldkamp et al., 2016) in areas of food production and of exceptionally high biodiversity, as well as areas where droughts have already had an impact on human displacement and potential violent conflict (von Uexkull et al., 2016).

Droughts are likely to become more frequent, severe and persistent in large parts of Africa as a result of less precipitation and greater evaporative demands with higher temperatures. A temperature increase of 3 °C would bring current 100-year droughts (severe droughts that currently only occur once every 100 years) to around 70 % of African territories on a 10-year basis (Naumann et al., 2017) and such droughts could occur approximately every two to five years in some parts of northern and western Africa. There is, however, considerable uncertainty in projected changes in precipitation for the Sahel and for Central Africa (see chapter I.5.1).

“Droughts are likely to become more severe and persistent in much of Africa due to global warming.”

The estimated damages and number of people affected by droughts will increase in most regions of Africa with global warming. The magnitude of impacts is strongly related to the level of warming. According to a recent analysis (HELIX, 2017), several regions in Africa could face a significant increase in drought damages if global warming reaches 1.5 °C or higher. However, the level of uncertainty in the estimations is greater in regions where the effect of increased precipitation masks or compensates the effect of evaporative demand. These climate uncertainties make the estimation less robust.

These scenarios suggest that drought risk may increase in many economic sectors and vulnerable regions unless appropriate mitigation and adaptation measures are implemented. Many regions in Africa with high population densities and vulnerable societies that rely on local agricultural production could experience significant losses because of droughts. These regions remain a high priority for better-targeted impact monitoring and quantification as a basis for drought management and adaptation.

31 It should be noted that due to low insurance penetration and a focus on humanitarian relief (people affected) by most of the international organisations, the figures on drought damages are prone to systematic underestimation.

BOX 16

Outlook on water demand for rain-fed and irrigated agriculture

Agricultural productivity and sustainability have been assessed using the Environmental Policy Integrated Climate (EPIC) biophysical model (Pastori et al., 2017) by making spatially explicit analyses to estimate water requirements of major crop-production systems in Africa.

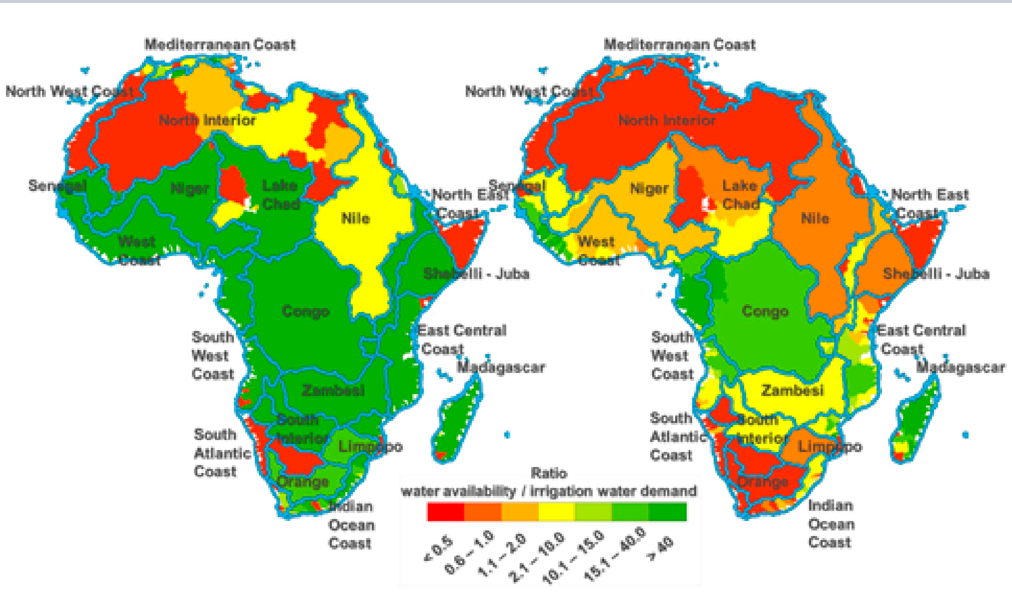
Results confirm that irrigation can substantially increase yields in water-rich regions, and that the lack of infrastructure does not allow countries to reach high production levels. As presented in Figure 61, under current crop-management practices, only a limited number of watersheds are under stress, mainly concentrated in North Africa, Ethiopia, South Africa and Namibia. However, under a high-production scenario, the number of river basins with a ratio of less than one increases considerably: the areas under water stress include all of North Africa, the Nile River Basin and South Africa (South West Coast, Orange and Limpopo river basins). On the other hand, most of the river basins in Central and Southeast Africa can meet the water requirements of full potential production without depleting water resources.

With a population expected to double by 2050[32] and a consequent tripling in the demand for cereals over the same period (van Ittersum et al., 2016), sub-Saharan Africa is one of the world regions where water resources for agriculture will be under greatest pressure in the coming decades. While climate models predict precipitation fluctuations with increasing or decreasing trends in different parts of the African continent, there is growing consensus that more irregular rainfall distribution and increasing temperatures will negatively impact crop yields (Kang et al., 2009). The increasing demand for agricultural products driven by rapid population growth pushes African farming towards intensification, which often leads to the extension of irrigated areas (Jimenez Cisneros et al., 2014). Mancosou et al. (2015) project that, while current irrigation water use is still rather low, demand for irrigation water in Africa will increase by 300 % during the period 2000-2080.

> “Demand for irrigation water in Africa is projected to increase by 300 % during the period 2000-2080. This increase would likely affect the availability of water for other sectors, and further deplete groundwater resources.”

Careful water management strategies, policy coordination, innovative methods for increased water productivity and investments in infrastructure will be crucial to meet the rapidly increasing water requirements of African economies.

FIGURE 61: Irrigation sustainability of different agricultural management strategies as simulated by the EPIC model. The ratio between river-basin water availability and irrigation-water demand is shown for the current management scenario (left) and a high-production scenario (right): a ratio lower than one indicates that more water is required to achieve the yield potential, leading to a depletion of (ground)water resources (*Source: Pastori et al., 2017*)



32 According to the medium fertility population projection of the United Nations for 10 major countries in sub-Saharan Africa.

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11. The marine environment

1) Key findings

Assessment of the situation

The African Seas cover about 35 000 km of coastline and 13 million km^2 of maritime economic zones in the Atlantic and Indian Oceans, the Mediterranean Sea and the Red Sea, all with diverse environmental features and processes. Strong upwelling currents along the north-western (the Morocco-Mauritania system) and south-western (the Benguela system) coasts support some of the world's richest marine production and fishing grounds. On the eastern coasts, including the Red Sea, coral reefs, mangrove forests and seagrass beds sustain a great diversity of marine life and are important food sources for coastal communities.

> “African coasts support some of the world's most productive marine areas and fishing grounds.”

Marine and coastal resources play a central role in African livelihoods and development, as recognised at the African Union's Extraordinary Summit on Maritime Security and Safety and Development in Africa (Lomé, Togo, 2016). Of the 54 countries that make up the African continent, 38 are coastal states whose populations are directly dependent on the services provided by coastal and marine ecosystems. They contribute significantly to reducing the national balance of payments deficit, creating employment and meeting the protein needs of the local population. In 2011, the fisheries sector as a whole employed 12.3 million people as full-time fishermen or full-time and part-time processors, representing 2.1 % of Africa's population aged between 15 and 64 years (fishermen represent half of all people engaged in the sector) (de Graaf and Garibaldi, 2014). In terms of food security, fish accounts for as much as 70 % of the daily intake of animal protein in coastal countries such as Ghana and Sierra Leone (Hewawasam et al., 2015).

Boats and fishermen by the sea in a fishing village in Kayar, Senegal ©EU, by Andreas Brink

As stated at the African Ministerial Conference on Ocean Economies and Climate Change, held in September 2016[33], the ocean-related economies of many African countries contribute to one-quarter of all revenues and one-third of export revenues. However, the continuously growing coastal populations, overfishing, illegal fishing, pollution and unsustainable tourism degrade marine and coastal biodiversity and increase poverty (Saghir, 2016).

Outlook

> “About half of the African population lives within 100 km of the coast, putting pressure on water quality, biodiversity and marine productivity.”

In recent years, the growing population (about 50 % of the continent's population lives within 100 km of the coast), urbanisation and industrial development in coastal areas have impacted Africa's coastal environment and marine resources, as it did in Europe from the 1960s to the 1990s. Water quality is deteriorating severely around large cities (e.g. Dakar, Abidjan and Conakry). Poor land-based management practices that trigger deforestation and soil erosion have led to massive sediment inputs in the coastal zone, which often degrade coastal habitats and reduce fish productivity. Areas of high biodiversity (such as mangrove forests and coral reefs) have been severely impacted by coastal developments and natural

33 http://climatesmartoceans.org

BOX 17

Marine wealth

hazards, with substantial net losses over the past 25 years (Obura et al., 2017).

A recent analysis of the Western Indian Ocean economy (10 countries34) estimated a total ocean asset base (a sort of shared wealth value) of at least US$ 334 billion, EUR 277.2 billion at 2017 exchange rates (Obura et al., 2017). This includes an annual gross marine product (country equivalent of the GDP) of at least US$ 21 billion (EUR 17.4 billion at 2017 exchange rates) generated by coastal and marine tourism (69 %), carbon sequestration (14 %), and other marine products (9 %), including fisheries. Non-monetary components of the value of the Western Indian Ocean, such as the intrinsic value of biodiversity and cultural and spiritual dimensions, were not accounted for. However, it was observed that the measured assets declined, mainly due to climate change, increasing urbanisation and decreasing fish stocks. In response to the United Nations 2030 Agenda for Sustainable Development, which sets out the SDGs (including SDG 14 on sustainable ocean use), the analysis proposes a set of seven actions, three of which directly involve the marine environment: 1) implement effective management of ocean assets (e.g. through a network of marine-protected areas); 2) implement integrated ocean planning and management (marine spatial planning); and 3) adopt a sustainable, inclusive blue-economy approach (internalisation of non-market environmental values).

> “Marine assets in the Western Indian Ocean are in decline due mainly to climate change, increasing urbanisation and declining fish stocks.”

34 Comoros, La Réunion (France), Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, South Africa and Tanzania

A fisherman showing his catch in Senegal ©EU, by Andreas Brink

In offshore waters, continuously expanding fish catches (whether illegal or through international trade agreements) over four decades have contributed to an important decline in fish stocks. Although tuna-like species are generally safely managed in the open ocean, stocks on the continental shelf of West Africa are not. By 2002, the biomass of demersal stocks (i.e. fish living and feeding at or near the sea bottom) in north-western African coastal and shelf waters had been reduced to a quarter of what it was in 1950 (OECD, 2008), destabilising the economy of several countries that rely on fisheries to achieve more than 20 % of their GDP.

Overfishing is exacerbated by changes in the physical and biological environment resulting from climate variability. Coastal erosion in the Gulf of Guinea (including Côte d'Ivoire, Ghana, Togo, Benin and Nigeria) has been linked to climate change and rising sea levels. Projected sea level rise by 2081-2100 of 0.4 m to 1.15 m in West Africa were estimated according to a scenario of a 4 °C increase in global temperature (Serdeczny et al., 2016), while any alteration in river dynamics would increase coastal flooding. This expected erosion will further endanger the populations and economies of continuously growing coastal megacities, and cause significant damage to extremely valuable productive ecosystems due to increased salt levels in transitional waters (World Bank Group, 2015). Care must also be exercised to address universally occurring challenges of sewage treatment before dumping it into the marine environment, other sources of chemical pollution (such as toxic run-off from the land), overfishing (and the need for recognised and respected marine protected areas), waste dumping (especially plastics and other persistent substances) and even noise pollution.

Challenges and opportunities

Appropriate observation systems are needed for monitoring, evaluating and managing the African Seas to support the sustainable use of their natural resources, protect their ecological balance, and assess and sustain their role in shaping the global climate. Data collection using traditional surface measurements remains a key component of much environmental research into these issues.

> “Earth-observation satellites are a cost-efficient means to monitor African seas at large spatial scales and over long periods.”

However, particularly in recent years, *in-situ* data collection has been hampered by the prohibitive cost of lengthy and repeated oceanographic expeditions over large spatial scales as well as the recurrence of piracy and political unrest in several coastal countries.

Remote-sensing from Earth-observation satellites can efficiently complement conventional *in-situ* data-gathering techniques by daily mapping the interaction of the main physical and biological processes that occur at the surface of all African seas at large spatial scales and over long periods. The benefits of using satellite data of the marine environment are even greater considering that most datasets are freely and globally available, facilitating cost-efficient assessments and useful comparative analysis. Combining satellite data and modelling outputs helps assess water quality and ecosystem health (Figure 63) and, with basic internet access, supplies the users with: i) continuous, detailed and accurate marine and coastal data from satellite observations (e.g. ocean colour and sea-surface temperature); ii) indicators of the state of and changes in the marine environment; and iii) basic navigation and interrogation tools with elemental statistics and time-series analysis to be carried out.

Satellite observations can also be used to create indicators, such as the Ocean Productivity Index for Fisheries (or Zooplankton Productivity Indices, Figure 64) which maps and monitors potential fish production at large spatial scales (Druon et al., 2015; 2016a; 2016b).

FIGURE 63: Satellite maps overlaid with countries' exclusive economic zones showing: (left) a proxy of the phytoplankton biomass concentration (chlorophyll-a in mg/m^3); (centre) sea-surface temperature (in °C); (right) anomaly of phytoplankton biomass with respect to climatology estimated from more than a decade of satellite data from around the African continent. Two of the world's four most productive waters are along the north-western coast (the Morocco-Mauritanian upwelling system) and the south-western coast (the Benguela upwelling system). The variability in plankton productivity ultimately affects commercial fisheries, seabirds and marine mammals. The maps are extracted from the website of the Environmental Marine Information System (EMIS).

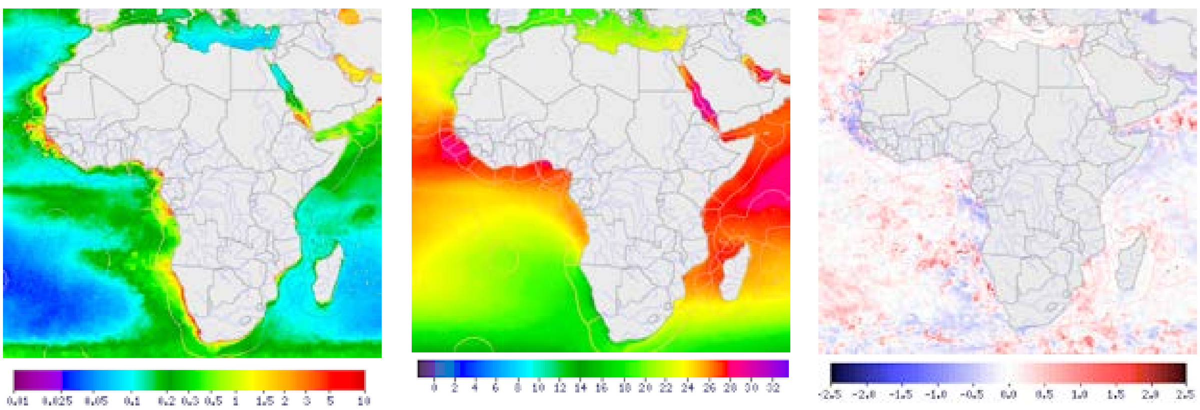
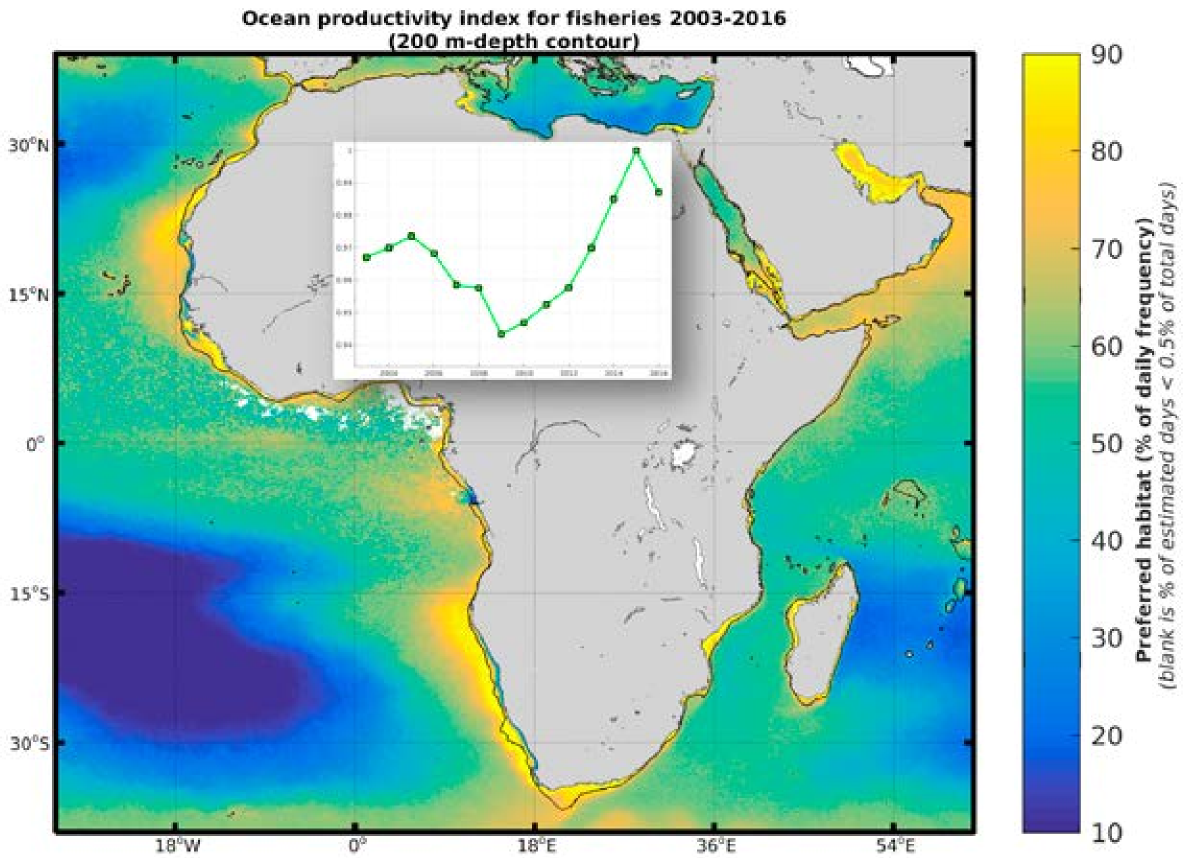


FIGURE 64: The Ocean Productivity Index for Fisheries (2003-2016) uses Earth-observation data to map the potential production of fish (the inset graph plots the annual variability of productive habitats). The permanent upwelling off Mauritania, Namibia and South Africa have the highest productivity levels, while most of the other less-productive areas show significant seasonal variability (*Source: https://fishreg.jrc.ec.europa.eu/fish-habitat*)



Policy framework

With regard to the marine environment, there are three main policy frameworks that govern EU relations with Africa. These are: i) Target 11 of the United Nations Convention on Biological Diversity (CBD), which aims to ensure that "by 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas" are conserved and protected; ii) the fisheries partnership agreements; and iii) The Joint Africa-EU Strategy (JAES) adopted by African and European heads of state at the Lisbon Summit in 2007. The JRC's activities regarding the marine environment in Africa contributed to the JAES 2014-2017 Roadmap, which notably aims to strengthen Africa's capacity to monitor environment and security using Earth-observation techniques through the implementation of the Global Monitoring for Environment and Security (GMES, now Copernicus) initiative.

2) Gaps, future actions and priorities to be considered

More integrated ecosystem assessments, including additional information, are necessary to answer key policy questions regarding the African marine environment, such as: how to sustainably manage the marine environment and maintain or restore the ecosystem services of the African seas in light of the rising population, food demand and development of human activities that is expected in the coming decades? In particular, significant volumes of high-spatial-resolution data on the coastal environment and on the socio-economic dimensions of coastal communities will need to be collected since such data, recently shown to be essential for progress in marine management in Europe, are largely missing for Africa.

"Data from the Copernicus programme, through the Sentinel satellites, will contribute to the integrated ecosystem assessment of African coastal waters."

Access to the data of present and future Earth-observation missions should be further improved, and collaborative training should be implemented with scientists and experts in African national agencies to facilitate data analysis, decision-making and feedback on lessons learnt. The development of marine services from observation systems (such as the Copernicus programme) at relatively high spatial resolution would also greatly help to develop scientific skills and knowledge for the sustainable management of Africa's marine and coastal environment (e.g. marine protected areas, pollution mitigation and spatial planning). The final objective, as it is progressively targeted in Europe, is to derive an integrated assessment of marine ecosystems through the evaluation and monitoring of their services to ensure the sustainable development of the blue economy.

The coast along the Cape region of South Africa ©EU, by Andreas Brink

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PROSPERITY

"OUR ASPIRATIONS
FOR THE AFRICA
WE WANT:
AFRICA SHALL BE A PROSPEROUS CONTINENT, WITH THE MEANS AND RESOURCES TO DRIVE ITS OWN DEVELOPMENT, WITH SUSTAINABLE AND LONG-TERM STEWARDSHIP OF ITS RESOURCES AND WHERE AFRICAN PEOPLE HAVE A HIGH STANDARD OF LIVING, AND QUALITY OF LIFE, SOUND HEALTH AND WELL-BEING"

– Agenda 2063

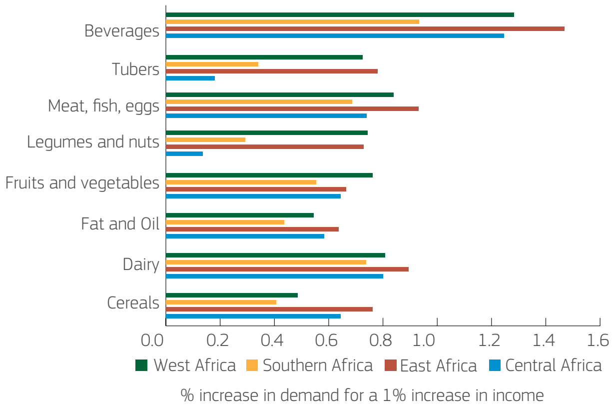
12. Agriculture and fisheries

1) Key findings

Assessment of the situation

The farming sector in Africa must address growing demands for food, feed, fibre and fuel. In addition to quantitative growth in demand, which is expected to continue in the medium and long term (largely due to population expansion), consumption patterns are also changing. This is particularly noticeable with respect to a shift towards more vegetable oils, sugar and livestock products and a growing biofuel market (Schaffnit-Chatterjee, 2014). Published research suggests that if incomes continue to grow by an average of about 4 % per year, demand for dairy products, meat, fish and eggs in Africa will have doubled by 2035 (Melo et al., 2015). A sizeable share of this rising demand will be concentrated in Africa's expanding urban areas.

FIGURE 65: Changes in food demand (% increase for different categories of products) for a 1 % increase in income *(Source: Melo et al., 2015)*



Supermarkets (a marked feature of the urban landscape) have both positive and negative impacts on agricultural production patterns. Based on figures from the 2000s, the retail market share of supermarkets is still generally low across the continent (for example, supermarkets account for 16 % of total food retail sales in Kenya and 20 % in the country's cities). South Africa is an exception, whereby 55 % of retail involves supermarkets. Large retailers are keen to expand their market share and want to develop local sourcing, which includes supporting direct farm-procurement programmes (Tschirley et al., 2011; Schaffnit-Chatterjee, 2014).

A local street market in Uganda ©EU, by Andreas Brink

Across Africa, agriculture is extremely diverse, with large variations in land suitability to agricultural uses, soil condition, the severity of land degradation (the measurement of which is gaining consensus (FAO and ITPS, 2015)), population densities and land-tenure systems (see Box 18), along with a huge range of crop types and grazing regimes.

During the last decade (2007-2017), 40 to 65 % of the labour force is estimated to have been engaged in farming in most sub-Saharan African countries (down from 60-80 % in the previous decade) (AGRA, 2016). In terms of the farming sector's contribution to sub-Saharan Africa's GDP, values ranged from 18 % (World Bank, 2017) to 25 % (AGRA, 2016). The economy is predominantly agrarian and dependent on smallholder farms. About 80 % of the farms cultivate an area of less than 2 ha, and 95 % are less than 5 ha (Lowder et al., 2016). Smallholders cultivate around 62 % of the cultivated land and provide up to 80 % of the food supply (FAO, 2015). Small farms also contribute to economic growth through the production of several agricultural export commodities, such as cocoa, coffee, tea, rubber and palm oil (Kuma et al., 2016; Maertens et al., 2012).

Commercial farms are also an increasing feature of African agriculture. Like their counterparts elsewhere in the world, these are large, heavily mechanised, use new technologies and rely on hired workers. Given this, it is perhaps surprising that a large body of evidence shows that land productivity declines as farm size increases, and that small farms are more productive (Barrett et al., 2010; Eastwood et al., 2010; Larson and Otsuka, 2014).

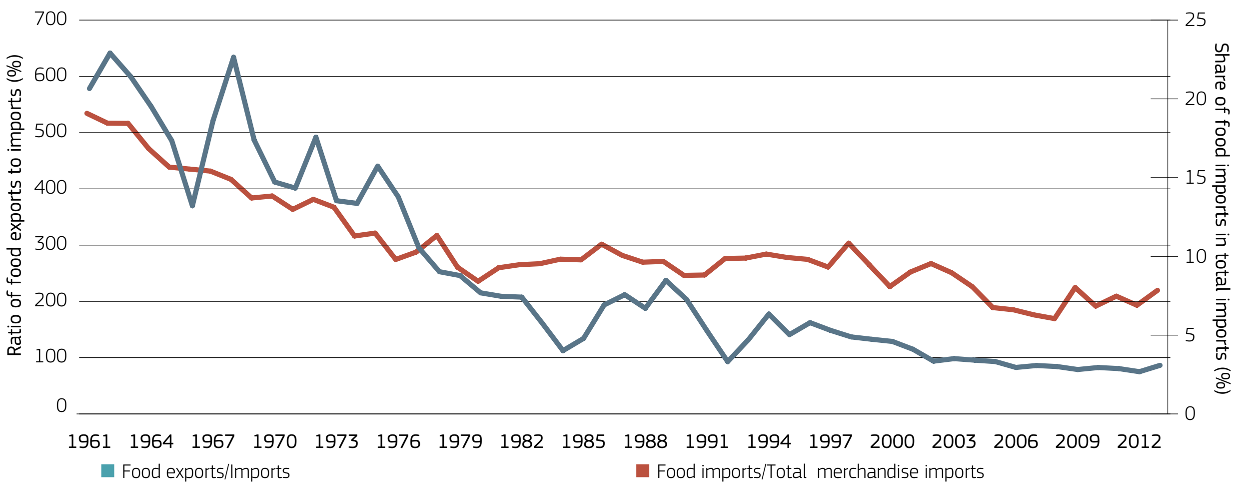
This is a complex relationship, governed in part by factors such as the lower real cost of labour on small farms (i.e. higher costs on larger farms due to the need for supervision), flexibility of family labour in small farms, and greater cropping diversity (which is a good risk-management strategy).

Fish is an essential food source for many, and with about 700 000 vessels, the African fishing fleet is the second largest in the world after Asia. The majority of these, however, are small-scale vessels. Just over 2 % of the African population aged between 15 and 64 years was engaged in the fisheries and aquaculture sector in 2011 (de Graaf and Garibaldi, 2014). In 2014, the estimated production volume was around 8.5 million tonnes, 85 % of which derived from marine fish (FAO, 2016). The value added by the fisheries sector was estimated at more than US$ 24 billion in 2011 (1.3 % of Africa's GDP at that time). Currently, about 25 % of all marine catches around Africa are by non-African countries (de Graaf and Garibaldi, 2014).

Income growth is an important driver of changing food-consumption patterns in Africa. In low-income regions, where the share of income spent on food is much larger (on average 45 %) than in high-income regions (about 10 %), food demand is highly responsive to changes in income. Phenomena such as food price volatility and food market speculation could dramatically affect large sections of the population in Africa. According to the World Bank (2013), the food price spike in 2008 kept or pushed 105 million people into poverty in low-income countries. Food-price volatility is thus a significant factor, yet economic institutions are relatively scarce in Africa, at least compared to the rest of the world; the paucity of institutions in the financial and insurance sectors that can either monitor or help resolve such volatility hampers the ability of farmers and fishermen to take greater risks and to increase investment.

Food imports into sub-Saharan Africa increased almost four times in value between 2002 and 2014, while the share of food imports as a proportion of total merchandise imports declined slightly, with significant oscillations (Figure 66). This marks the increasing integration of sub-Saharan African countries into the world economy during this period, while the spikes reflect higher food imports in times of crisis (e.g. droughts, etc.). The ratio of food exports to imports shows a significant downward trend since the 1970s. Sub-Saharan Africa has become a net food importer since 2000; in 2013, the real value of exports was less than 75 % of that of imports. The main drivers of this trend are sustained domestic demand due to rapid population growth and low average agricultural yields in sub-Saharan Africa (Fuglie and Rada, 2012).

FIGURE 66: Ratio of food exports to food imports35 and food imports as a % of merchandise imports in sub-Saharan Africa *(Source: FAO36)*



35 Food exports/Imports is the ratio of the real value of food exports to food imports. Food imports/Total merchandise imports is the ratio of the nominal value of food imports to total merchandise imports.

36 http://www.fao.org/faostat/en/#data/TP (accessed 7 August 2017).

As regards exports, violations of EU pesticide residue limits constitute about 70 % of EU rejections of all Africa's fruit and vegetable exports (2008-2013), although natural geographical hurdles, poor trade-related infrastructure, inefficient border procedures and a lack of technical personnel also contribute. This high percentage of rejections highlights an important market-access problem (EC-RASFF, 2014; Kareem et al., 2016). The impacts of EU food standards on trade are commodity-specific. Some are trade-inhibiting (coffee, tomatoes) and others trade-enhancing (e.g. fish, oranges and limes) (Kareem et al., 2016; Kareem, 2016).

Outlook

Population growth and higher incomes will strongly reshape the composition of future food demand, with a shift to a more protein-rich diet (Figure 65). Much of this rising demand will be concentrated in Africa's urban areas. Because population and income growth will be largely concentrated in cities, supermarkets will play a growing role in shaping consumption habits; different lifestyles and the increased participation of women in labour will also lead to a shift in diets (Cockx et al., 2017).

Although the medium- and longer-term projections show further increases in continuation of the upward trend, agricultural production may not be able to keep pace with the rapidly evolving demand. This may lead to higher and volatile food prices, and increased competition among production systems, regions and countries. This imbalance between supply and demand may ultimately contribute to greater inequalities among various components of the farming sector, as small and (semi)-subsistence farmers find themselves in competition with large commercial farms. While this growing inequality is particularly likely to happen in medium- and low-income countries across the continent, inequalities may also expand within and among favoured or marginal regions, i.e. regions differently endowed with natural resources, agro-ecosystems and socio-economic features.

Long-term food balances in 11 countries of the Sahel[37] have been modelled under climate change scenarios to 2050 to test whether food production (in terms of biomass) will cover future human needs. In 2012, imports covered about 15 % of food needs. Given the expected climate change impact on crop yields, food self-sufficiency is not expected to be reached. By the year 2050, food biomass imports are expected to reach 40 % of the total food needs under the most productive agriculture scenario and up to 65 % in the less optimistic scenario (Ceccarelli et al., 2017).

With the need for greater agricultural production under conditions of high economic and environmental variability, climate change adaptation and resilience to extreme weather events will be critical. As dramatically shown again by the 2015 El Niño-induced droughts, agricultural drought remains the climate-related factor with the greatest potential for negatively impacting food availability and societal development (Rembold et al., 2014). Extreme droughts, like those that hit the Sahelian region in the 1970s and 1980s, the Ethiopian drought in 1984, and the Horn of Africa drought in 2010/2011 directly caused hunger and death of millions of people. Most climate projections indicate rising temperatures on the African continent and, with more frequent rainfall fluctuations also expected (see chapters I.5.1 and I.10), this will further increase the exposure of African agriculture to climate risks.

Alongside the growth in agricultural production, it is estimated that an additional 4.2 million tonnes of fish will be needed on an annual basis by 2030 to ensure food security in Africa, compared to 7.5 million tonnes of total production in 2009 (Worldfish Center, 2009; FAO, 2016). This rapid increase will only be possible if wild capture fisheries are sustained and improved, and fish farming developed. Currently, most stocks of tuna-like species in the open ocean are considered to be safely exploited (with the exception of yellow-fin tuna in the Indian Ocean), but overall, fish stocks in the north-western African coastal and shelf areas have declined markedly (see also chapter I.11). In the Mediterranean Sea, 93 % of stocks exploited by industrial fisheries are regarded as overexploited, but there are large data gaps; knowledge of many African small-scale fisheries is generally hampered by the lack of data.

According to the FAO, the fisheries sector of African countries is highly vulnerable to disasters, in terms of mortality, livelihoods and capacity to adapt. Illegal, unreported and unregulated fishing is a major concern, particularly along the West African coastline, where it generates about 40 % of catches and a considerable loss in revenue for Mauritania, Senegal, Gambia, Guinea Bissau, Guinea, and Sierra Leone, estimated at US$ 2.3 billion (EUR 1.9 billion at 2017 exchange rates) annually (Doumbouya et al., 2017). However, illegal fishing activities decline as the fines increase, as has been seen in Sierra Leone and Gambia. The EU fishing fleet is active along the African coastline, under the remit of fisheries partnership agreements, providing financial and technical support in exchange for fishing rights, and

37 Senegal, Gambia, Mauritania, Mali, Burkina Faso, Niger, Nigeria, Chad, Sudan, South Sudan and Eritrea.

promoting resource conservation and environmental sustainability.

Challenges and opportunities

Demographic growth, climate change, political instability and conflicts are putting increasing pressure on efforts in the farming and fisheries sectors to provide sufficient and healthy food, while at the same time protecting the environment and using natural resources sustainably. Recent global analyses show that the vast majority of countries that require external food assistance are located in Africa. One in nine people still do not have enough safe food to ensure a healthy lifestyle, and one in four undernourished people live in Africa.

> "The vast majority of countries that require external food assistance are located in Africa. One in nine people still do not have enough safe food to ensure a healthy lifestyle, and one in four undernourished people live in Africa."

Sustainable intensification of agriculture is the cornerstone of any strategy towards food and nutrition security. Declining land productivity and land degradation that affect large areas of cropland and rangeland, and are a major constraint, need to be recalled (see chapter I.7.2). Improved input management (e.g. fertilisation, use of high-quality seeds and optimised irrigation) of available agricultural land areas will undoubtedly help. However, the promotion of improved access to inorganic fertilisers alone is not likely to address the challenges of food and nutrition security, land degradation or agricultural expansion. Complementary approaches are important (Hazell, 2016). Furthermore, for inclusive agricultural modernisation, special consideration should be paid to opportunities for small-scale farmers (especially for women, who continue to perform the bulk of rural work), and for young people. Key issues include:

- the promotion of land rights and efficient land markets. Land rights need to be secure, and land sale and rental markets should be allowed to operate freely without size constraints. This would not only help to improve the functioning of land markets, but would also generate incentives to farmers to make land-improving investments and adopt more input-intensive technologies: investing in agricultural R&D to produce more with less;
- the expansion of smallholder-friendly agricultural research and development for breeding high-nutrient crop and livestock varieties;
- increasing resource-use efficiency (e.g. water and energy) and promoting climate-smart practices (e.g. 'triple-win' strategies for adaptation/mitigation and productivity);
- supporting efficient and inclusive food value chains;
- promoting smallholder-friendly innovations such as mobile-phone-based payment services for finance, the World Food Programme's Purchase for Progress (P4P) and weather index insurance: improving post-harvest handling (post-harvest losses in sub-Saharan Africa are estimated to be around 10-20 % for cereals and higher for perishable products (World Bank et al., 2011)), enhancing food safety and quality standards, and investing in rural infrastructure;
- closing gender gaps. Research shows that gender equality in agriculture leads to higher agricultural output and productivity gains.

BOX 18

Land tenure and agricultural practices

Common farmland areas are not generally associated with good long-term land management practices. Uncertainty about land tenure or the extension of granted tenure acts as a disincentive for investments such as soil conservation or improvement practices. For Ethiopia, Tanzania, Kenya and Malawi, Kassie et al. (2013; 2015) found a strong link between land-tenure security and soil-conservation investments. A meta-analysis of West Africa conducted by Fenske (2011) found a more nuanced relationship between tenure security and certainty of investment. The length and frequency of fallow practices are negatively affected by weak tenures. However, tree planting may enhance rights to future use of the land, depending on the nature of the security of tenure (i.e. titling, gender-biased inheritance systems, etc.). This is echoed by Lovo (2013) for Malawi and by Deininger and Jin (2006) for Ethiopia. Short-term investment decisions (e.g. production input intensity) were not found to be sensitive to the tenure status of land (Fenske, 2011).

Because of the diversity of Africa's agriculture, there is no single response to sustainably improving agriculture. As with conventional input intensification, the outcomes of different management-based approaches (conservation agriculture, organic agriculture, agro-forestry, etc.) are context-specific (Garzon Delvaux and Gomez y Paloma, 2017). Hence, comprehensive and varied agronomic support services for farmers are required. Ultimately, in order to ensure sustainable agriculture, specifically tailored farm practices need to be in place as well as land management tools that integrate sectoral interventions in agriculture, local environmental management and overall land policy.

Efforts must also continue to improve the quality and availability of drought monitoring and seasonal weather predictions for informing agricultural development policies and disaster preparedness and response.

Farming on steep hills in Uganda ©EU, by Andreas Brink

Agricultural policies must ensure that the domestic agricultural sector in Africa can respond to the growth and change in food demand, and help contain its dependence on imported food. For this, the agricultural sector will have to overcome the following challenges: reorientation of domestic staple-food production according to new preferences; improved coordination along the food chain, including post-harvest and processing facilities, to respond to rising demand for high-quality products and processed food; investments in infrastructure (roads, storage, cold chains) to reduce transport and distribution costs; investment in vertical coordination schemes that connect smallholder farmers with processors, traders and other private actors in the agricultural sector; improving linkages between rural centres and secondary towns and mega-cities, in order to reduce competition from cheap imported foods; and encouraging peri-urban agriculture as a source of healthy food for urban populations.

Accessing value chains will depend on meeting EU (and other) quality standards (Tschirley et al., 2015). However, there is a debate around conventional standards and certification, as they can be seen to marginalise the poorest farmers (Maertens and Swinnen, 2009). Acute policy challenges regarding the pace of imports (e.g. rice) are related to the need to improve food standards, both for export and to strengthen consumption of local produce. Africa's urban consumers are willing to pay for better quality, as has been found for domestic rice (Demont et al., 2015).

Developing the value-adding chain is critical. The ratio of value added in agri-business to that of farming in sub-Saharan Africa is typically around 0.6, compared to 3.3 in Latin America and the Caribbean and up to 13 in the USA (World Bank, 2013).

Value-chain models often focus on high-value export crops (i.e. coffee, fresh vegetables and cocoa), mainly involving global agri-food firms. However, most of the food produced by smallholder farmers relates to staple foods marketed in local markets, and involves small and medium-sized enterprises (SMEs).

Several avenues can foster the adoption by smallholders of promising business models by facilitating farmer-SME interactions, building the capacities of SMEs and farmers' organisations, and improving smallholders' access to information services, finance and climatic risk-management instruments (UN-ECOSOC, 2016). Factors identified as facilitating the development of agri-business include, notably (Koira, 2014; Kelly, 2012; Fan et al., 2013):

- support farmers' organisations to help individual farmers devise strategies;
- external support to links between farms and agri-businesses;
- high levels of dependence between actors along a given value chain, which favours long-term relationships and requires coordination among smallholders, including group lending, marketing cooperatives and producer associations;
- support to help meet quality standards;
- support to help reach high-volume requirements for shipment and logistics;
- appropriate policies, in terms of legal and institutional framework and governance (such as land policies that enable efficient smallholders to expand their operations by acquiring or renting land);
- provision of financial services to stimulate the creation of new enterprises;
- information and communications technology (ICT), with ICT firms devising new ways to connect farmers to markets and to each other.

Policy framework

Food security and sustainable agriculture and fisheries are highlighted in SDG 2 (End hunger, achieve food security and improved nutrition, and promote sustainable agriculture) and 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development). Sustainable agriculture also contributes to SDG 15 to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. These objectives are part of the priorities of the Joint Africa-EU Strategy (JAES) Roadmap for 2014-2017 (sustainable and inclusive development and growth and continental integration). The enhancement of research on food and nutrition security and sustainable agriculture is also in line with the Science Agenda for Agriculture in Africa and the African Agricultural Technology Platform (part of the Comprehensive Africa Agriculture Development Programme).

Within the EU's Framework Programme for Research and Innovation 2014-2020 (called Horizon 2020), the EU has invested around EUR 27.5 million in research on food security, sustainable agriculture and forestry, marine and maritime and inland water resources, and on the bioeconomy in Africa. The European Commission has taken initiatives to define how Africa-EU cooperation could further help improve food and nutrition security and sustainable agriculture in African partner countries, which is a priority theme within the Horizon 2020 Work Programme 2018-2020. In April 2016, a roadmap was adopted on the 'EU-Africa Research and Innovation Partnership on Food and Nutrition Security and Sustainable Agriculture', which highlighted in particular the following priority themes: sustainable intensification of agricultural activities; agriculture and food systems for nutrition; and expansion and improvement of agricultural trade and markets.

Fishermen in Mozambique ©EU, by Paolo Ronco

2) Gaps, future actions and priorities to be considered

Timely and good-quality data on the agriculture and fisheries sectors remain a challenge in many African countries. The availability of data on aggregate national production is fairly good. However, disaggregated data, and the lack of information on agricultural inputs and investments, and on trade in agricultural commodities and livestock, are often limiting factors to sound analysis in support of policymaking. There are also major gaps in information about agricultural production and food security in countries affected by conflicts, which often coincide with situations of high food security risk.

These gaps need to be addressed but can only be partially overcome with remotely-sensed information. Some gaps may be filled through intensified data collection using new methodologies (crowdsourcing) and technologies (mobile phones) to cover the food-price dynamics along the whole food chain (from farmers to consumers).

Ex-ante and *ex-post* economic analyses of high-frequency time series of food prices (including the spatial dimension) are required, along with new data on food prices. Furthermore, such data must be freely accessible online (Donmez, 2017).

BOX 19

Collaboration and capacity-building on agricultural monitoring and information systems

With the Malabo Declaration on Agriculture and Postharvest Losses (2014), African leaders reiterated the need to strengthen early warning systems to facilitate rapid response to food security emergencies. Since the late 1980s, the JRC's experience in providing agricultural policy support developed through its Monitoring Agriculture with Remote Sensing (MARS) Crop Yield Forecasting System has been used to strengthen the agricultural monitoring capacity of national and regional institutions in Africa (e.g. for national institutions in Morocco, Algeria and Tunisia). Specific free-to-use tools have been developed and scientific support has been provided to national agricultural information systems (e.g. the African Postharvest Losses Information System – APHLIS, and the Anomaly hot Spots of Agriculture Production - ASAP) for early-warning and food security, in collaboration with international organisations. Monthly information on crop conditions is provided, for example, to the G20 initiatives 'Global Agricultural Geo-Monitoring' (GEOGLAM) and the Agricultural Market Information System (AMIS).

FIGURE 67: Group on Earth Observations Global Agricultural Monitoring Initiative (GEOGLAM) Early Warning Crop Monitor first season maize map, synthesising information as of 28 June 2017 (*Source: GEOGLAM website*)

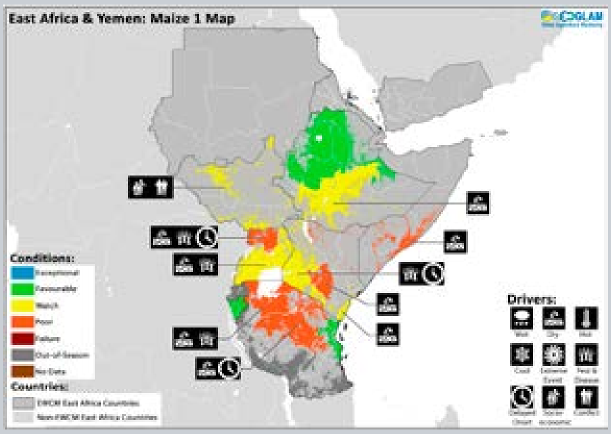
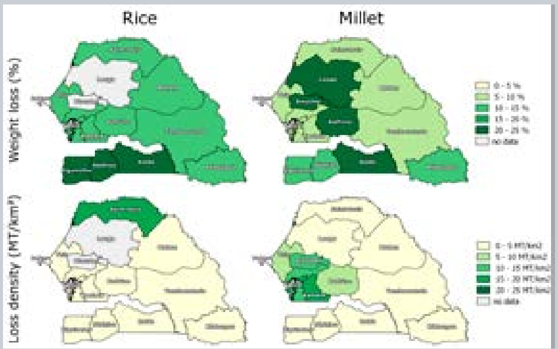


FIGURE 68: Map showing APHLIS (African Postharvest Losses Information System) estimates of different post-harvest cereal losses in Senegal (Source: APHLIS website)



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13. Energy

13.1. Access to modern energy services

1) Key findings

Assessment of the situation

The United Nations 2030 Agenda for Sustainable Development calls on countries to ensure universal access to affordable, reliable and modern energy services (SDG 7). The global scale and importance of this challenge is clear from International Energy Agency estimates (IEA, 2016): in 2016, 1.2 billion people worldwide did not have access to electricity, while more than 2.7 billion were found to rely on solid biomass for cooking.

Africa's energy consumption levels per capita are only a fraction of those in developed countries, in combination with very low rates of access to modern energy services. Over 600 million people have no access to electricity. Even more rely on solid fuels (traditional biomass and charcoal) to meet their basic needs. This has severe consequences for social services, well-being, the economy and the environment. There are strong geographical differences: North African countries enjoy almost 100 % access to electricity, while the rate is only 23 % in East Africa and 25 % in Central Africa. Even where electric grid access is available, the service can be poor and unreliable. The World Bank estimates that, for sub-Saharan African countries, the average value lost due to electrical outages rose from 6 % in 2015 to 8.3 % in 2016 (Kojima and Trimble, 2016). For these reasons, sub-Saharan Africa is the main focus of development support for energy access.

Illegally imported petrol from Nigeria sold on the streets of Benin ©EU, by Andreas Brink

The discrepancy between African energy use and available resources is huge, with use dramatically outpacing supply. This reflects insufficient investment in electricity generation and distribution, despite the fact that the continent has a wealth of both fossil fuels (coal, oil, gas) and renewable energy resources.

The largest oil producers are Nigeria and Angola in sub-Saharan Africa, followed by Libya, Algeria and Egypt in North Africa. New discoveries have also been reported in Ghana, Kenya and Uganda. While 30 % of global gas and oil discoveries in the past five years have been in Africa, it is estimated that overall oil production in Africa will fall between 2020 and 2040 (IEA, 2014; OPEC, 2016), and that it will be just enough to cover the continent's growing needs. Gas production is expected to continue to rise, given the new discoveries in Mozambique, Tanzania and Egypt. However, the lack of pipeline infrastructure makes the projection of growth trends uncertain. A further consequence of insufficient infrastructure is the practice of gas flaring, which has been a major environmental issue in Nigeria, the largest African oil producer (IEA, 2014).

Coal is a major energy source in South Africa, and is also exported to other African countries as well as to Asia and the EU. However, its further exploration is hindered by the lack of transport infrastructure, the depletion of existing mines, and global competition from low-cost producers.

Although several African countries have reserves of uranium, only South Africa uses nuclear power for electricity generation.

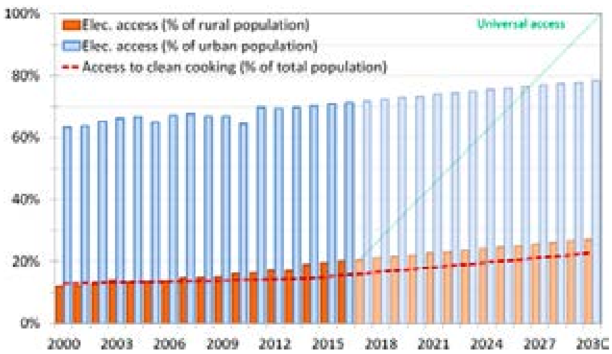
International trade in energy carriers is a sensitive issue throughout the continent, in view of several factors: reliance on foreign investment, an unbalanced distribution of such funds, and exploitation of national resources by overseas companies or by small groups within society. The economic benefits of exploiting these resources have frequently increased rather than mitigated disparities in income distribution.

Outlook

Energy access is slowly improving in sub-Saharan Africa. Figure 68 shows how the situation has developed since 2000, based on World Bank figures (World Bank, 2017).

There is a clear divergence between rural and urban areas in access to electricity; currently, 71 % of the urban population have access to electricity, compared to 18 % of the rural population. The data show only a modest increase in access to clean fuels and technologies for cooking, from 12.9 % of the total population in 2000 to 14.6 % in 2014. Therefore, although progress is being made, these trends need to accelerate rapidly to meet the SDGs. The projected rise in population makes the situation even more challenging.

FIGURE 69: Trends in energy access for sub-Saharan Africa
(Source: World Bank Open Data, 2017)



Challenges and opportunities

Electrification represents a great challenge and opportunity for Africa's energy sector. Today, the electricity generation capacity installed in sub-Saharan African countries does not cover the population's energy needs. Even modest population and economic growth will drive a strong increase in energy demand, which is expected to almost double by 2040, requiring a corresponding increase in electricity generation capacity of 4 % a year (IEA, 2014). Both factors (underdeveloped electricity infrastructure and rapid increase in demand) can create a dynamic new sector, which offers potential for high-quality employment.

> "Increased energy demand due to population and economic growth presents opportunities and challenges for high-quality employment in a dynamic new sector."

Similarly radical growth and changes are foreseen for the energy transmission and distribution system. Sub-Saharan Africa currently has only 300 000 km of power lines, compared to the EU's 10 million km. Large-scale deployment of microgrids and off-grid systems offer a solution for providing electricity to rural communities and areas far from the grid infrastructure. Designing new grid infrastructure with interoperability capabilities can facilitate their future communication and interaction with other elements in the overall power system. Furthermore, by interconnecting the different electric power systems in Africa with themselves and with Europe, both continents would better exploit their renewable generation potential. An initial assessment (Brancucci Martinez-Anido, 2013) of the synergies of and opportunities for interconnections between Europe and North Africa highlights demand time and spatial complementarities, e.g. in the different peaks in electricity use in winter and summer periods, and the different demand and renewable power output in different time zones and regions.

The EU and its Member States play a major role in the provision of aid for energy projects in the overall context of United Nations Sustainable Energy for All (SE4ALL) initiative for affordable and clean energy. This takes various forms, ranging from technical facilities that support policy dialogue, institutional reforms and capacity-building, to investment projects. Out of the more than 50 major energy policy support schemes and programmes (AEEP, 2016a), the flagship initiatives are the European Union Energy Initiative, the African Renewable Energy Initiative, the Africa-EU Energy Partnership and its Renewable Energy Cooperation Programme, the Technical Assistance Facility, and the recent extension of the Covenant of Mayors initiative to sub-Saharan Africa (see chapter II.2).

The European Commission focuses its support policies for energy on various indigenous resources that are available and affordable in all African countries (AEEP, 2016b). This brings direct benefits to local communities and creates business opportunities for the small-to-medium business sector.

Large hydropower water reservoir in Lesotho ©EU, by Paolo Ronco

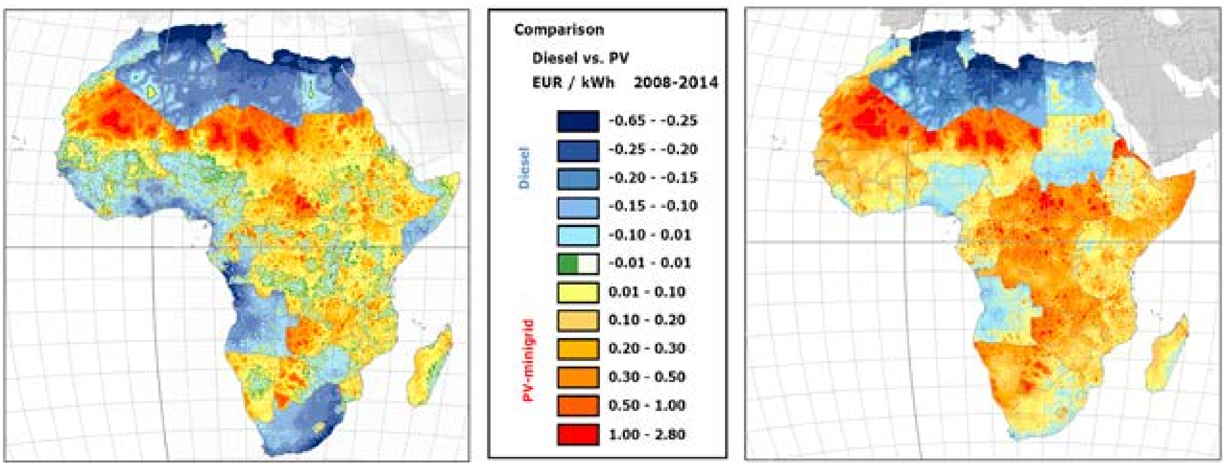
As regards project funding, the earlier EU programmes for grant-based support (Energy Facilities I and II) have evolved into financing schemes based on loans, guarantees and equity, involving, for example, the Electrification Financing Initiative, the Global Energy Efficiency and Renewable Energy Fund and the European Development Finance Institutions. The Electrification Financing Initiative is an innovative financial blending38 instrument for energy projects, designed to increase private-sector investment in energy-access projects. It has been developed to help overcome major barriers to investments in access to energy in developing countries: the lack of access to seed, mid-term and long-term capital.

The improvement of electricity access in Africa has a very strong spatial dimension, due to the vast land areas and the distributed nature of renewable resources, which already play a key role in the production of biomass, the traditional source of energy in Africa. As a result, analyses based on geographic information systems (GIS) are particularly useful for evaluating the availability and economic potential of modern renewable energy sources.

Key GIS resources include39: the International Renewable Energy Agency (IRENA) 'Global Atlas for Renewable Energy' – a map catalogue of energy-related applications; the Economic Community Of West African States' (ECOWAS) regional planning and investor support tool 'Observatory for Renewable Energy and Energy Efficiency'; and the JRC's least-cost methodology to help policymakers in the African continent assess alternatives to fossil fuels for rural electrification 'Renewable Energies for Rural Electrification in Africa'.

Figure 69 shows how the relative competitiveness of diesel generators and photovoltaic (PV) mini-grids for off-grid rural electrification has evolved. The area in which PV-generated electricity (in yellow/red) is cheaper markedly increased in 2014 compared to 2008, with a corresponding reduction in the area where diesel is more competitive (blue). This is mainly due to a 60 % drop in the PV module price compared to 2008, but variations in the price of diesel fuel (including its transport) were also considered.

FIGURE 70: Model results of the competitiveness of diesel generators and photovoltaic mini-grids in providing off-grid electricity in 2008 and 2014 (in the yellow/red areas, PV-generated electricity is cheaper, while for the blue areas, electricity from diesel generators is cheaper) *(Source: Szabó et al., 2013; online access and updated maps: JRC Ren²AF)*



38 Blending refers to funding instruments that combine EU grants with loans or equity from public and private financiers.

39 See web links at the end of the chapter.

2) Gaps, future actions and priorities to be considered

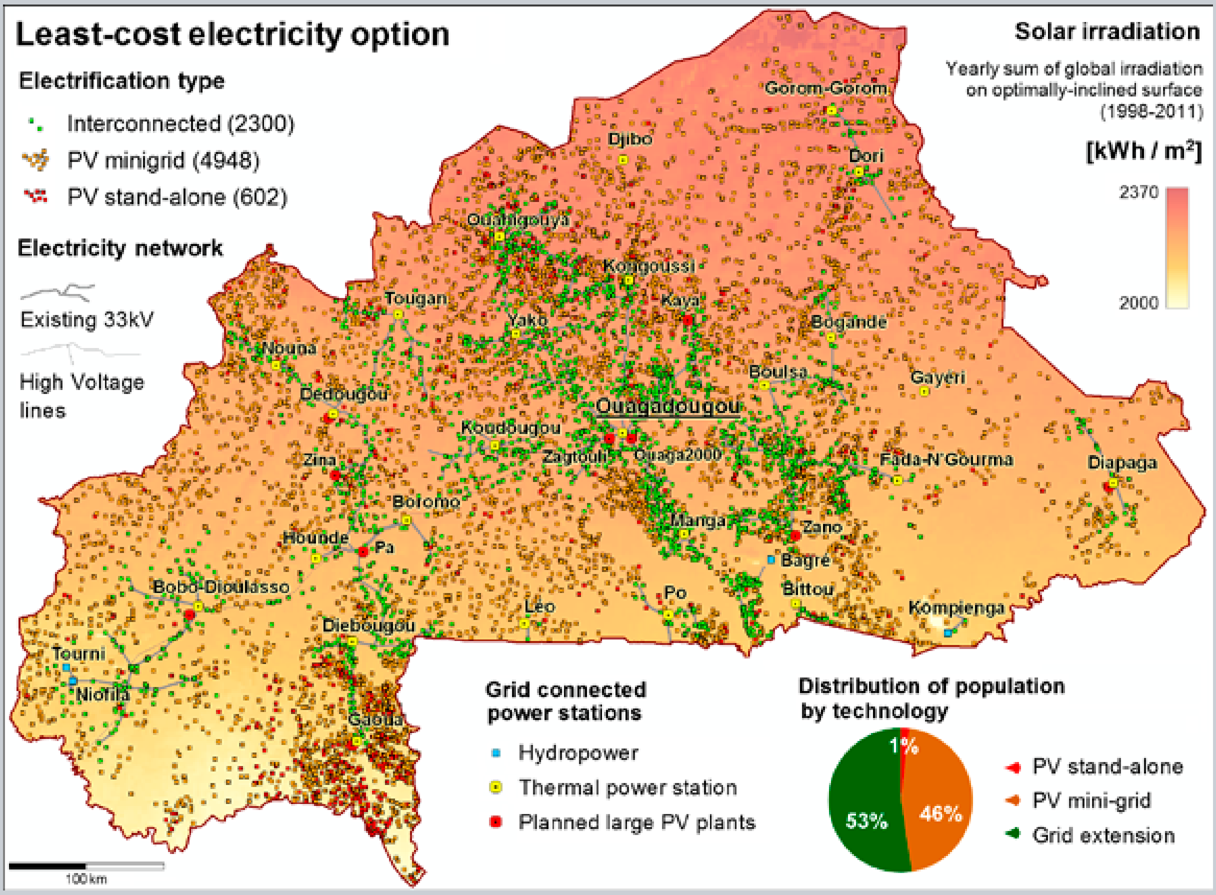
Sub-Saharan Africa has some of the poorest access to modern energy services in the world. Some progress is being made but, even if the projected growth rates are met, hundreds of millions of people will still lack these basic services in 2030 and beyond, particularly in rural areas. Coordinated efforts are needed to increase public and private investments, but these also rely on appropriate policies and governance at the local level. Work is needed to analyse proposed national and local policies, evaluate data and their uncertainties, monitor the situation and promote capacity-building.

BOX 20

JRC analysis of rural electrification options under country-specific conditions

The JRC's spatial analysis tools can be adapted to the specific conditions of a region or country to assess pathways towards sustainable rural electrification. As a starting point, the JRC has carried out assessments of three countries with different situations in sub-Saharan Africa: Burkina Faso, Tanzania and Kenya. The findings that off-grid renewable energy options can be cheaper than grid extension can help national authorities and development partners in the selection of optimised rural electrification options.

FIGURE 71: Mapping the least-cost technology for off-grid mini-systems in Burkina Faso (*Source: Moner-Girona et al., 2016a and 2016b*)



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13.2. Renewable energies

1) Key findings

African countries face a major challenge to expand energy production to meet the needs of economic development and population growth while, at the same time, developing modern and sustainable renewable energy sources. As things stand, according to the International Renewable Energy Agency (IRENA), renewable sources provide just over 50 % of Africa's final energy consumption (IRENA, 2016), but this is dominated by the traditional use of biomass, i.e. the firewood, charcoal and waste burnt for cooking and other domestic needs. To improve efficiency and reduce the negative environmental and health impacts of traditional energy sources, a major transformation is needed towards more efficient and clean stoves, alternative systems, the cleaner use of waste and residues and sustainably grown feedstocks. For electricity, IRENA projections indicate the possibility of tripling total output by 2030[40], with a renewables share of 49 %, up from 17 % (mostly hydropower) in 2013. This includes contributions from a range of technologies, in particular solar photovoltaics (PV), solar thermal electricity, wind, hydropower, geothermal and biomass.

> “The same photovoltaic panel in Africa can produce twice the electricity it would in Central Europe.”

Africa has great solar resources across the whole continent: typically, the same photovoltaic panel in Africa can produce twice the electricity it would in Central Europe (JRC Photovoltaic Geographic Information System PVGIS, which is a solar photovoltaic energy calculator for stand-alone PV systems and plants, or those connected to the grid. It provides solar-electricity-generator simulation and solar radiation maps). In the areas where solar energy is lower due to the greater cloud cover in the equatorial belt, the photovoltaic resource is complemented by great hydropower potential due to the high levels of precipitation, wind in coastal areas, and geothermal energy in the Rift Valley.

With seven major rivers, Africa has a technical hydropower potential of 283 gigawatt (Kumar et al., 2011). However, it is estimated that only 8 % of it has been harnessed to date, compared to 53 % in Europe. The exploitation of this potential has historically been hampered in Africa by the need to build new power-generation infrastructure. Moreover, the high upfront capital costs of hydropower projects are a barrier in the African context, due to limited government and private finance. Hydropower project development may involve long periods of planning, licensing and construction. Various technical challenges, land ownership issues and the environmental impact of large dam construction and disputes over the management of transboundary water resources increase the risk of hydropower investments.

Despite the challenging environment, Africa has recently shown upward trends in the development rate of new energy-generation projects. In 2016, 3.4 gigawatt (GW) hydropower capacities were added (IHA, 2017), a fivefold increase over the 0.7 GW in 2015 (IHA, 2016) and the 0.12 GW in 2014 (IHA, 2015). These additions have been mainly driven by Ethiopia and South Africa. Similar values are also foreseen for 2017, with Angola's 2.07 GW Lauca hydropower station coming online. Small-scale hydropower systems are particularly important for Africa, due to their potential to supply remote mini-grids located close to areas of consumption.

Bioenergy (particularly from biomass) plays a central role in the energy system in sub-Saharan Africa. It can be developed for domestic purposes or for exports (or both), and can be used in the electricity, heating, cooling, and transport sectors (Monforti-Ferrario, 2011). The potential sources of conflict between these uses must be identified. Biomass production for export could improve rural development, job creation and the local economy, but local needs must take priority.

Charcoal is the prime energy source for cooking in many African cities ©EU, by Andreas Brink

40 The International Energy Agency's (IEA) projected annual compound growth rate of 4 % is considerably more conservative, but the technical and resource issues are the same.

Environmental and social sustainability issues must be fully addressed. Biomass in protected areas should not be used for bioenergy purposes. Even though biomass could be collected in a sustainable manner from tropical-forest ecosystems, protected areas should be maintained for their full environmental benefits and not for energy purposes (see chapter I.9). The water footprint of bioenergy, at the biomass production or conversion stages, must also be taken into account since many parts of Africa are already experiencing water shortages, and about one-third of Africa's productive agricultural areas are already classified as dryland (see chapter I.7.2).

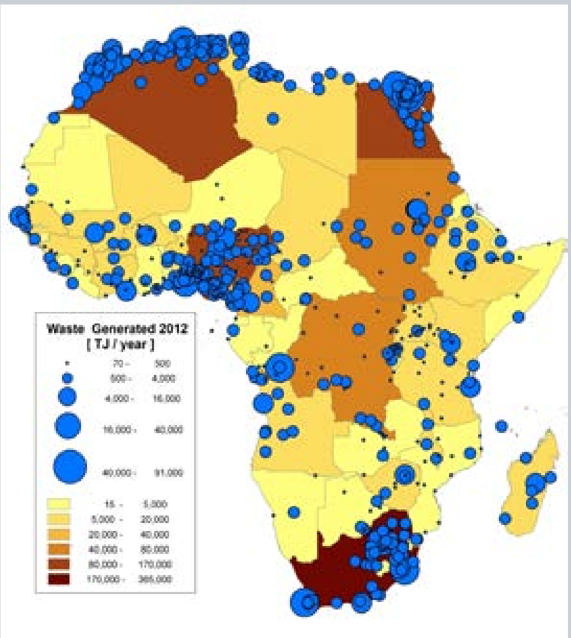
Other key points must also be addressed in relation to the status of and prospects for bioenergy in Africa, such as the availability of more efficient cooking stoves, the use of degraded and marginal land, and the possible impacts (and related uncertainties) of climate change on biomass availability. A preliminary JRC study of climate change effects on renewable energy resource availability underlined the complexity of the issue, with positive and negative effects varying with technology and geography (Monforti-Ferrario, 2013).

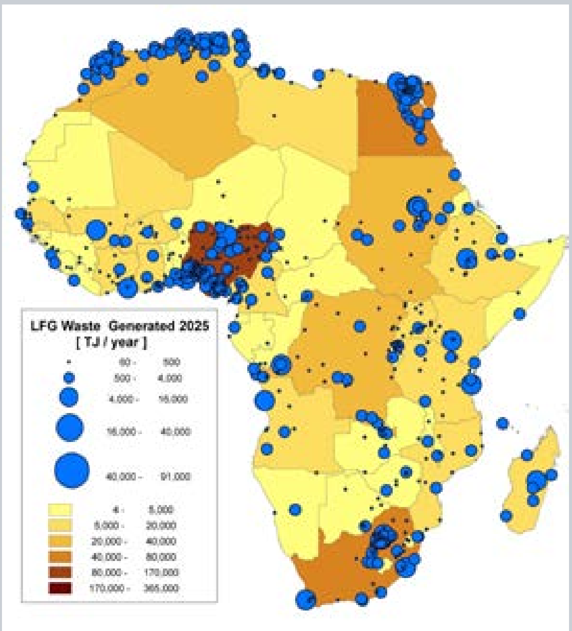
BOX 21

The value of waste in African urban areas

While the issue of competition for biomass resource use is often raised for the agricultural and forest sectors, there is generally little competition for the use of organic waste. In addition, waste is often associated with negative environmental impacts (as in the case of unregulated disposal). A JRC study evaluated the energy potential of municipal solid waste from African urban areas (Scarlat et al., 2015). The results show an energy potential of 1125 petajoules (PJ) (approximately 3.6 % of total energy consumption in Africa) in 2012, rising to 2199 PJ in 2025. If energy recovery through landfill gas is also considered, approximately another 155 PJ could have been recovered in 2012, and 363 PJ in 2025. The use of full waste collection could have led to electricity generation of 62.5 terawatt hours (TWh) in 2012 (about 10 % of reported production) and 122.2 TWh in 2025. Considering the waste actually collected, these estimates fall to 34.1 TWh in 2012 and 83.8 TWh in 2025.

FIGURE 72: Energy potential of waste generated in urban areas in 2012 and of landfill gas recovery from waste generated in 2025 (*Source: Scarlat et al., 2015*)





Outlook

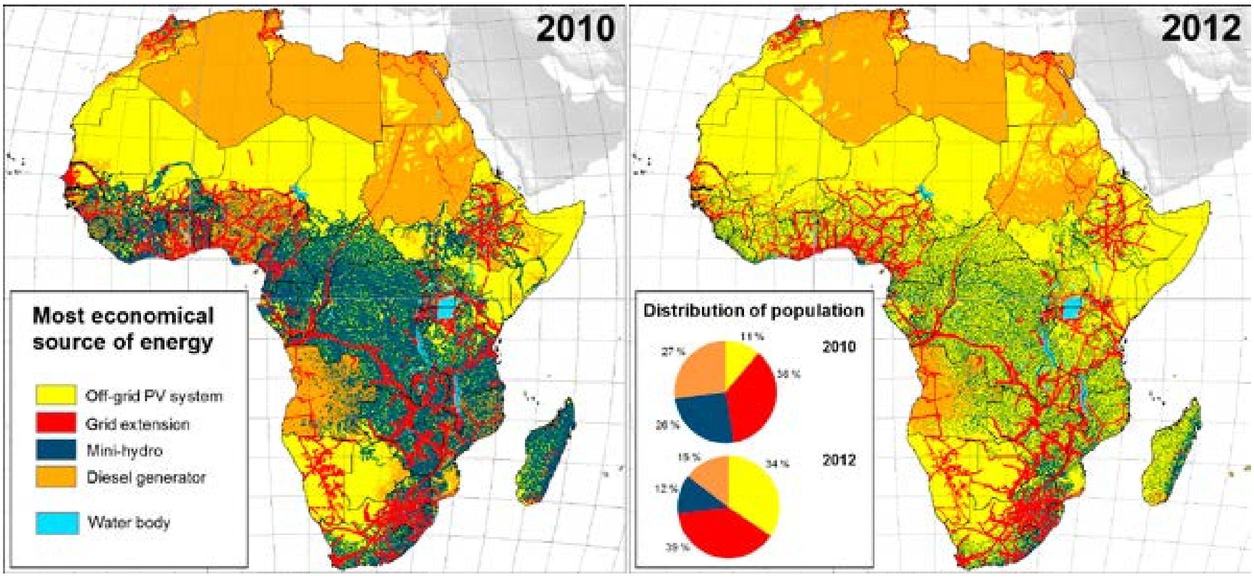
A recent report by Kofi Annan's Africa Progress Panel stated that "Africa cannot wait for the development of electricity infrastructure and should exploit more quickly deployable solutions such as solar PV" (Africa Progress Panel, 2017). This reflects current calls for a diverse energy mix, with an emphasis on developing off-grid solar power in tandem with the development of grid infrastructure. This is particularly relevant for remote areas, where the nearest grid infrastructure may be unreliable and overloaded. In areas where household density is low, investment in larger grid infrastructure may not be cost competitive, at least in the short term. Conclusions consistent with the Progress Panel proposal can also be seen in the results of a JRC comparative analysis of electrification options for 2010 and 2012, presented in Figure 72. The thickness of the red grid lines indicates the physical area for which traditional grid extension is considered the most cost-effective option. Further development scenarios could include links to existing stand-alone mini-systems, forming an interconnected network.

According to the most recent analysis (Jäger-Waldau, 2016), solar PV electricity is the most competitive technology for almost 40% of Africa's population. Until the end of the last decade, the main application for PV was in small stand-alone systems, the market statistics for which are extremely imprecise or even non-existent. However, since 2012, major policy changes have led to a large number of utility-scale (megawatt) PV projects. The documented capacity of installed PV systems had risen to more than 2.6 GW by the end of 2015, over 40 times the capacity installed in 2008. This rapid growth continued in 2016, and latest projections foresee an installed capacity in excess of 10 GW by 2020.

> "Solar PV electricity is the most competitive technology for almost 40 % of the population in Africa."

Looking to the medium term, the IRENA roadmap identified modern renewable technology options (i.e. excluding traditional biomass for cooking and heating) across sectors and countries, which could collectively supply 22% of Africa's total final energy consumption by 2030 (IRENA, 2016). This represents more than a fourfold increase compared to the 5% share in 2013. PV solar power could contribute 70 TWh (4% of total energy consumption) with 31 GW of PV systems.

FIGURE 73: Competitiveness of off-grid PV, diesel generators and mini-hydro-produced electricity compared to grid extension (red lines); modelled period: 2010-2012. The comparison includes the most widespread off-grid technologies used in Africa. The pie-charts indicate which proportion of the total population would be served by each least-cost option *(Source: Szabó et al., 2013)*



Global employment in renewable energy reached 8.1 million in 2015, with approximately 60 000 in Africa (IRENA, 2017). An additional 1.3 million people worldwide have jobs related to large hydropower plants. There is clearly huge potential in this area for Africa in terms of the energy industry itself and the positive effects on communities: studies on South Africa and Peru, for instance, indicate that female employment levels can increase following electrification. In addition, since the energy market in Africa must grow rapidly, with a significant proportion of small systems, the employment benefit can be much larger than in developed countries, where any estimate of the employment benefits of the introduction of renewable energies needs to take account of job losses in traditional power-generation technologies.

2) Gaps, future actions and priorities to be considered

Although renewable energy already plays a critical role in energy supply in Africa, the full exploitation of the vast amount of available resources requires an holistic perspective that considers economic, environmental and climate change impacts. Integrated scenarios for expanding the use of renewables should be a key element in the overall response. In addition, there is a need to better track and understand the impact of projects and development activities, which can only be achieved by close collaboration with local partners. New project monitoring tools need to be developed that take into account social, geographic and infrastructural aspects.

The role of modern energies as the main source for hundreds of millions of people raises a range of specific questions to be analysed as well as priorities for further research.

Traditional renewable energy resources (such as biomass and hydropower), as well as newly competitive technologies (such as solar, wind and geothermal power) and the mini- and micro-grid systems are needed to create coherent and resilient networks both at the regional and country levels.

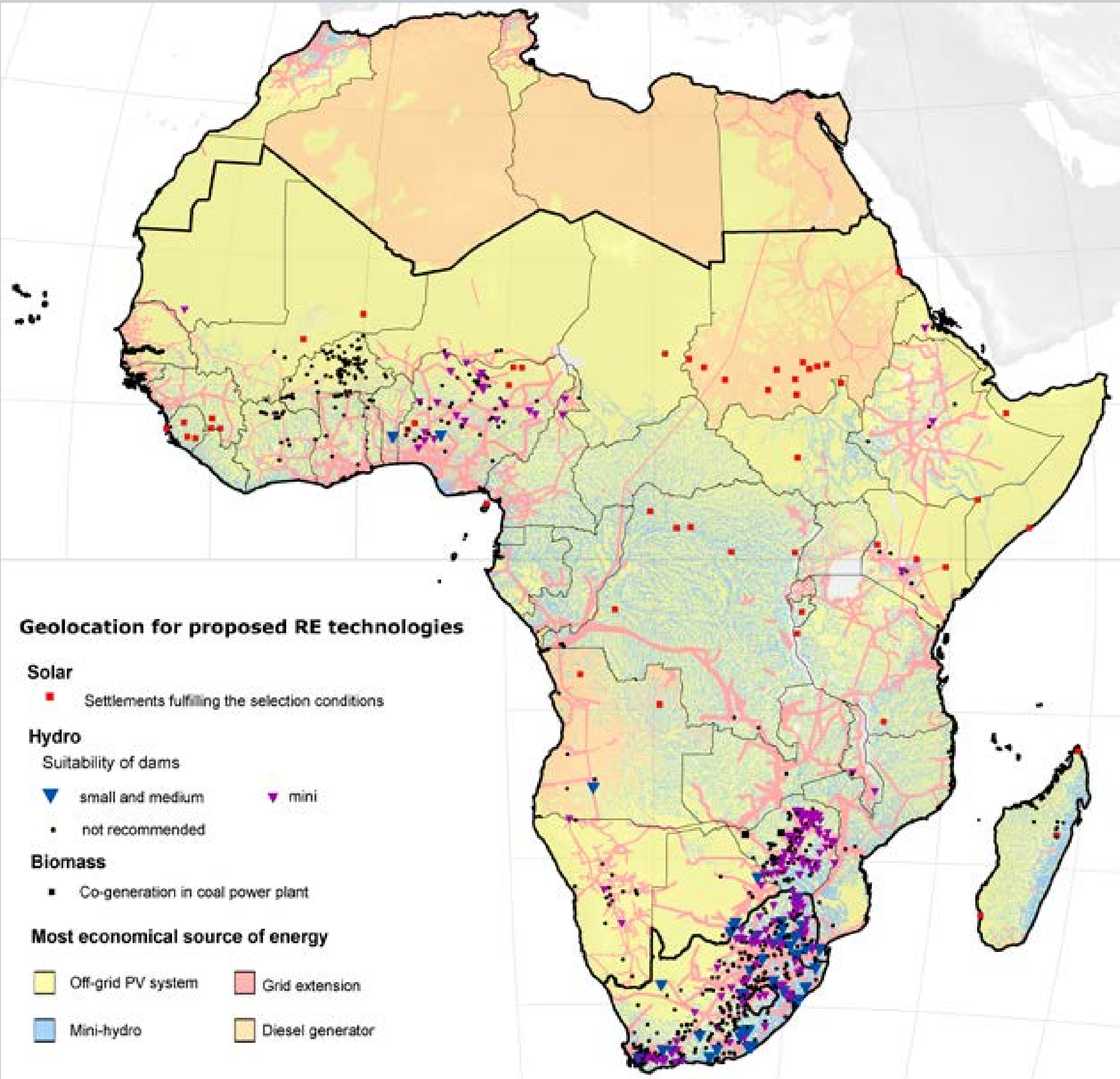
The wider scientific community in Africa should also be strengthened, especially in the context of the Africa-EU Energy Initiative and the Africa-EU Renewable Energy Research and Innovation Symposium.

BOX 22

Identifying opportunities for investment in renewable energies in Africa

The JRC has analysed the potential use of the existing energy infrastructure (in which a significant up-front investment has already been made) for electricity generation (Szabó et al., 2016). This aimed at boosting private investment and speeding up the deployment of renewable energy systems in sub-Saharan Africa. A comprehensive methodology was developed to identify and estimate the potential of suitable locations in sub-Saharan Africa for integrating non-powered dams, co-firing bagasse and PV systems into decentralised rural mini-grids. These locations have been further analysed in terms of potential power capacity, electricity output, investments needed and the population that would benefit. This strategy can be used to attract additional finance, engage private investors and help achieve SDG 7.

FIGURE 74: Identification of renewable energy (RE) electricity-generation options in sub-Saharan Africa, integrating existing resources (*Source: Szabó et al., 2016*)



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14. Raw materials

1) Key findings

Assessment of the situation

The sustainable and secure supply of raw materials is essential for maintaining and improving quality of life. Non-energy raw materials, such as minerals and metals, are used in all industries across all supply chain stages. Modern technologies increasingly rely on a range of specific metals and minerals whose supply is often concentrated in certain areas of the planet. Several of these are classified as critical raw materials (see Box 23). For example, a mobile phone can contain up to 50 different kinds of metals, most of which help to keep it lightweight and small. Critical raw materials are also found in many modern technologies, such as solar panels, wind turbines, electric vehicles and energy-efficient lighting, which are essential to low-carbon and circular economies, and thus to sustainable development.

The supply of specific minerals from developing and emerging countries is sometimes sourced, to a large extent, from artisanal and small-scale mining. For instance, this is the case for 60 % to 70 % of the diamonds mined in Ghana (McQuilken and Hilson, 2016). The informal sector also plays a critical role in the recycling of secondary metals in these countries. While artisanal and small-scale mining can make a positive contribution to the establishment of sustainable community life and rural economic development, the uncontrolled and illegal extraction and recycling of raw materials can have negative social and environmental consequences (e.g. poor health and safety standards, negative environmental impacts, use of child labour and smuggling).

Knowledge on the available supply of global raw materials is fragmented, with major gaps concerning primary materials extracted from mining and subsequent processing, as well as secondary raw materials that can be obtained from waste recovery and recycling. Basic knowledge is often lacking on economic, trade, environmental and social aspects of both domestic and international supply.

Challenges and opportunities

A better understanding is needed of the contribution of mining to sustainable development, as mineral industries can be strategic catalysts for economic and social development. However, this issue is controversial in several respects (e.g. conflict minerals, conflict prevention and early-warning). The Mining Contribution Index shows that the major mineral-producing countries (a list topped by China, Australia, Russia and the USA) are not necessarily the most economically dependent on mining. Among the top 20 mineral-producing countries, only Australia, the Democratic Republic of the Congo (DRC), Mozambique and Ukraine appear in the index top 20 (ICMM, 2016).

Africa remains a major source of several critical raw materials for the EU, such as cobalt (DRC, Uganda), platinum (South Africa, Zimbabwe), tantalum (Nigeria, Rwanda) and phosphate rock (Morocco). Moreover, Africa has become a growing market for EU construction and mining equipment, with imports doubling from US$ 2.2

BOX 23

Critical raw materials

Although all raw materials are important, some of them are of more concern than others, particularly for manufacturing products such as laptops and mobile phones, which are fast becoming essential to modern living. Critical raw materials are of great economic importance to society, specific sectors and key technologies, and have a high risk of supply disruption.

Examples include cobalt, platinum and tantalum, which are mostly mined in Africa (see Box 25).

The European Commission regularly updates a list of critical raw materials for the EU41.

41 https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en

billion in 2005 to US$ 4.3 billion in 2011 (EUR 1.75 billion at 2005 exchange rates to EUR 3 billion at 2011 exchange rates). In addition, several mining companies active in Africa originate from Europe or are listed on European exchanges.

In order to promote the sustainable management of e-waste, the Sustainable Recycling Industries (an initiative of the Swiss Federal Laboratories for Materials Science and Technology and the World Resources Forum) supports national initiatives and implements pilot projects to improve local capacity for the sustainable recycling of electronic devices and household equipment in some developing countries, including Ghana, South Africa and Egypt.

BOX 24

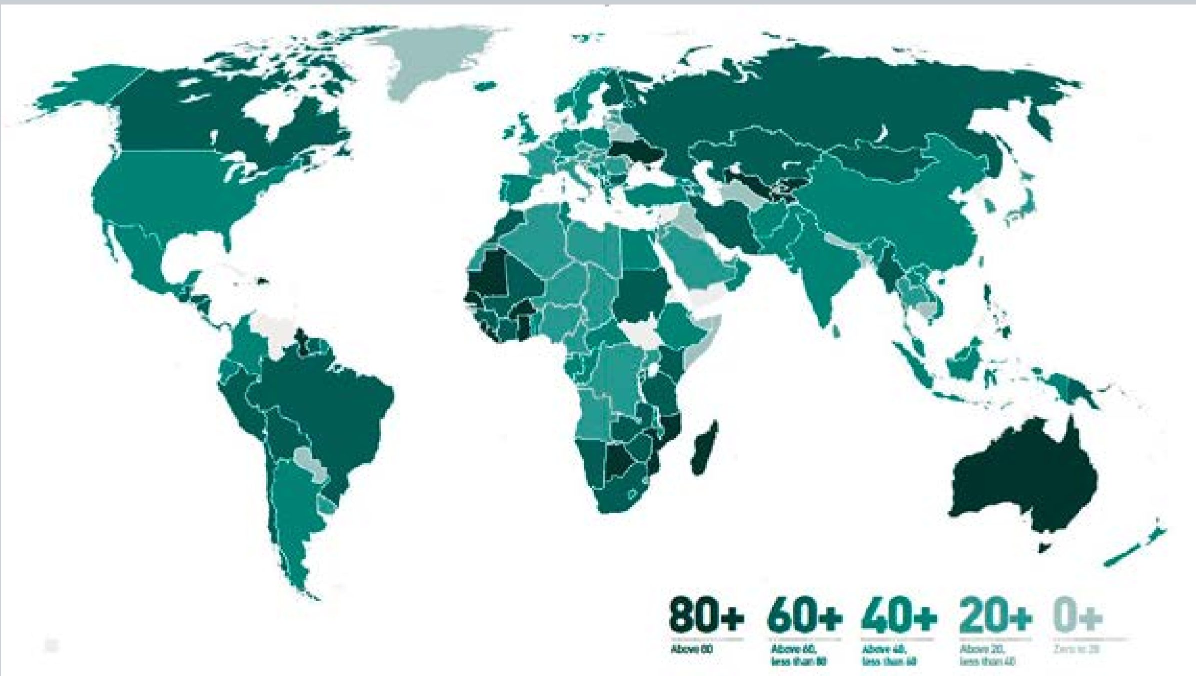
The role of mineral raw materials in national economies

According to a recent report by the International Council on Mining and Minerals (ICMM, 2016), six African countries (Democratic Republic of Congo, Mauritania, Burkina Faso, Madagascar, Botswana and Liberia) rank in the top 10 of the Mining Contribution Index (MCI). This index ranks countries by the importance of mining and metals within each national economy (Figure 74). It is a composite of four quantitative indicators: (1) contribution of minerals and metals to exports; (2) change in contribution to exports over the preceding five years; (3) value of production as a percentage of GDP; and (4) mineral rents42 as a percentage of GDP.

The index is a good starting point for understanding the contribution of the mining sector to a country's economy, but it remains a compromise between what should ideally be measured and what can actually be measured in all countries. The higher the index, the greater the contribution of mining to the economy, including the creation of job opportunities (which is a positive aspect); but the higher the index, the greater the dependency on mining (which is less positive, especially for low and middle-income countries, which are more vulnerable to downturns in international commodity markets).

A failing of the index is that it does not capture some other highly significant factors that influence how effectively mining contributes to broader development. For example, it does not take into account whether or not the revenues from mining activities are managed equitably and transparently.

FIGURE 75: Mining Contribution Index (MCI) (*Source: ICMM, 2016)*



42 The mineral rent is a measure of the profitability of mineral extraction (the value of production minus 'normal production costs').

BOX 25

Critical raw materials, trade in minerals and related technologies

Africa is a major global supplier of several minerals that are classified as critical raw materials (Figure 75). The DRC extracts 53 % of the global supply of cobalt; Rwanda extracts 31 % of global tantalum; and South Africa extracts 77 % of global platinum, 83 % of global rhodium, 85 % of global iridium and 93 % of global ruthenium, all classified by the EU as being critical. According to estimates, the continent houses more than 30 % of the world's mineral reserves and an even greater proportion of deposits of gold, platinum, diamonds, manganese, tantalum and phosphate rock.

Although Africa is an important trading partner of the EU in terms of mineral raw materials, the share of EU imports of ores, metals, precious metals and minerals from Africa fell from 17 % in 2001 to 8 % in 2015 (Figure 75), and the share of African exports of ores, metals, precious metals and minerals to the EU fell from 57 % in 2001 to 17 % in 2015. This dramatic decline is due to the rapid increase in demand from Asia.

FIGURE 76: Mapping Africa's mineral wealth: selected countries and commodities
(*Source: Africa Progress Panel, 2013 Equity in Extractives. Stewarding Africa's natural resources for all*)

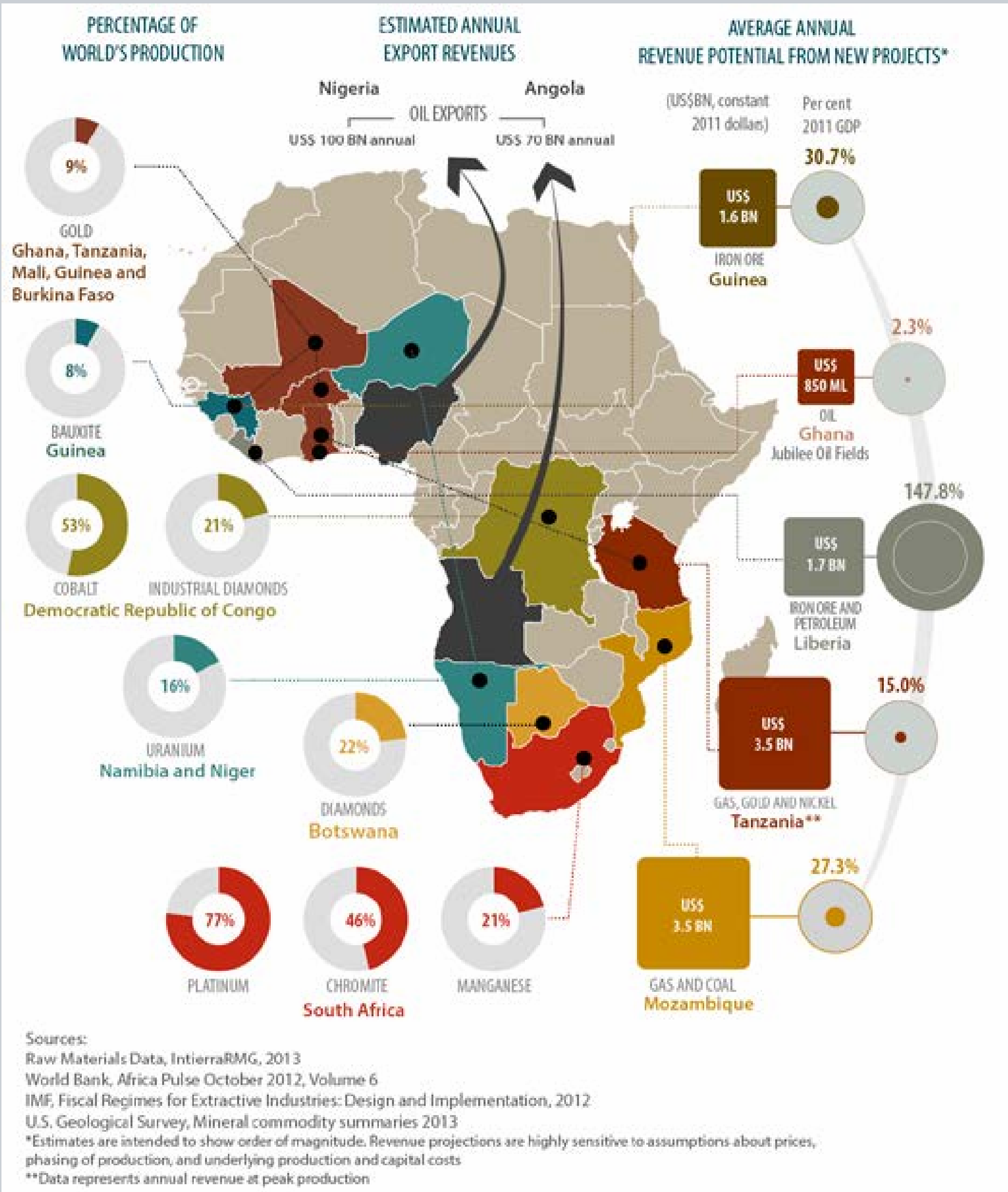
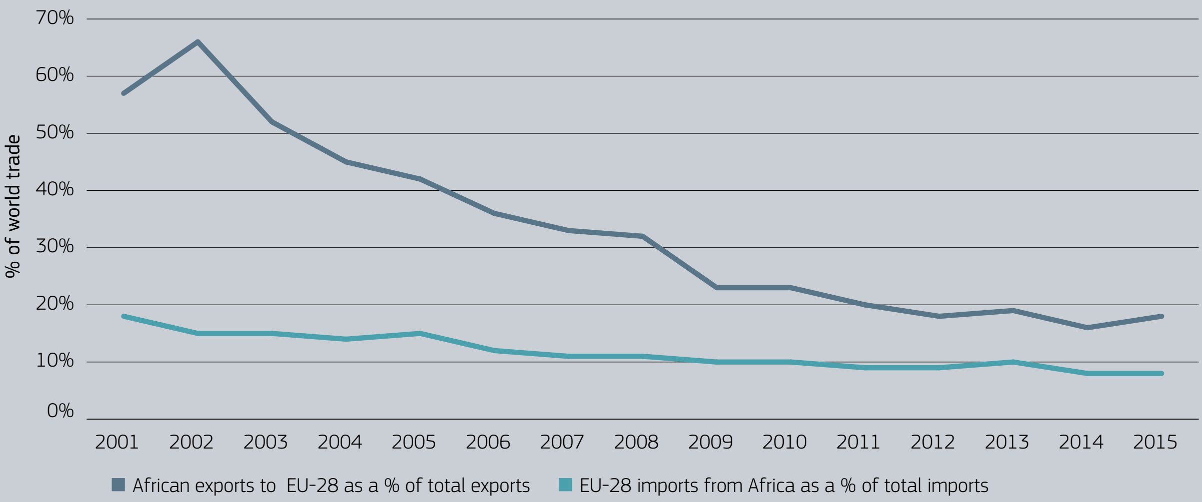


FIGURE 77: African exports and EU imports of ores and metals
(*Source: STRADE European Policy Brief No 06/2016, based on ITC-COMTRADE 2016*)



BOX 26

Secondary raw materials and (illegal) trade in e-waste

Raw materials that originate from the recycling of waste (also known as secondary raw materials) are valuable resources that can be used as inputs in the economy. Greater recycling rates and subsequent use of secondary raw materials increase the circularity of the economy, with positive effects in terms of reduced environmental impacts and enhanced resource efficiency (COM(2015) 614). Moreover, the waste-management and recycling sectors contribute significantly to the economy through gross value added, tax revenues and job creation.

According to the International Labour Organization, illegal shipments of waste electrical and electronic equipment (WEEE, also known as e-waste) are often labelled as donations, or imports of second-hand products, to cross borders as a legal transaction. Illegal e-waste is often exported to developing countries (e.g. Côte d'Ivoire, Ghana and Nigeria) to be disassembled and stripped of valuable metals (and other secondary raw materials) using a cheap and informal labour force and without following health, safety and environmental standards. The treatment of these waste flows (which is often carried out with rudimentary techniques and within the informal economy) has adverse environmental and health implications.

The EU-funded Countering WEEE Illegal Trade (CWIT) project found that, in Europe, only 35 % (3.3 million tonnes) of all the e-waste discarded in 2012 ended up in the officially reported collection and recycling systems (Huisman, J. et al., 2015). The other 65 % (6.15 million tonnes) were exported, treated under non-compliant conditions in Europe, scavenged or thrown into waste bins. According to the same source, 1.3 million tonnes left the EU as undocumented exports, of which 0.4 million tonnes has probably been dumped as e-waste. The remaining 0.9 million tonnes have probably been sent for reuse or repair.

Social and environmental impacts in the world's largest e-waste dump at Agbogbloshie near Accra (Ghana) ©Lantus, CC BY 2.0 (https://creativecommons.org/licenses/by/2.0/)

Policy framework

"The mining industry has the opportunity and the potential to positively contribute to all 17 SDGs" (World Economic Forum, 2016). Mining can foster economic development by providing opportunities for decent employment, business development, increased fiscal revenues, etc. Minerals are also essential building blocks for technologies, infrastructure, energy and agriculture. However, mining has contributed to several of the challenges the SDGs are trying to address, such as environmental degradation, the displacement of populations, social inequality and armed conflicts. Recently, the mineral industries have made significant efforts to mitigate and manage such impacts and risks, for instance in terms of reduced air and water pollution, better recycling of water, increased recovery of mineral resources, enhanced transparency (e.g. through the Extractive Industries Transparency Initiative) and responsible business practices.

The European Commission's Raw Materials Initiative, the European Innovation Partnership on Raw Materials, and the Circular Economy Action Plan all recognise that the sustainable and secure supply of raw materials (both primary and secondary) is essential to the EU.

The treatment of e-waste in developing countries is often dealt with in the informal economy, using rudimentary techniques. Standards, guidelines and recommendations for the sustainability of the secondary raw materials sector have been produced worldwide, such as the performance standards of the Aluminium Stewardship Initiative (ASI, 2014), the Step Initiative recommendations (Step, 2014) on e-waste management and the WEEE Forum set of standards (WEEELABEX).

2) Gaps, future actions and priorities to be considered

The availability and quality of knowledge on raw materials supplied to and within the EU must continue to evolve. Initial insights suggest that knowledge about the domestic and international supply of raw materials remains limited and fragmented. Key geo-referenced information is missing, and there are significant gaps and a lack of harmonisation in fundamental trade-flow data (particularly for critical raw materials) and in the information available on the environmental and social aspects of raw materials sourcing, e.g. child or forced labour associated with raw material imports to the EU. Significant data gaps limit the effectiveness of actions in the area of illegal trade in e-waste. For instance, a recurring issue is the mixing of WEEE with mixed metal scrap. Improved reporting will enable the production of more accurate country- and EU-level statistics, in particular, to estimate the actual amounts of illegal waste shipped annually from Europe to developing countries. Better guidelines and formal definitions are required to help authorities distinguish between used non-waste electronic and electrical equipment and WEEE.

The Mining Contribution Index needs to be improved substantially to incorporate factors that influence how effectively mining contributes to broader development. Such factors include, for instance, the creation of qualified skills and jobs, the fair distribution of revenues, and the development of manufacturing industries that use the minerals.

As highlighted by the EU's Strategic Dialogue on Sustainable Raw Materials for Europe (STRADE) project, in order to enhance its credibility as a long-term mineral trade and investment partner, the EU needs to position itself as Africa's development partner rather than seeing it as a source of raw materials. A first step may be to become an even more active partner in the AU's Africa Mining Vision and the African Minerals Development Centre endeavour.

Using technologies and services such as those developed through Copernicus, the EU's Earth observation programme, could enhance the sustainable development of Africa's raw materials sector (e.g. in terms of environmental protection, health risks related to mining waste and the monitoring of illegal mining activities, including in the context of conflict minerals, conflict prevention and early-warning).

Additional recommendations include: (1) increasing user awareness and involvement in the early stages of the e-waste chain; (2) mandatory treatment of WEEE in developing countries according to approved standards, and dedicated mandatory reporting of treatment and depollution activities.

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PHARMACY
SAMSUNG

15. Digital infrastructures

15.1. Telecommunications and the internet

1) Key findings

Assessment of the situation

Information and communications technologies (ICTs) are helping to change people's lives in unprecedented ways. Telecommunications and the internet have opened a new way for companies and people to work, socialise and do business. Their impact on accessing day-to-day services and commerce has led to personal convenience and business innovation. Digital connectivity, through the internet and mobile phones, allows for easy access to market information, health services and financial services, even in remote areas.

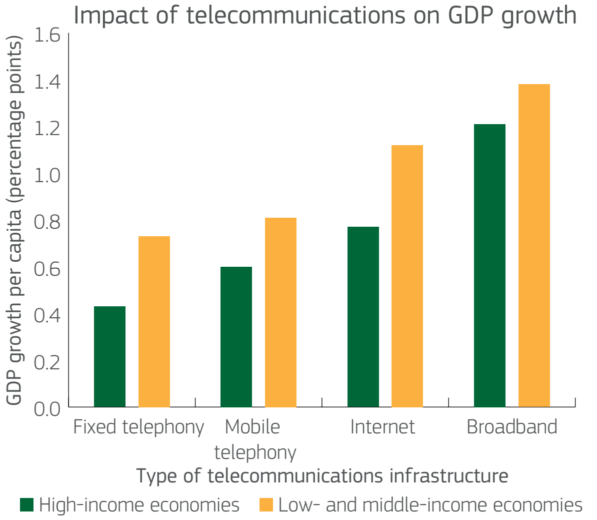
Africa, as the world's second largest continent, with a population of more than 1.2 billion people43, comprises 54 countries whose state of economic development, including in the field of ICT, ranges from developing to least developed. This is the continent with the highest potential for growth in terms of the economy, knowledge sharing and education. Telecommunications networks and broadband internet services are essential infrastructures for the overall societal development of African countries. To promote digital infrastructures as a key part of its overall development policy, the AU launched the internet domain 'dotAfrica' in March 2017 (African Union, 2017).

According to a World Bank study (World Bank, 2017; Qiang et al., 2009), which covered 120 developing and developed countries over the period 1980-2006, with every 10 % increase in high-speed connections44, GDP growth per capita increases by 1.3 percentage points (Figure 77). Mounting evidence points to the significant impact of broadband on the economy, although this impact is neither homogeneous nor automatic (Katz, 2012). This suggests that enabling e-commerce by investing in telecommunications networks would open up a path for rapid future development in Africa.

43 Worldometers: http://www.worldometers.info/world-population/africa-population/

44 A high-speed connection to the internet is also known as a broadband connection. This contrasts with the low-speed dial-up connection over a telephone line, used in the early days of the internet.

FIGURE 78: Impact of investment in telecommunications on GDP growth per capita *(Source: Qiang, 2009)*



In support of the United Nations (UN) 2030 Agenda for Sustainable Development (see policy context below), the International Telecommunications Union (ITU), the UN agency for ICT, has set out four Global ICT Strategic Goals and related targets for 2020, for telecommunications and internet access worldwide: growth, inclusiveness, sustainability and innovation45. Eleven ICT Development Indicators (IDIs) have been set out by the ITU to help measure progress towards these goals.

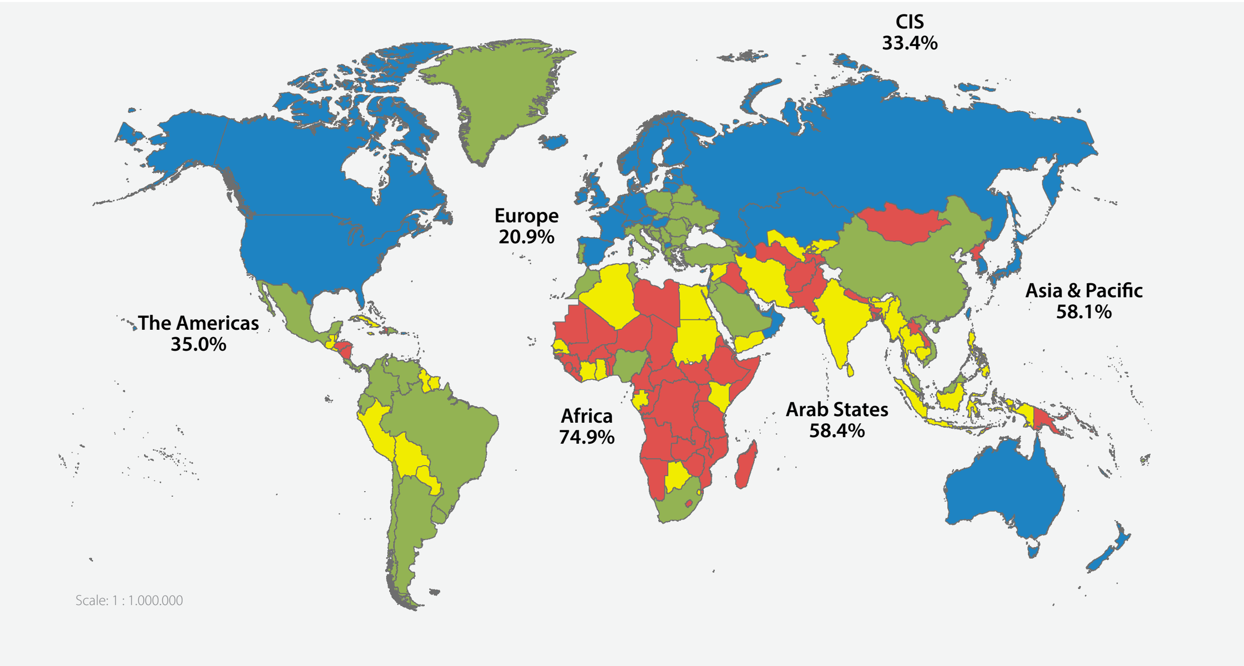
On the digital divide in the use of internet and mobile phones, the African continent follows the worldwide trends based on urban-rural, gender, age and socio-economic factors. However, internet penetration of the overall population remains amongst the lowest in the world (Figure 78).

According to the ITU, in 2017 18 % of households in Africa enjoyed the use of the internet, compared to a 2020 target of 15 % for least-developed countries (LDCs) and 50 % for developing countries. Globally, internet penetration rates in 2017 were 17.5 % in LDCs compared to 41.3 % in developing countries and 81 % in developed countries. For Africa, rising from 2 % in 2005, an average of 21.8 % of the overall population

45 http://www.itu.int/en/connect2020/PublishingImages/Pages/default/Connect-2020.pdf

used the internet in 2017, although this figure reached over 50 % in some countries. In terms of infrastructure, fixed broadband penetration in Africa was only 0.15 % of the population. This means that the mobile broadband infrastructure provides access to the internet for the vast majority of users. However, 3G mobile networks were still absent in most rural areas that also lack the infrastructure for fixed broadband services. Since only 22 % of the population in low-income countries worldwide currently has access to the mobile broadband service, it is likely that mobile infrastructure development could rapidly improve internet access in Africa.

FIGURE 79: Internet penetration in the world *(Source: ITU, 2016)*



Percentage of individuals
NOT using the Internet

- 0 - 25
- 26 - 50
- 51 - 75
- 76 - 100

By end 2016, 3.9 billion people - 53% of the world's population – is not using the Internet.

In the Americas and the CIS regions, about one third of the population is offline.

While almost 75% of people in Africa are non-users, only 21% of Europeans are offline.

In Asia and the Pacific and the Arab States, the percentage of the population that is not using the Internet is very similar: 58.1 and 58.4%, respectively.

TABLE 4: Growth in number of internet users in Africa (as % of population) (Source: ITU, 2017)

Internet users in Africa			
Year	2005	2010	2017
Internet users:	5 %	10 %	21.8 %

BOX 27

Connectivity in sub-Saharan Africa

In recent years, sub-Saharan Africa has been experiencing a rapid rise in telecommunications and mobile broadband, free public Wi-Fi initiatives, fibre-optical cable roll-outs and submarine communications cables. Connectivity is taking hold in Africa, albeit at differing degrees of urgency.

Outlook

The strong growth of internet use in African countries (see Table 4) is expected to continue, driven by rapid urbanisation and economic development. Although the rate of change is not uniform across all countries, it is still rising steadily. According to the World Bank Indicators, mobile cellular connections in sub-Saharan Africa rose steadily from 12 to 76 per 100 inhabitants from 2005 to 2015, while fixed broadband connections only rose from 0.1 to 0.375 per 100 inhabitants. In the same period, the fixed telephone connections actually dropped from 1.384 to 1.088 per 100 inhabitants. The trend clearly shows the key role of mobile telecommunications infrastructure in facilitating access to the internet in Africa.

> “Between 2005 and 2015, mobile phone connections in sub-Saharan Africa rose steadily from 12 to 76 per 100 inhabitants, while the number of fixed lines fell.”

Africa is known as a ‘mobile first’ continent where mobile operators are the main driving force in providing access to the internet. However, the potential role of complementary approaches is also evident. Global technology giants such as Google, Microsoft and Facebook are actively engaged in projects in Africa to enhance infrastructure for rural wireless broadband through innovative spectrum-sharing technologies, such as TV White Spaces (unused broadcasting frequencies in the wireless spectrum between TV channels, which can be used for 4G communications), as well as in skills development for several million Africans. Such approaches will make it easier for new and innovative ICT service providers to enter the market.

With such a promising trend, timely, proactive policies could help achieve the SDGs and the ITU’s ICT goals (see policy framework below).

Challenges and opportunities

Opportunities for rapid economic growth enabled by digital infrastructures are well documented. Research by the World Bank covering 20 000 firms from 26 sectors in 56 developing countries shows that businesses that intensively use ICT (phone, PC and email) are more productive, grow faster, invest more and are more profitable. This study includes many small and medium-sized enterprises (SMEs) (World Bank, 2004). However, several challenges remain.

> “Spectrum sharing in the TV White Space has huge potential for broadband connectivity in rural and remote areas.”

ITU findings in 2016 showed that internet value and quality of service was lowest in the LDCs (ITU, 2016).

One practical challenge is to have high-speed internet at affordable prices in most African countries. Connectivity gaps at international, regional, national and rural levels make it difficult to reap the full benefits of a highly functional and effective ICT sector.

Another major constraint to the adoption of ICTs by small businesses is the lack of an ICT-trained work force.

A flexible and growth-oriented regulatory framework for telecommunications, e-commerce, internet services and spectrum management needs to be put in place to ensure that Africa can enjoy the benefits of advances in ICTs by creating the right conditions for rapid development in the ICT infrastructure.

Innovative wireless communications technologies, along with regulatory policies for efficient use of the radio spectrum, are complementary means that can help reach broadband-for-all objectives.

Policy framework

At the international level, the ICT policy framework is set out quite clearly in the SDGs and the derived ICT goals set by the ITU. The SDGs include the following goals:

- 5.b Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women;
- 9.c Significantly increase access to information and communications technology and strive to provide universal and affordable access to the internet in least developed countries by 2020;
- and 17.8 Fully operationalise the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology.

In support of the UN 2030 Agenda, the ITU (the UN agency for ICT) set four Global ICT Strategic Goals for 2030 and related targets for 2020, for telecommunications and internet access worldwide: growth, inclusiveness, sustainability and innovation.

In recent years, the AU itself has adopted several major initiatives under the Reference Framework for the Harmonisation of Telecoms and ICT Policies and Regulations in Africa. Among others, these include: the Programme for Infrastructure Development in Africa (PIDA); the ICT Broadband Infrastructure Programme of the New Partnership for Africa's Development (NEPAD); the Harmonization of ICT Policy in Sub-Saharan Africa (HIPSSA); Cyber-security; the Digital Dividend from the Analogue Switch Off for TV Broadcasting; the Pan-African e-Network for Tele-medicine and Tele-education project; as well as e-Post and e-School initiatives. These AU initiatives could be juxtaposed, in the EU policy context, with the Radio Spectrum Policy Programme and the Broadband Europe Policy.

Internet access is unavailable in many African schools ©EU, by Paolo Ronco

Having reached the first goal for universal broadband connectivity in the EU of achieving a download speed of 2 Mbps by 2010, a further goal was set for faster internet access while addressing the risk of digital divide. The Europe 2020 goal is to achieve a download speed of 30 Mbps for all EU citizens, and 100 Mbps for at least 50 % of European households subscribing to internet connections, by 2020. Under the Africa-EU Partnership, a phased approach to improving internet coverage would be best in terms of economic and technical feasibility. However, the means of achieving universal internet connectivity in Africa could be mainly through wireless and mobile broadband rather than fixed connections, since mobile networks are the most predominant infrastructure for communications and connectivity in Africa. The upgrade and further development of mobile networks would provide a rapid evolutionary path.

2) Gaps, future actions and priorities to be considered

The main information needed to improve infrastructure for internet and broadband access is on how the quality of user experience compares with the quality of service planned by the network providers. The quality of the user experience in a network depends on the overall traffic pattern, which varies over time and location. These key statistics must be captured on a continuous and sustained basis. Determining the range of these variations requires a large user base of a crowdsourcing app such as netBravo, as well as collaboration with network service providers to determine future trends in growth of traffic and eventual strategies for investment in the infrastructure.

Test beds and pilot studies to achieve the efficient use of the radio spectrum for mobile broadband and next-generation 5G communications should continue to be developed. Indoor and outdoor experiments and technical studies on wireless technologies, according to the needs of the EU Telecommunications and Electronic Communications Framework, related standardisation activities by the European Telecommunications Standards Institute (ETSI), and implementation of the 5G Action Plan by Member States could be extended to AU countries in the context of AU-EU cooperation.

The deployment of NetBravo in the AU is already planned, in collaboration with the European Commission's DG DEVCO. Pilot projects can also be planned on alternative techniques for introducing broadband access into rural and remote areas and enhancing broadband in high-density urban areas, to benefit from modern spectrum-sharing approaches.

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15.2. Digital services and online security

1) Key findings

Assessment of the situation

Africa is home to just over 1.2 billion people, and with a median age of 19.5 years, has the youngest population in the world (Worldometers). In 2012, there were already over 650 million mobile phone subscriptions, and more than 60 % of the population currently has access to ICT infrastructure. This, along with rapid economic growth and the large diffusion of mobile devices and networks (the key enablers of the African ICT revolution), leads experts to predict that the e-commerce and online services industries will expand to an estimated US$ 75 billion (EUR 62.3 billion at 2017 exchange rates) by the year 2025 (Manyika et al., 2013), promising to be one of the fastest and strongest boosts for the African economy.

> “There were over 650 million mobile phone subscriptions in Africa in 2012, and more than 60% of the population currently has access to ICT infrastructure.”

According to the United Nations Conference on Trade and Development (UNCTAD, 2015), Africa is ahead in terms of money transfers using mobile phones, with 14 % of all Africans receiving money through mobile transfers. However, this also makes mobile devices one of the preferred targets of cybercrime. For example, in South Africa alone, 67 % of adults reported experiencing cybercrime in 2016, which is estimated to have cost the South African economy US$ 242 million, with an average cost per cybercrime of US$ 274 (Symantec, 2016).

The explosion of mobile and globally interconnected new technologies has altered the cybersecurity landscape and highlighted the need to develop a cybersecurity culture and skills among internet users of all ages, races and social and economic status. While cybersecurity needs to be ensured in terms of technology, the societal viewpoints should also be taken into consideration. The human factor in cybersecurity is considered to be the weakest link in the whole security process. The big players in the ICT sector are fully aware of this; for example, between 2016 and 2017, Google provided digital skills training to 1 million Africans, and has committed to train even more in the coming year.

FIGURE 80: Mobile networks are key enablers of digital services

Outlook

Digital services have great potential for Africa. In a continent where distances are enormous and where it is not always possible to physically reach government offices easily, digitisation offers a real possibility to greatly improve citizens' access to e-Government services. The lack of previously existing infrastructure will help speed up the diffusion of these services as well as the Internet of Things (IoT) and the smart world paradigm, as this diffusion is free of the constraints of ‘interoperability with the past’. For instance, smart meters, which record electricity consumption, are already being installed in South Africa.

Mobile phones are widely used throughout Africa ©EU, by Andreas Brink

Challenges and opportunities

A joint study of the World Bank and the African Development Bank (2012), in collaboration with the AU, clearly pointed out "how issues of cybersecurity and data protection will also come to the fore, as security and trust become increasingly important".

On the other hand, in a study conducted together with the Global Forum on Cyber Expertise initiative (AUC-Symantec, 2016), the AU notes that, in 2016, the majority of African countries did not foresee any specific criminal law provisions on cybercrime and electronic evidence.

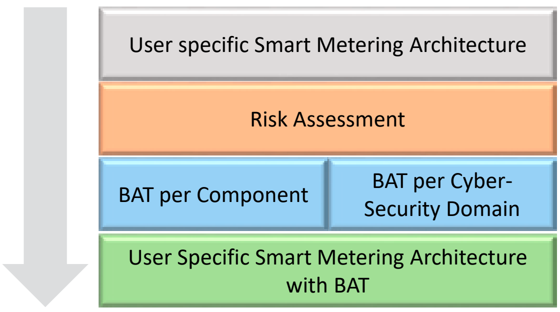
From this perspective, it is evident that action must be taken to shape and enforce the principles of cybersecurity in digital African infrastructures.

However, cybersecurity has the peculiarity of being a transversal and multifaceted challenge, which involves several aspects of societal development: sectoral standards and best practices are needed to enforce the integration of digital domains and cyber-physical systems; interoperability principles are required to ensure a homogeneous level of cybersecurity among sectoral infrastructures; electronic identities need to be established to enforce trust in the digital services and among the actors involved in digital transactions; secure and innovative digital paradigms are needed to securely deploy e-Government services; and education strategies must be put in place to ensure that the weakest link of the digital infrastructure (i.e. the end-user) is aware of the cyber risks to which he or she might be exposed and of the proper behaviour to adopt to safely enjoy the benefits of cyberspace.

2) Gaps, future actions and priorities to be considered

In light of the above, some areas of strategic intervention/ collaboration are listed below.

FIGURE 81:THE best available techniques (BATs) process applied to smart-metering systems, per component and cybersecurity (CS) domain *(Source: Smart Grid Task Force, 2016)*



Enhancing the level of cybersecurity in a country or continent requires a well-developed and precise strategy. Key principles and strategic elements should be identified, policy actions and technical steps planned and information shared.

Implementation of the European cybersecurity strategy along with the definition of sectoral cybersecurity strategies (e.g. in the energy sector) are under way. This accumulated experience could be shared with African countries to inform the design of their national cybersecurity strategies.

The fight against cybercrime is a key element in ensuring the security of the digital society and enhancing citizens' trust in digital services. As with cybersecurity, the experience gained in supporting the cyber activities of Europol and its European Cybercrime Centre could be used to help build the capacities for cybercrime investigation in African countries.

The 'Sevilla Process for the identification of best available techniques' in cybersecurity and privacy provides one framework for such collaboration. It can be applied to expertise in electronic identity and public key infrastructures in well-defined sectoral domains, including the energy sector, the IoT, mobile devices, digital identities and the transport sector.

Technology transfer and capacity-building in digital identities and emerging technologies such as distributed ledgers could also support African countries in designing new innovative and interoperable e-Government services.

An example of such an exchange of know-how is the use of distributed ledgers to fight energy poverty, which is defined as a lack of access to modern energy services. According to the World Economic Forum's Energy Poverty Action initiative: "Access to energy is fundamental to improving quality of life and is a key imperative for economic development". Distributed ledger technologies combined with low-cost photovoltaic energy generators could be used to create flexible and completely autonomous neighbourhood energy grids. Such grids help minimise the waste from solar energy production by stimulating the creation of small energy market 'islands' that support the exchange of energy among neighbours. Originally conceived to boost the European "prosumer" energy market, such experience could be translated into a pilot study to tackle energy poverty in developing African countries.

Expertise in raising awareness and enhancing digital skills would be beneficial for African countries in the setting up of media literacy programmes and cybersecurity-awareness campaigns.

Virtual social networks are also expected to play a growing role in entrepreneurship. For example, the Adansonia Program is dedicated to training entrepreneurs in Africa and connecting them with investors (http://www.adansonia.net). The United Kingdom's Private Enterprise Development in Low-Income Countries (PEDL) initiative of the Centre for Economic Policy Research (CEPR) and the Department for International Development (DfID) is also sponsoring research in this domain. It offers a competitive research grants scheme for projects related to company behaviour in low-income countries, which aims to better understand what determines the strength of market forces driving efficiency. Results of pilot programmes suggest that virtual links do generate business projects and stimulate entrepreneurship. Further research is extending this analysis to the pan-African level.

FIGURE 82: The JRC Helios Energy Accounting System based on distributed ledger technologies for autonomous neighbourhood energy grids *(Source: JRC)*

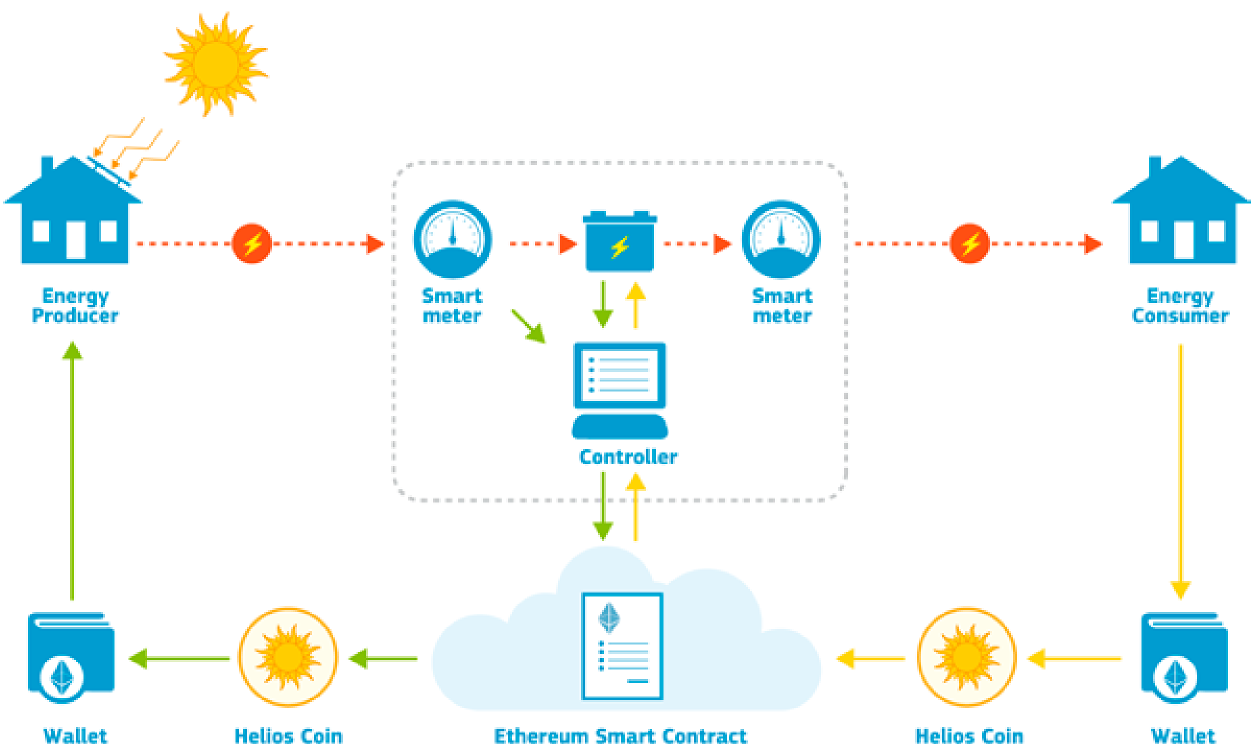


FIGURE 83: Illustration of the Happy Onlife paper-based toolkit, a set of resources that promotes the safe and responsible use of ICT among adults and children

:-/ :-)

HAPPY ONLIFE

The toolkit

Happy Onlife promotes positive engagement, mediation, dialogue enhancing digital competences especially in **privacy**, **online safety**, **netiquette** and **digital identity management**.

The digital toolkit is available as open-source under EUPL licence (European Union Public Licence).

JOIN US!

The Happy Onlife open-source community!

https://github.com/happyonlife/hol

The Happy Onlife toolkit is a paper '**toolbox**' with a number of resources:

- a game with 40 challenge cards, 10 cards 'Stop Online bullying!', 10 cards 'Let's Chat', 10 cards 'Watch-Out! ' and 10 cards 'Play Safely';
- four 'Powercards' summarising the golden rules for a responsible and safe use of Internet;
- a set of 17 extra activity cards collecting ideas for home or school projects. These are also referenced in the project booklet promoting digital competences and shared experiences of the digital world among teachers, parents and children between 8-12 years old;
- Stickers and emoticons commonly used in the digi- tal world.

The toolkit also includes a digital version of the Happy Onlife game and complementary resources.
It is available on **mobile** platforms (**iOS**, **Android** and **Windows Phone**) and on desktop computer or smartboard through the web.

Schools can either request a free copy of the box in English and Italian (limited to available stock) at this e-mail address:

jrc-happyonlife@ec.europa.eu

or download, print and cut out a Do-It-Yourself copy in English and Italian at:

http://europa.eu/!pD47hy

Link to the web application, reports and papers:

https://web.jrc.ec.europa.eu/happyonlife

BOX 28

Digital tachograph in North African countries

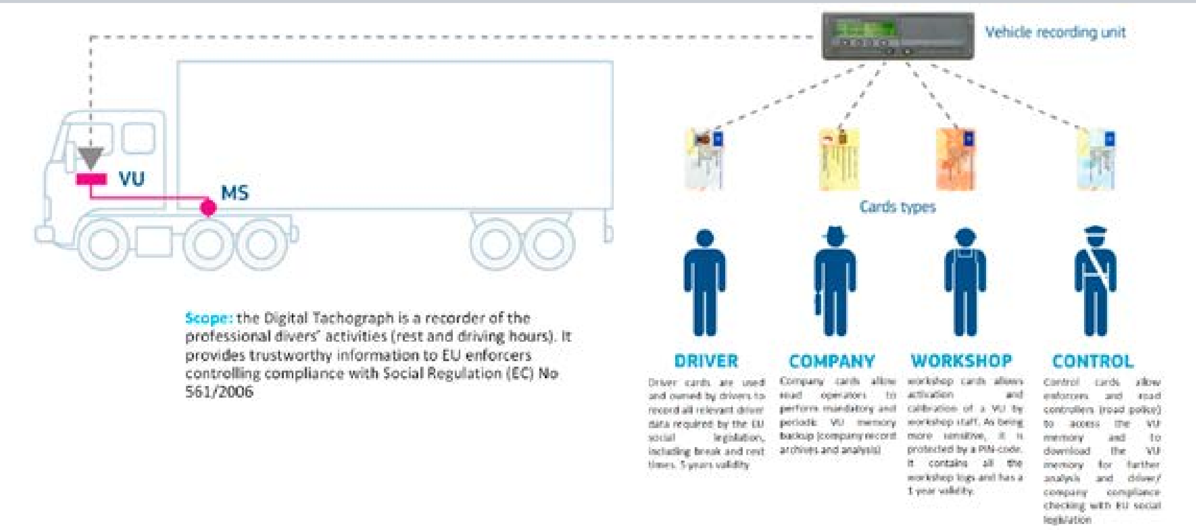
The digital tachograph is a trusted and secure piece of mandatory recording equipment deployed in more than 50 countries across Europe and into Central Asia46. It provides law enforcers with reliable and indisputable data about the driving times and rest periods for heavy-vehicle drivers. It was introduced in 2006 in EU territory with the aim of improving road safety, professional drivers' working conditions and fair competition among road transport companies. Since its introduction, more than 6 million European trucks and buses have been equipped with a digital tachograph. In 2011, the instrument was further deployed in the territory of those additional countries adhering to the United Nations Economic Commission for Europe (UNECE) European Agreement concerning the work of Crews of vehicles engaged in international road transport (AETR).

the only viable solution identified was to invite North African countries to join the AETR.

An important step in that direction was reached in July 2016 with the UNECE decision to open AETR to three non-UNECE African countries, namely Algeria, Morocco and Tunisia. These three countries, together with Jordan, are now finalising the steps required to adhere to the AETR agreement.

The digital tachograph is a clear example of cyber-physical infrastructure whereby digital techniques are used to enhance the level of monitoring and control of physical devices (trucks) and where the use of digital infrastructures (e.g. the European Root Certification Authority) is used to digitally enforce truck driver licences.

FIGURE 84: The digital tachograph consists of the vehicle unit (VU), motion sensor (MS) and smart cards (*Source: JRC*)



North African countries such as Morocco, Algeria and Tunisia have transport business and road exchanges with the EU, and most of the goods from this area enter Europe on trucks crossing the Mediterranean Sea, via Spain and Italy. The introduction of digital tachographs in Europe created an issue for these activities, since African-plated trucks cannot circulate in Europe (as they are not equipped with digital tachographs) and African drivers cannot drive European trucks (as these drivers are not entitled to receive tachograph driver cards).

This situation was recognised in 2012 in a workshop co-organised by the European Commission, the UNECE and the European-Mediterranean (EUROMED) project, where

The JRC has been involved in the design and implementation of the digital tachograph since 2004, and is responsible for two essential services:

- the European Root Certification Authority (ERCA), which oversees the digital security of tachographs and generates the electronic certificates, ensuring the integrity and authenticity of the recorded data, and which monitors the enrolment of participating countries by reviewing and approving their national security policies for correct implementation of the tachograph-secured infrastructure (the full infrastructure includes elements such as digital tachographs, e-ID documents and tachograph cards;

46 Digital tachograph nation codes: https://dtc.jrc.ec.europa.eu/dtc_nation_codes.php

- and the Laboratory for Interoperability Certification, which is responsible for issuing the final certificate needed for type-approval and entry of new tachograph equipment on to the market.

When the digital tachograph was extended to non-EU AETR countries, support was provided to many of these new countries to prepare and finalise their national security policies. Similarly, advice is provided to various experts working for Algeria, Morocco and Tunisia in the context of the EUROMED road, rail and urban transport project on how best to prepare for the deployment of the digital tachograph in their national territories. The JRC is also committed to directly supporting these countries in the preparation and submission of their respective national security policies for review and approval.

JRC expertise as a Root Certification Authority could be beneficial for African countries for the establishment of similar infrastructures for ID cards, residence permits, and other services where key public infrastructures are required to enforce the integrity and confidentiality of documents and data flows.

BOX 29

Critical raw materials, trade in minerals and related technologies

Electronic identities are the cornerstone of every digital infrastructure as they are the primary means for establishing trust among parties involved in online transactions. Although, strictly speaking, electronic passports cannot be considered as electronic identities (as they are legislatively considered to be 'travel documents'), they can be considered as elements that help establish the holder's identity in a standardised and interoperable way.

> "The AU launched the pan-African passport in July 2016."

In July 2016, the AU launched the pan-African passport. This initiative is meant to boost the free movement of people which, in turn, can help create new jobs and stimulate economic activity. The intention is that the passport will be distributed to all African citizens by 2018.

During the 10 years it took to introduce the biometric passport, as we know it today, throughout the EU, the JRC played an important role in assessing the conformity of biometric passports issued by the EU Member States and in supporting the technical activities associated with interoperability testing. A number of interoperability test events were organised, and work was carried out to identify issues that could render verification of a document issued by one country difficult in another, thereby helping to facilitate hassle-free border crossing.

Thanks to its expertise in electronic travel documents and, more specifically, in the security measures implemented to protect access to the data contained in the electronic chip (particularly the passport holder's biometrics), the JRC was asked to contribute to the design and to operate the security infrastructure of the EU laissez-passer, the European institutions' electronic travel document.

European institutions' laissez-passer © EU

Given the challenging objective of the African Passport Initiative, some areas of strategic synergies have been identified:

- mutual exchange of best practices in the management of a key public infrastructure-based security, and support in the field of travel document security;
- conformity testing and security assessment of the currently issued pan-African biometric passport. The AU could be invited to participate in an interoperability test event organised by the JRC;
- mutual exchange of best practices and lessons learned in the collection and management of biometric identifiers such as fingerprints, faces, irises, etc.;
- and support in the design of national electronic identities, making use of the experience developed at the European level with the electronic identification authentication and signature (eIDAS) legislative package.

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PEACE

"OUR ASPIRATIONS
FOR THE AFRICA
WE WANT:
WE RECOGNIZE THAT A
PROSPEROUS, INTEGRATED
AND UNITED AFRICA, BASED ON
GOOD GOVERNANCE, DEMOCRACY,
SOCIAL INCLUSION AND RESPECT
FOR HUMAN RIGHTS, JUSTICE
AND THE RULE OF LAW ARE
THE NECESSARY PRE-CONDITIONS
FOR A PEACEFUL AND
CONFLICT-FREE CONTINENT"

– Agenda 2063

16. Conflict prevention and early-warning

1) Key findings

Assessment of the situation

Africa is a continent at relatively high risk of conflict. According to the Global Conflict Risk Index (GCRI), 50 % of the countries identified as being at very high risk worldwide are in Africa, specifically in the northern, eastern, central and Sahel regions. The Peace Research Institute Oslo (PRIO) reports that, although battle deaths are decreasing overall in the African continent, armed conflicts are not following the same trend (compare trends in Figures 84 and 85). The African Peace and Security Architecture (APSA) provides a continental framework within which the AUC, Regional Economic Communities and Regional Mechanisms help prevent, manage and resolve conflicts in Africa.

FIGURE 85: Battle deaths in Africa 1975-2008 *(Source: PRIO, based on Gleditsch et al., 2002)*

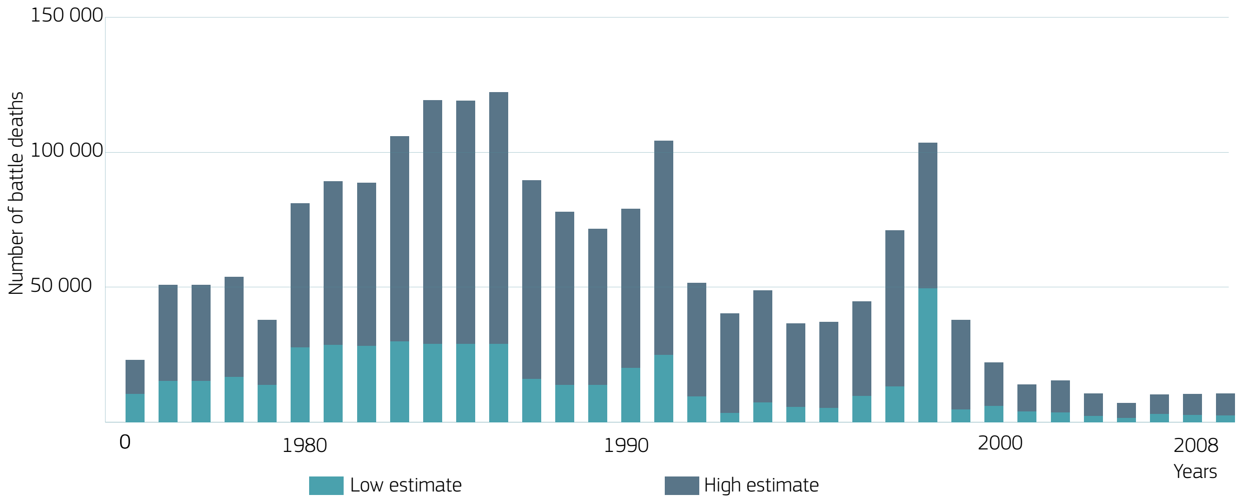
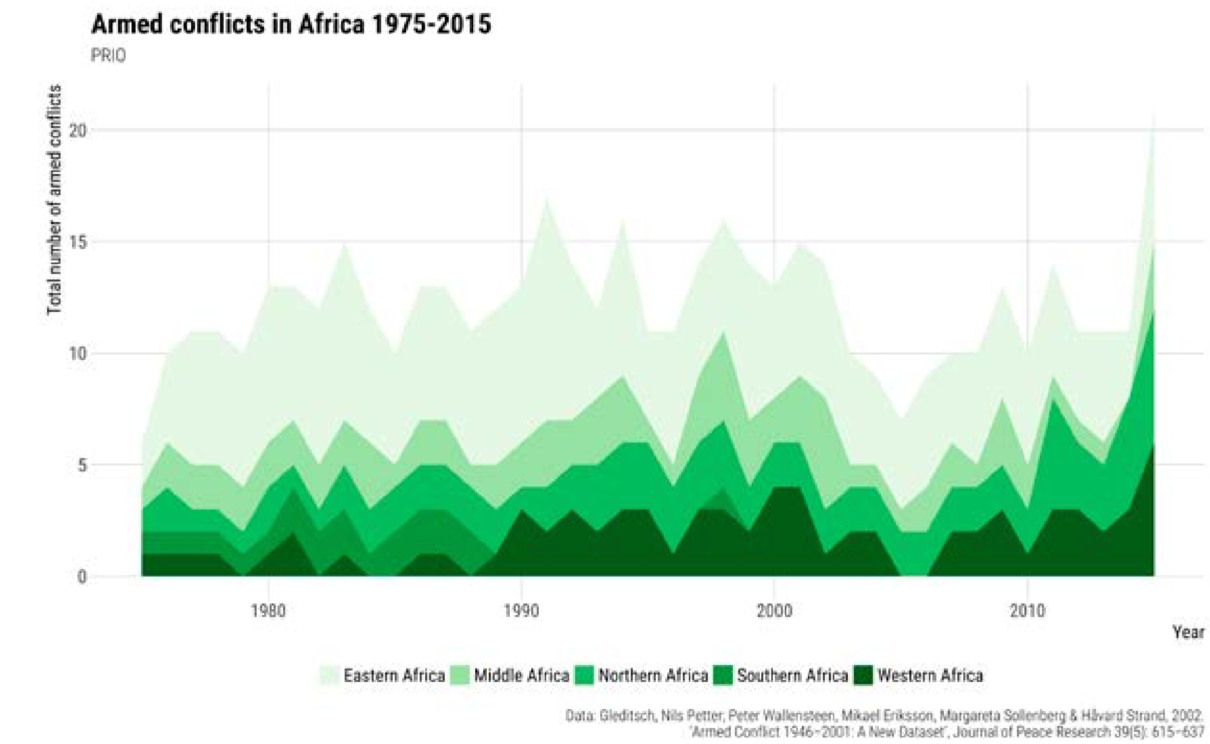


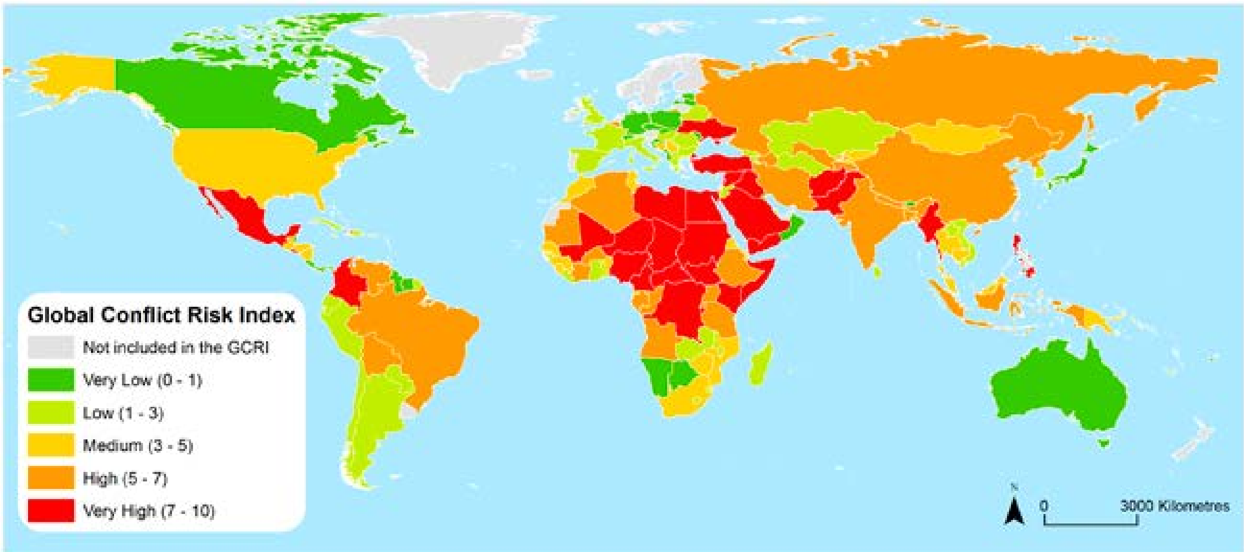
FIGURE 86: Armed conflicts in Africa 1975-2015 *(Source: UCDP/PRIO, based on Lacina et al., 2005, using UNSTAT's definition of regions in Africa)*



The GCRI is an early-warning system that helps identify countries at risk of violent conflict, including national and sub-national conflicts. Developed by the JRC in consultation with the Conflict prevention, Peace building and Mediation Instruments Division of the European External Action Service (EEAS), the index provides policymakers with a global risk assessment based on socio-economic, political and environmental factors. It gives a grading of the statistical risk of violent conflict in the next one to four years, ranging from 0 (no risk) to 10 (very high risk). Based on the assumption that a country's structural conditions are linked to the occurrence of violent conflict, the index collects 24 variables under five different 'risk areas' (political, social cohesion and public security, conflict prevalence, geography and environmental, and economy), and uses statistical regression models to calculate the probability and intensity of violent conflicts.

While the global average value of the GCRI is around 3 (medium risk), it reaches 5 (high risk) on the African continent. Only seven of the 54 African countries are considered to be at low or very low risk, mainly in the southern part of the continent. Figure 86 indicates the conflict risk by country.

FIGURE 87: Global Conflict Risk Index, 2016 *(Source: GCRI)*

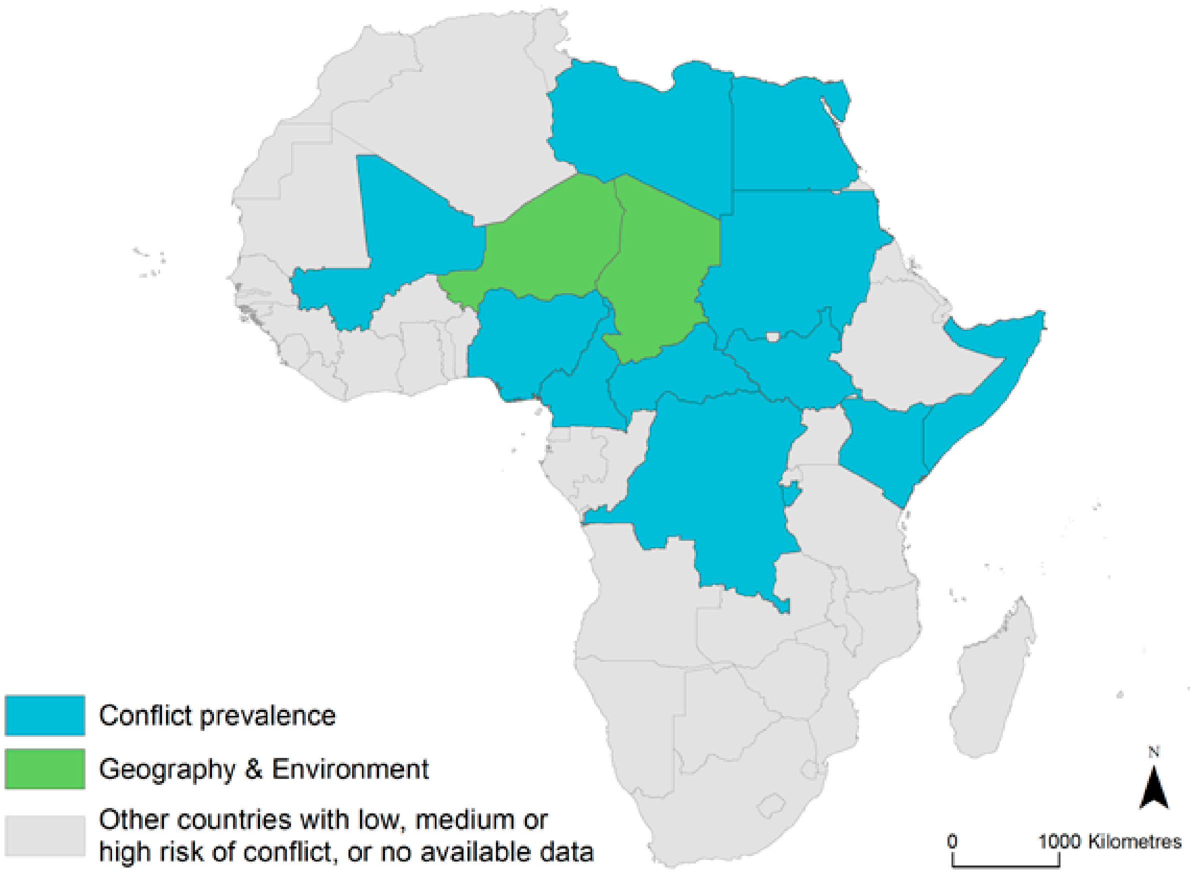


Outlook

What increases the risk of conflict in Africa?

All dimensions of the GCRI contribute to the high index values in the African continent, but the existence of a violent history and environmental factors (such as water stress or hydrocarbon resources) appear to have the greatest impact. Countries in the western, Sahel and south-eastern regions which face demographic pressures, structural constraints, and natural resource challenges have a medium (3-5) index value of risk. Several African countries (e.g. the Republic of the Congo, the DRC, Sudan, and Kenya) have a higher risk, due to recent intra-state or highly violent national conflicts, or the risk of conflict expanding from bordering countries. While the history of conflict is a determining risk factor in most of the African territory, demographic and environmental challenges are also key (see Figures 87 and 88).

FIGURE 88: Main determinants of risk in countries classified as being at very high risk of conflict, 2016 *(Source: GCRI)*



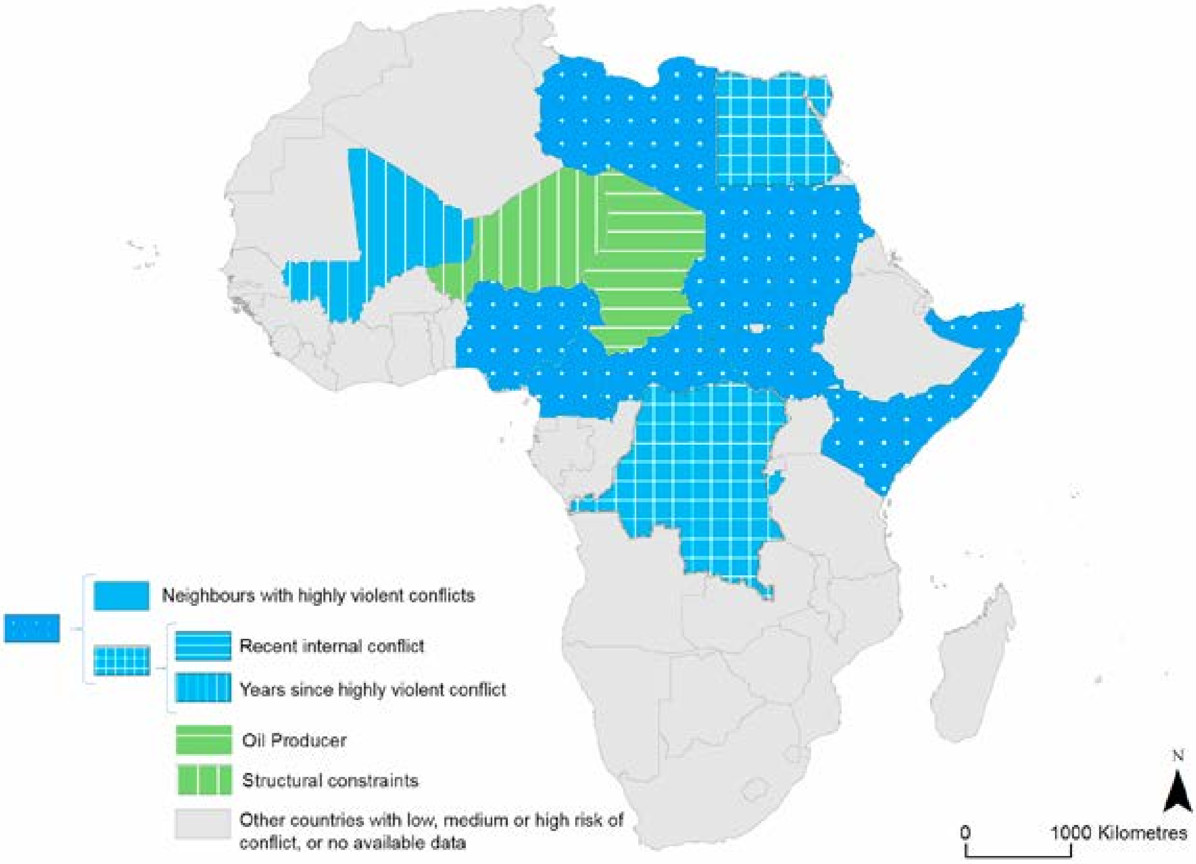
Which geographic challenges increase the risk of conflict, according to the GCRI?

Environmental and demographic constraints trigger geographic challenges which can increase the probability of the occurrence of a conflict event. Oil production and structural constraints, such as the state of political and economic transformation and political leadership towards democracy and a market economy, appear to be the predominant drivers in African countries at very high risk of conflict. In contrast, in countries at moderately high risk, the prevalence of youth in the population (which appears as a 'youth bulge' in the population curve) seem to have the greatest effect.

Which GCRI security challenges can increase the risk of continued or recurring conflict?

The security situation is worrying in many African countries. While some countries have experienced conflicts in recent years (e.g. Mali in 2012), others are still considered to be in a state of war (e.g. Libya and Sudan), and the situation remains generally unstable in extensive African regions. Among the countries at very high conflict risk due mainly to security challenges, neighbouring countries also face poor security conditions. For example, the Central African Republic scores high on all GCRI indicators, leading to the conclusion that the country is in a highly unstable situation and the probability of a conflict is extremely high, if not already taking place. In other countries (e.g. Mali), the history of conflict is a driver of the risk of conflict, for instance due to the presence of weapons in the country and the fighting experience acquired.

FIGURE 89: Factors that most influence the prevalence of conflict or geographic constraints in countries classified as being at very high risk of conflict, 2016 *(Source: GCRI)*

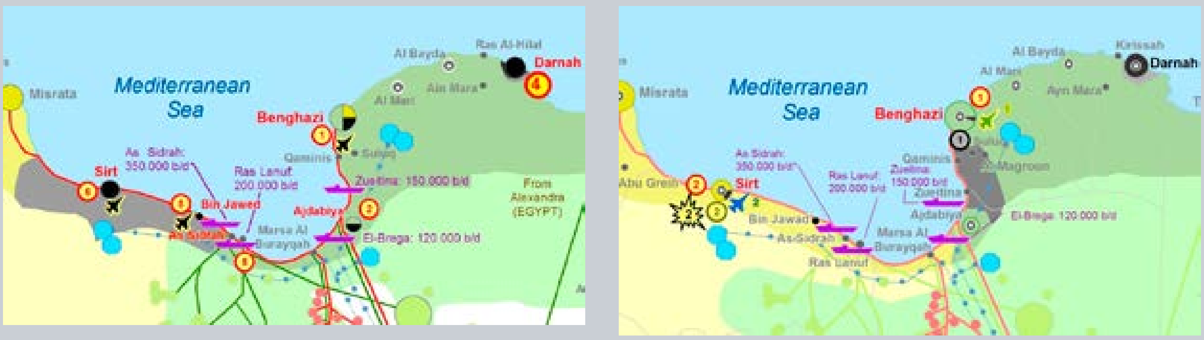


BOX 30

Monitoring the security situation in Libya

The JRC supports the EEAS in its diplomatic mission by regularly monitoring the security situation in Libya. The maps in Figure 90 show the coastal areas in Libya in January and September 2016. Territorial control is represented in different colours. Important or critical infrastructures are also mapped, as are migration and transport routes. Open-source news monitoring is combined with geospatial information to identify critical areas of violent events.

FIGURE 90: Areas of territorial control by different groups (represented in different colours), infrastructure (ports and airports and numbered sites) migration and transport routes (dotted lines) around Sirte and Benghazi in January and September 2016 (*Source: ESRI, JRC, RiskIntelligence, newsnow.co.uk, and EU Delegation Libya*)



BOX 31

The Kimberley Process

The Kimberley Process is a joint government, industry and civil society initiative that aims to stem the flow of conflict diamonds (rough diamonds used by rebel movements to finance wars against legitimate governments). It aspires to be a conflict-prevention mechanism. The diamond trade has played a significant role in financing several civil wars in Africa, such as in Sierra Leone, Liberia and the Central African Republic. Therefore, the monitoring of diamond mining and trade is key to the peace process in Africa.

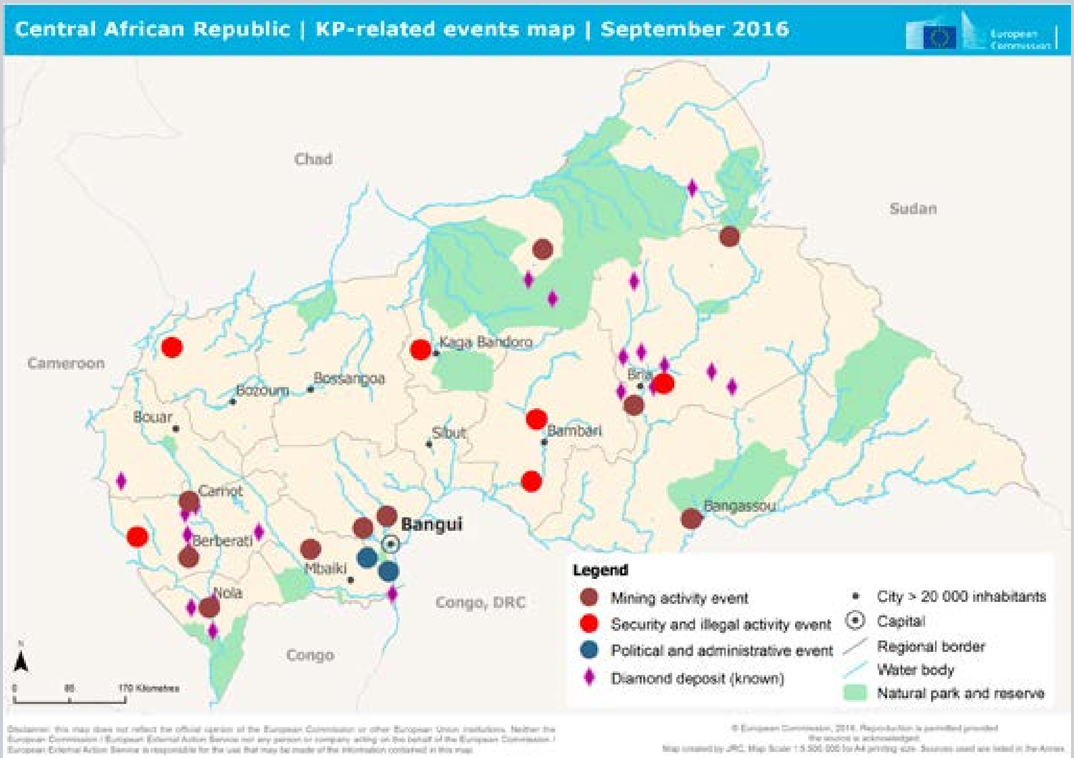
> “Thanks to the Kimberley Process, the conflict diamond trade fell from 15 % of the global diamond trade in the 1990s to less than 1 % by the mid-2000s.”

Implementation of the Kimberley Process Certification Scheme has enabled those African countries which trade in diamonds to strengthen their internal administrative and legislative frameworks, build up and enhance their internal diamond control systems, develop relevant infrastructures and build sustainable resource governance. Review missions conducted periodically by members of the process (for instance in Côte d'Ivoire in 2013 and in the Central African Republic in 2015) help assess local capacity and propose recommendations for capacity-building. The success of this mechanism can be seen in the decline in the conflict diamond trade, which fell from 15 % of the global diamond trade in the 1990s (mostly from conflict zones in Africa) to less than 1 % 15 years later (World Diamond Council, 2007).

The JRC supports the implementation of Council Regulation (EC) No 2368/2002 of 20 December 2002 and provides monitoring support. It monitors cases with a high propensity for involvement in the conflict diamond trade, using geospatial data, statistical data and open-source information. It regularly creates maps of events related to diamond mining and security, which aim to improve the understanding of the local mining situation (Figure 91). Upon request, the JRC also analyses satellite images in order to detect changes in the mining activity in specific areas.

This map does not reflect the official opinion of the European Commission or other EU institutions. Neither the European Commission/EEAS nor any person or company acting on the behalf of the European Commission/EEAS is responsible for the use that may be made of the information presented in this map.

FIGURE 76: Mapping Africa’s mineral wealth: selected countries and commodities
(*Source: Africa Progress Panel, 2013 Equity in Extractives. Stewarding Africa’s natural resources for all*)



Challenges and opportunities

In recent years, initiatives such as the Armed Conflicts and Natural Resources project (Kucera et al., 2011) have analysed the links between natural resources and conflicts (in this project the scope was the African Great Lakes, the Horn of Africa, Central Asia and Western Africa). Environmental challenges, such as climate change, extreme weather events, water scarcity and desertification, are expected to increase the need for geographically explicit indicators for measuring conflict risk.

> “Crowdsourcing and 'big data' present opportunities for further developing conflict-measurement methodologies.”

Crowdsourcing and greater use of 'big data' present opportunities for collecting such data and further developing conflict-measurement methodologies. Satellite imagery, open-source news and statistical data also have a key role to play. The Copernicus programme, with its free data and services, provides on opportunity for further cooperation.

Datasets that include information on regional violent events, such as the Armed Conflict Location & Event Data Project[47], can also help improve conflict modelling. Efforts to build up such datasets, albeit of limited geographical scope, should be supported.

Policy framework

One objective of EU external policies, as explicitly stated for the first time in the Lisbon Treaty (2009), is “to preserve peace, prevent conflicts and strengthen international security […]” (Article 21(c), TEU). This is an overarching objective to be pursued by all EU external policies, instruments and tools, while respecting their respective primary/specific objectives. In the 'Agenda for Change' Communication (European Commission, 2011), the Commission reaffirmed that EU objectives in the field of development policy, peace-building, conflict prevention and international security are mutually

BOX 32

Continental Early Warning System – support to the African Peace and Security Architecture

The African Peace and Security Architecture (APSA) provides a continental framework within which the AUC, Regional Economic Communities and Regional Mechanisms help prevent, manage and resolve conflicts in Africa. The innovative Continental Early Warning System (CEWS) has been established in the AU headquarters in Addis Ababa in order to operationalise the APSA. The initial phases of the system were funded by the FPI but is now supported by the African Peace Facility. Since 2008, the JRC has worked in close collaboration with the AU to build the technical capacity and know-how necessary for establishing the CEWS. This collaboration has resulted in the installation of numerous tools for the automatic detection and classification of socio-political events, the production of a newsletter, and reporting activities. In 2017, a Conflict Alerting and Analysis System has been developed, which brings together all the CEWS products and provides an analysis and reporting platform. Numerous training sessions have been organised over the years. Further sessions are jointly planned by EU and AU partners (including the JRC and the AU Peace and Security Department) to help build the capacity to maintain and run the CEWS.

A Ugandan park ranger protecting wildlife and people close to the border of the DRC ©EU, by Andreas Brink

47 https://www.acleddata.com/

reinforcing. In their joint Communication on 'The EU's Comprehensive Approach to External Conflicts and Crises' (European Commission, 2013), the Commission and the High Representative for the Common Foreign and Security Policy (CFSP) advocated addressing conflicts and crises 'comprehensively', using EU external policies and their related instruments in a consistent manner, while respecting their specific objectives and decision-making procedures.

The European Commission's Service for Foreign Policy Instruments (FPI), which works alongside the EEAS, runs a number of EU foreign policy actions. The FPI is responsible for the execution of operations with respect to the CFSP and the Instrument contributing to Stability and Peace (IcSP). The IcSP priority areas include: i) the promotion of early-warning and conflict-sensitive risk analysis in policymaking and implementation; and ii) the provision of assistance to curb the use of natural resources to finance conflicts and to support compliance by stakeholders, with initiatives such as the Kimberley Process Certification Scheme, especially as regards implementing efficient domestic controls.

2) Gaps, future actions and priorities to be considered

The EU will chair the Kimberley Process in 2018, which will provide an opportunity for European leaders to align it with the AU-EU cooperation agenda.

The importance of early warning in conflict prevention cannot be overstated. While working on an evolving crisis, policymakers may not notice warning signs of an upcoming or nascent security situation. Quantitative risk modelling can help anticipate emerging threats to peace and security.

Mapping crises and security situations has proven very valuable for strengthening the information basis and supporting political dialogue and decision-making, especially for addressing specific threats/situations. Initiatives such as the Global Crisis Atlas will ensure that such mapping work continues.

Quantitative risk modelling could be developed in several directions to improve its performance as an early-warning tool. Research into the interdependencies of conflict factors and events at an international scale could reveal relevant indicators that are not currently included in modelling exercises. Statistical conflict modelling is required to better understand the link between the location of natural resources and the occurrence of armed conflicts. The role of rapid urbanisation, climate change, and conflict resilience should be explored further.

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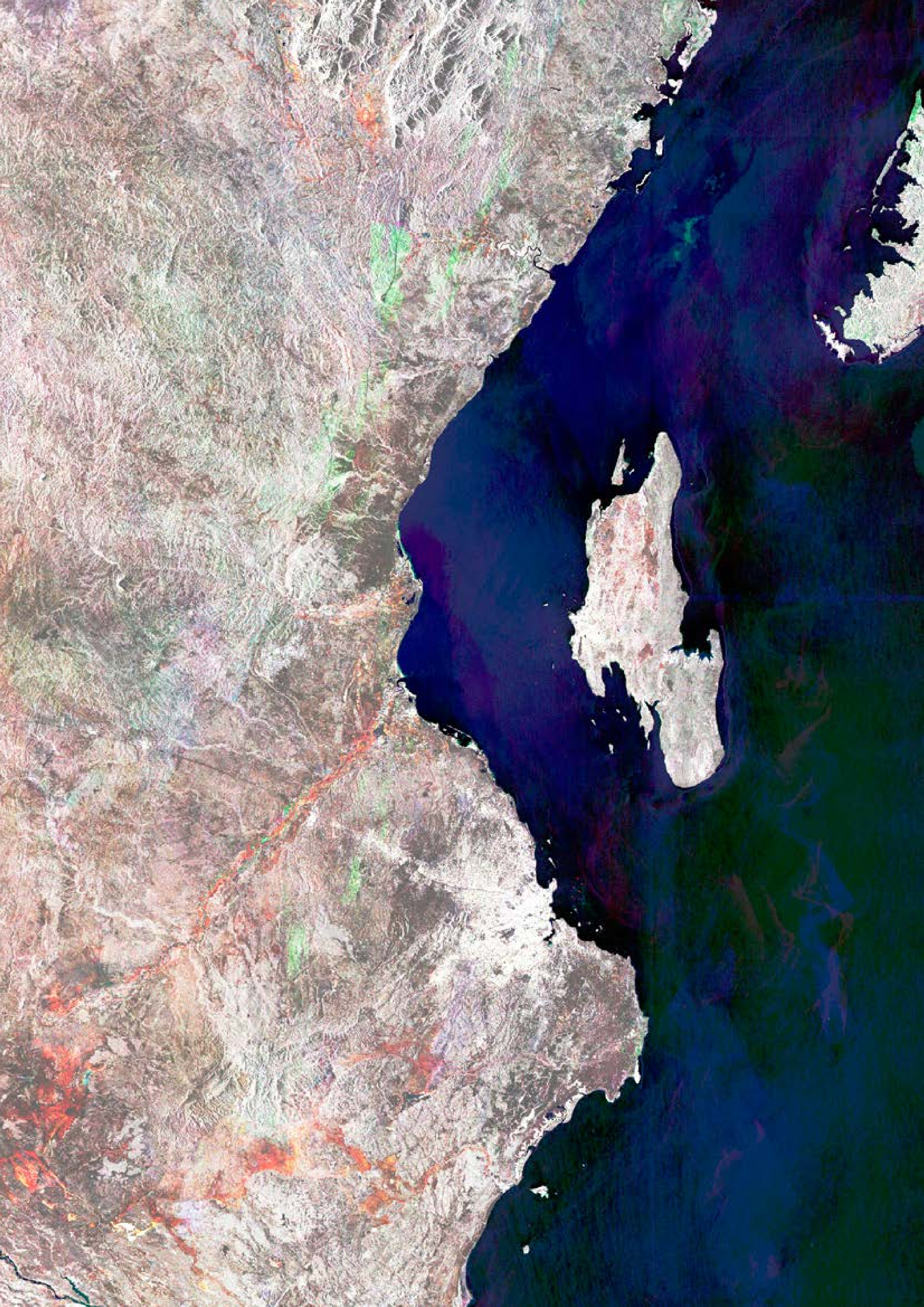


17. Maritime security

1) Key findings

Assessment of the situation

“More than 90 % of Africa’s imports and exports are transported by sea.”

Seas and oceans offer human society both resources (such as fish, minerals and hydrocarbons) and functions (such as transport, trade, tourism and ecosystem services). A country can have jurisdiction up to 200 nautical miles off its coast under its Exclusive Economic Zone, and beyond that it can have some rights on the continental shelf. The seas under African jurisdiction cover 13 million km2, which is the equivalent of 40 % of its land surface, and the continental shelf adds another 6.5 million km2 (UNECA, 2016). Fish make a vital contribution to the food supply of over 200 million Africans (AU, 2012); the gross value added of marine fisheries is estimated at US$ 15 billion, EUR 12.45 billion at 2017 exchange rates (De Graaf & Garibaldi, 2014). More than 90 % of Africa’s imports and exports (which amounted to about US$ 600 billion each in 2013; UNECA, 2015) are transported by sea (UNECA, 2016). Several African countries are already tapping offshore oil and gas reserves, and promising new discoveries are being made in others. However, to reap the benefits of the seas, a secure maritime environment is needed.

A typical Senegalese pirogue used for fishing ©EU, by Andreas Brink

Maritime security is “understood as a state of affairs of the global maritime domain, in which international law and national law are enforced, freedom of navigation is guaranteed and citizens, infrastructure, transport, the environment and marine resources are protected” (EU, 2014). Threats to the African maritime domain, however, include Illegal, Unreported and Unregulated (IUU) fishing (see also chapter I.11), the smuggling and trafficking of people and goods (drugs, weapons, products from protected species), the theft or illegal bunkering of oil, pollution, the facilitation of terrorism, and piracy (including armed robbery). Most of these threats target the security and economy of individual African countries, and sometimes, such as with irregular overseas migration, the safety of African individuals – often, however, with international ramifications for the rest of the world, including Europe. Some threats even directly target international interests, which is notably the case for piracy. In its 2010 report (Bowden et al., 2010), ‘Oceans Beyond Piracy’ estimated that maritime piracy costs the international economy between US$ 7 and US$ 12 billion per year. By 2015, this estimate had fallen to US$ 1.3 billion per year (OBP, 2015). The number of seafarers held hostage dropped from 1090 in 2010 to 17 in 2014, but was up again to 108 in 2015.

Around 2008, the rise in piracy in the Gulf of Aden prompted the international community to respond by deploying foreign military assets to the waters around the Horn of Africa in various international alliances, in particular the Combined Task Force 151, the North Atlantic Treaty Organization (NATO) Ocean Shield operation and the EU Naval Force Operation Atalanta. The international shipping community also sought protective (regulatory and operational) measures, and began to arm itself.

“While the rise in piracy around 2008 triggered a major international military response, sustainable solutions for maritime security need to be implemented by African authorities.”

However, it was recognised from the start that for maritime security (including piracy suppression) to be sustainable in Africa, it would need to be implemented by African authorities. Therefore, a number of initiatives for maritime security capacity building and for regional cooperation were set up. Initiators of and donors to these initiatives included the International Maritime Organization (IMO) and other United Nations (UN) agencies, the EU, individual countries, and private charities. While navies often have a leading role in providing security at sea, the EU has focused much of its attention on supporting African civilian authorities (maritime police, coast guards). In addition, recognising that the root causes of maritime insecurity often stem from political and social problems on land, the EU also aims to address those directly, e.g. in helping to rebuild Somalia.

For many years, the flow of irregular overseas migration from Africa to Europe has waxed and waned. Recent years have seen this problem assume crisis proportions, with an alarming death toll. Although a matter of maritime and border security, it is also a maritime safety issue. Its complex problematics deserve special attention, which this chapter cannot accommodate (see also chapter I.1.2)[48].

Outlook

While piracy has subsided off the coast of Somalia, the situation in the country itself (and others in the region) remains unstable, and there is a generally recognised risk of its re-emergence. In fact, early 2017 saw incidents in the Gulf of Guinea and East Africa; yet again, piracy appears to be closely linked to the political and economic situation. Moreover, as global fish stocks decline while demand keeps growing, the pressure of illegal fishing is constantly increasing. At the same time, the demand for narcotics and valuable protected goods (e.g. certain hardwoods and animal products) enables illegal trade to flourish, and international terrorism remains an issue. Thus, the need to enhance the counter-piracy and maritime-security capacities of African countries will continue to exist in the foreseeable future.

> “Although piracy off the coast of East Africa has subsided since 2012, there is a generally recognised risk of its re-emergence.”

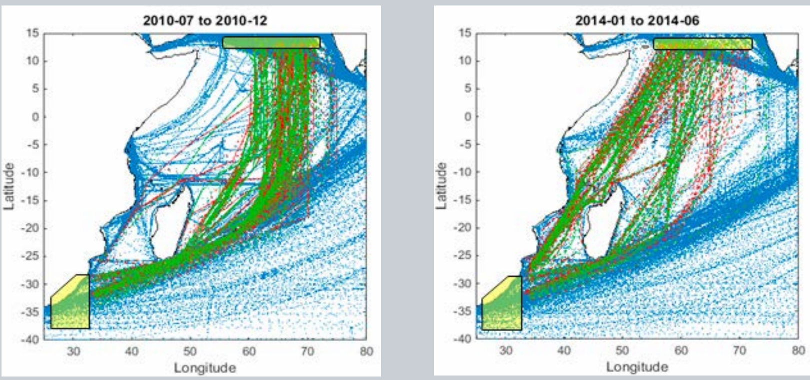
BOX 33

Effects of piracy on ship routing

In the years around 2010, much of the economic cost of piracy to international shipping was due to having to take longer routes to avoid high-risk zones. This is illustrated by the maps below that show the shipping tracks of EU vessels over two six-month periods, as seen on the long-range identification and tracking (LRIT) ship reporting system. The tracks of ships going south along the coast of Africa are plotted in red, those going north in green. Other tracks are shown in blue.

The map on the right shows the shipping tracks for the first half of 2014, when piracy had subsided significantly; most ships followed the shortest route. By contrast, the map on the left shows the situation in 2010, when ships made large detours to the east to avoid piracy (*Vespe et al., 2015)*

FIGURE 92: Shipping tracks around the Horn of Africa



48 A discussion of irregular migration focusing on the central Mediterranean is the topic of a recent Strategic Note by the European Political and Strategy Centre (EPSC, 2017).

Challenges and opportunities

The costs of building and operating maritime capabilities may be difficult to cover from national budgets alone (even though such investments are far less than the financial losses resulting from not enforcing the rule of law at sea). Maritime security is best attained through international and (in particular) regional cooperation. Regional information exchange and joint operations are necessary to ensure cost efficiency and to make a sufficient impact. This is not only true for cooperation between countries, but also for cooperation between ministries and agencies within a country, as maritime responsibilities are often widely distributed across the government, involving both the military and civilian sectors.

> “The potential of the 'blue economy' to generate EUR 2.5 trillion per year by 2020 can only be fully realised if the seas are secure.”

At present, operational cooperation between countries on maritime security is still a sensitive topic, as it pertains to sovereignty and primacy. However, such challenges are dwarfed by the opportunities that the economic exploitation of the sea has to offer. It is forecast that, by 2020, the global ‘blue economy’ could reach EUR 2.5 trillion per year (UNECA 2016; Hoegh-Guldberg et al., 2015) – but this potential will not be reached without adequate maritime security.

One crucial element needed to attain maritime security and to combat piracy is maritime awareness: that is, the ability to know what is happening at sea. (Other crucial elements include legal and regulatory frameworks, operational and organisational structures, and the capacity for intervention at sea.) With little infrastructure (such as coastal sensors and patrol ships or aircraft), maritime awareness has been very limited around most of Africa to date. Foreign or illegal ships could be active in a country’s exclusive economic zone without the authorities even being aware. Now, however, low-cost space-based, computing and web technologies are starting to make it possible to collect information about shipping activities over large areas in an affordable manner, for both military and civilian users.

From 2010 to 2015, the JRC carried out three piracy, maritime awareness & risks (PMAR) projects to identify the best technical tools for African authorities to monitor the maritime situation in the seas around them, and to provide hands-on experience with operational users and quantify the level of maritime awareness that can be reached (Greidanus et al., 2015a and 2015b).

During these projects, an information system was set up based on fact-finding missions, analysis of requirements, and state-of-the-art knowledge of maritime surveillance technologies. This system can produce a real-time picture of the maritime situation at sea, showing the ever-changing positions of all medium- and large-sized ships, from the coast out to the high seas. This was done for the Western Indian Ocean (including the Gulf of Aden) and for the Gulf of Guinea (see left panel of Figure 92). The technology makes use of the ships’ self-reporting systems – the Automatic Identification System (AIS) and the Long-Range Identification and Tracking (LRIT) system – which are globally mandated by the International Maritime Organization. The ship classes covered include merchant ships of 300 tonnes and above, passenger ships, fishing ships (depending on size and flag), and some recreational boats. The tool allows authorities to be aware of all major shipping activities. By analysing the data gathered over a longer period of time, ship density maps can be produced (right panel of Figure 92). These maps indicate normal shipping behaviour and patterns, so that abnormal (and therefore potentially risky) behaviour can be more readily identified. Last but not least, images from Earth-observation satellites can be used to assess the presence of ships not covered by the self-reporting systems.

The overall accessibility of these technologies to African operational users was demonstrated by running the system for an entire year in two African locations, at the Regional Maritime Rescue Coordination Centre in the Kenya Maritime Authority in Mombasa, and at the Anti-Piracy Unit of the Indian Ocean Commission in the Seychelles. In addition to tools for visualising and understanding the maritime situation at sea, a tool to store, share and analyse piracy incidents (PIRATES – Piracy Incident Reporting And informaTion Exchange System) was developed by the JRC and installed and tested with the authorities in West Africa in 2013. This served to make the participating national authorities better aware of the wider picture and the regional nature of the piracy problem.

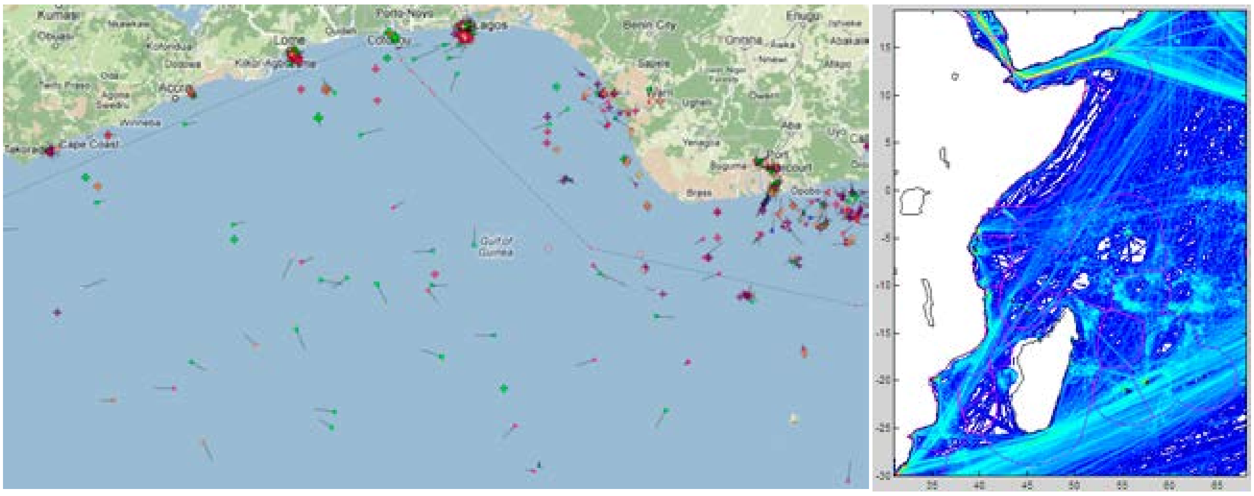


FIGURE 93: Left: maritime situational picture in the Gulf of Guinea showing the positions, types (by colour) and movements of ships at a particular moment in time. Right: ship-density map based on one month of data (January 2015) from the Western Indian Ocean, showing the main traffic routes (light blue and yellow line bundles) and fishing activity (light blue cloudy areas) *(Source: PMAR project, JRC)*

Policy framework

The EU funds the Critical Maritime Routes programme which, together with other strands of the IcSP, targets maritime security in Africa. In its latter stages, the EU Naval Force Operation Atalanta has also become engaged in capacity-building, and the EU Maritime Capacity Building Mission Nestor developed such activities from the start. In addition, the JRC's activities were closely coordinated with the International Maritime Organization, which focused on anti-piracy for some years and brokered the Djibouti Code of Conduct – a multinational agreement to cooperate on the repression of piracy and armed robbery against ships in the Western Indian Ocean and the Gulf of Aden (2009). Similarly, the Yaoundé Code of Conduct was agreed in 2013 for Western and Central Africa. The UN Office on Drugs and Crime deploys a Global Maritime Crime Programme. Some of the international coordination with national and international authorities and the shipping industry was facilitated by the Oceans Beyond Piracy programme.

The PMAR projects were partly funded by the European Development Fund under the Programme to Promote Regional Maritime Security, (MASE), which put a number of African Regional Economic Communities in charge of the implementation; in the case of PMAR, this was the Indian Ocean Commission.

> “The 2050 Africa's Integrated Maritime Strategy reflects a clear commitment to enhance the security of Africa's maritime domain.”

In the meantime, Africa has conceived and published its own framework for the protection and sustainable exploitation of its maritime domain, as a tool to address Africa's maritime challenges for sustainable development and competitiveness: the 2050 Africa's Integrated Maritime Strategy (AU, 2012). This strategy shares many of the considerations put forward in this chapter, and is referred to in the context of the maritime security priority in the Joint Africa-EU Strategy (JAES) Roadmap for 2014-2017 (EU-Africa, 2014).

2) Gaps, future actions and priorities to be considered

Many of the challenges to maritime security and maritime awareness are identical across most regions of the world. These include: sharing the right information across government departments and between countries; finding the actual hazards at sea against the busy background of regular shipping, and finding the illegal items in the large trade flows without unduly disrupting them; and dealing with the security threats posed by small boats that can remain undetected too easily. These are current topics of research in the EU and worldwide, where international cooperation can foster progress.

Today's technologies for maritime awareness and information sharing can significantly improve maritime security around Africa – if they are implemented. As such, the 2017 Communication for a Renewed Impetus of the Africa-EU Partnership (European Commission, 2017) proposes as one of the flagships to “support African initiatives in the field of maritime security by upgrading maritime awareness strategies, tools and information networks as well as police and judiciary systems”.

As many of the tools for maritime awareness depend on space assets (satellites) in both Africa and Europe, the build-up of capabilities to better support policymakers with scientific and technical advice on decisions related to space-based activities should receive due attention.

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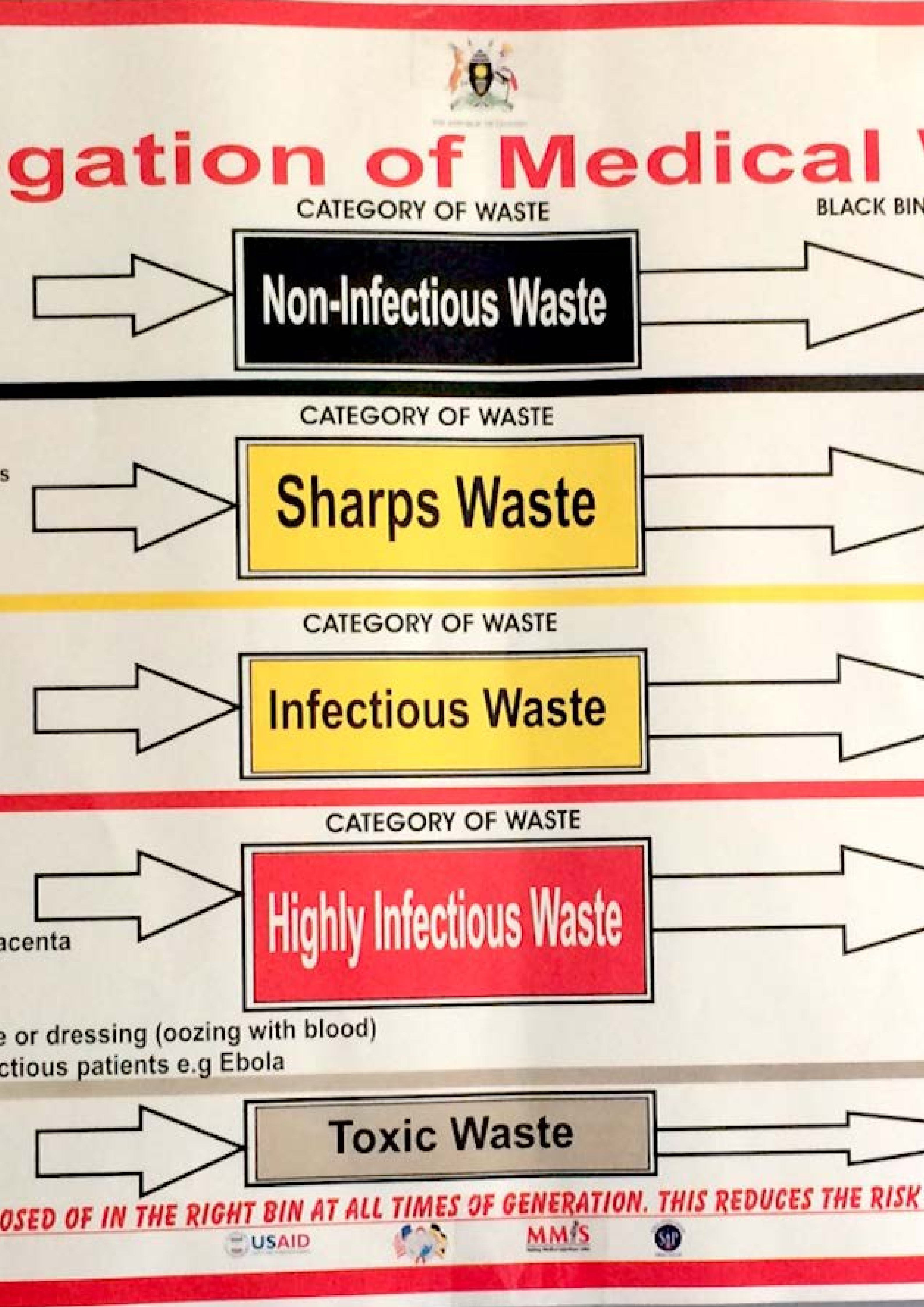
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18. Chemical, biological, radiological and nuclear security and safety

18.1. Chemical, biological, radiological and nuclear (CBRN) security

1) Key findings

In a globalised world where people and goods are constantly circulating, the risk of global threats in the chemical, biological, radiological and nuclear (CBRN) area is increasing, as is the risk of the intensification of terrorist threats and the number of tense political situations worldwide. To fulfil public health and security requirements, countries must not only continuously monitor their population's health, but also constantly improve the legal framework and its implementation, and develop the capacity to identify and prevent potential emerging risks that can affect their population and environment.

Thus, there is a need to mitigate CBRN risks which might affect several global regions, including Africa. Several international instruments (such as the United Nations Security Council's Resolution 1540, the Chemical Weapons Convention, the Biological and Toxin Weapons Convention, the Treaty on the Non-Proliferation of Nuclear Weapons, the International Health Regulations (2005) and the Convention on the Physical Protection of Nuclear Material) call for specific measures to be taken at the national and international levels. National, regional and international cooperation, information sharing, assistance and capacity-building programmes as well as coordination among donors are crucial for effective preparedness for, and response to, CBRN threats. The EU plays an important role in this, namely by supporting activities in different countries and regions through its instruments for EU external policies and development cooperation, such as the EDF, the Development Cooperation Instrument, the European Neighbourhood Instrument, the IcSP, and the Instrument for Nuclear Safety Cooperation.

A chemical lab in Uganda ©EU, by Josephine McCourt

Chemical risks

Risks associated with the industrial and agricultural sectors in Africa have considerably intensified in recent decades due to the increased use of chemicals and greater exploitation of natural resources. The growth in extraction activities in many African countries has led to an increased use of chemical substances and their derivatives in many sectors. The production of agricultural chemicals is also a key focus of the chemical industry in Africa, especially as most African economies are based on agriculture. Although pesticides are generally imported, Africa contributed to 5 % of total world pesticide production in 2002 (UNECA, 2009).

This intensified production, storage, use and disposal of chemicals in Africa increases the probability of accidental releases and dispersions in the environment. Such discharges may permanently damage soils and water resources. Accidental releases can also lead to emergencies such as fires and explosions. Furthermore, urbanisation is occurring more rapidly in sub-Saharan Africa than anywhere else in the world, increasing the fragility of the population concentrated in cities that cannot provide the necessary infrastructures and services and of those in settlements which are in close proximity to potentially hazardous chemical installations, such as oil tanks, farms and depots.

Biological risks

Regions that are in conflict and post-conflict situations and subject to unfavourable climate conditions run a high risk of epidemics. Such areas are typically characterised by a high level of population displacement, poverty, a breakdown in health infrastructure and highly insecure conditions – all of which create conditions for epidemic outbreaks. The Mediterranean and the African Atlantic Façade regions, and sub-Saharan Africa in general, are particularly exposed to health risks (emerging diseases, epidemics and potential pandemics) and disasters that have large-scale devastating effects regionally, as seen during the recent West African Ebola virus epidemic (2013-2016), when a total of 28 616 cases and 11 310 deaths were reported by the World Health Organization in Guinea, Liberia and Sierra Leone.

Undetected epidemics are common in these regions, because surveillance is often weak, access to remote regions is difficult, and there are not enough trained professionals available. Most deaths in developing countries are due to infectious diseases, as these countries are least equipped to deal with outbreaks and have minimal preventive measures in place. Improvements in epidemiological approaches are urgently needed. The occurrence of an outbreak may affect a large number of people across multiple borders, as witnessed during the recent Ebola epidemics. Other dangerous infectious diseases prevalent in African regions include yellow fever, cholera, Lassa fever, Rift Valley fever, dengue fever and meningitis (WHO Africa, 2016). Malaria epidemics also affect non-immune populations in many areas of Africa. In 2015, Africa accounted for 88 % of malaria cases and 90 % of deaths from malaria worldwide (WHO, 2015).

Radiological and nuclear risks

Nuclear materials, ores and facilities are used in several African countries, and radioactive sources are widely used in healthcare and industry. These materials and sources are of growing interest to terrorist groups for their potential use in malicious acts. The three main lines of defence are prevention, detection and response, in particular with regard to radioactive and nuclear materials that are not subject to regulatory controls.

In all African regions, radioactive sources are widely used in healthcare institutions and industry, and their licensing is controlled. However, the regulations applicable to their use, handling and enforcement differ across countries. The management and control of radioactive sources approaching the end of their economic lifetimes is often unclear, resulting in the risk that sources slip through regulatory controls. This situation encompasses cross-border safety and security issues, and therefore calls for strengthened international cooperation. Several countries have initiated programmes to develop a national register of all radioactive sources, and some have also set up centralised storage areas for radioactive waste. Where such sources are not subject to controls, it is necessary to establish detection capabilities by deploying adequate detection instrumentation and to train officers on the procedures for responding to an alarm. Correct safety procedures for the protection of front-line officers and the public, as well as appropriate investigation procedures, must be followed. A dedicated set of instrumentation, well-established procedures and communication channels are essential, and training and exercises are of the utmost importance.

EU CBRN Risk Mitigation Centres of Excellence initiative in Africa

Acknowledging the global, multidimensional and cross-border nature of CBRN security threats, and the links between Europe's security and development and stability in the neighbouring regions (including Africa), the EU CBRN Risk Mitigation Centres of Excellence (CoE) initiative was launched in 2010 under the Instrument for Stability (IfS), and continues under the IcSP. It was designed by the European Commission and the EEAS, and is managed by DG DEVCO, with scientific and technical support from the JRC and in cooperation with the United Nations Interregional Crime and Justice Research Institute (UNICRI). With the aim of strengthening national CBRN policies and capacities in partner countries and promoting national, regional and international cooperation on CBRN risk mitigation, it provides a comprehensive framework covering legal, regulatory, enforcement and technical issues.

The initiative has 56 partner countries, including 27 African countries from three regions (see Figure 93):

- African Atlantic Façade (AAF): Benin, Cameroon, Côte d'Ivoire, Gabon, Liberia, Mauritania, Morocco, Senegal, Sierra Leone and Togo;
- North Africa and Sahel (NAS): Algeria, Burkina Faso, Libya, Mali, Morocco, Niger and Tunisia;
- Eastern and Central Africa (ECA): Burundi, the Democratic Republic of the Congo, Ethiopia, Ghana, Kenya, Malawi, Rwanda, Seychelles, Tanzania, Uganda and Zambia.

FIGURE 94: African partner countries in the CBRN CoE initiative by region, 2017 *(Source: JRC)*

The initiative provides a platform for voluntary regional cooperation on all CBRN-related hazard issues, be they of criminal, natural or accidental origin. Countries work together to identify risks, assess capacities and needs, and advise on the activities or projects to be taken forward, supported by regional secretariats. National focal points and teams of national experts are in place, including stakeholders responsible for CBRN risk mitigation.

The JRC supports the initiative by providing technical input, participating in regional meetings, analysing project proposals, and facilitating communication between stakeholders. It also helps partner countries identify CBRN risks, assess capabilities and needs, and develop national action plans. As of January 2017, 10 African countries have carried out a needs assessment, and nine are developing or have finalised a national action plan.

EU CBRN CoE projects in Africa

To date, there are 32 ongoing or completed EU CBRN CoE projects in African countries, which address a wide variety of topics: border control and monitoring, illicit trafficking, import and export control, crisis management, first response, post-incident recovery, public health impact mitigation, waste management, safety and security, and the legal framework. Focused on capacity-building, most of these projects include a training component, awareness-raising events, and desktop and field exercises. With a strong bottom-up approach, the projects are proposed by the partner countries and prepared in close collaboration with their authorities and national experts according to their national and regional needs. Furthermore, the involvement during the implementation phase of local institutions and experts encourages ownership. Examples of EU CBRN CoE projects include:

- Management of hazardous chemical and biological waste in the AAF region and Tunisia
- Mediterranean Programme for Intervention Epidemiology Training (MediPIET);
- High Risk Chemical Facilities and Risk Mitigation in the AAF Region;
- Establishment of a Mobile Laboratory for *in-situ* interventions on viral haemorrhagic fever outbreak sites in combination with CBRN Capacity Building in Western Africa (EU West African Mobile Laboratory, EUWAM-Lab);
- Improving the management of outbreaks with settling coordinated regional teams in the AAF region;
- Strengthening cross-border capacity for control and detection of CBRN substances;
- Supporting ECA countries in nuclear and radiological security;
- Chemical safety and security in the ECA region;
- Building regional border control capacity to identify and detect CRN materials, directly implemented by the JRC in the framework of the EU CBRN CoE initiative in Benin, Gabon, Mauritania, Morocco and Senegal.

Three new regional projects are in preparation: one focusing on combating falsified medicines in the ECA region, and the other two addressing food safety and security issues and the transport of dangerous goods in the AAF region.

Nuclear security projects implemented in Africa

(beyond the EU CBRN CoE framework)

Training on radiation detection techniques and procedures for radioactive and nuclear material out of regulatory control, held at the European Nuclear Security Training Centre (EUSECTRA) Ispra site ©EU

Three projects with African countries, funded by DG DEVCO through the IfS include work aiming to combat the illicit trafficking of nuclear and radioactive materials by enhancing detection and response capabilities, in Algeria, Morocco and the DRC. They all include the provision of specialised detection instrumentation at crucial nodal points and for mobile units, and the training of front-line officers and their trainers on the use of these instruments and procedures in the case of a nuclear or radiological terrorist event. Support is also given to partner countries to help establish nuclear detection architecture at the national level. All decisions on the projects are taken by the partner country beneficiaries. The Border Monitoring Working Group closely coordinates the projects with the main international players in the field, by ensuring regular exchange of information and the joint implementation of projects to provide maximum support while optimising resources.

Building Seveso capacity in European Neighbourhood countries

The Seveso ENPI (European Neighbourhood Partnership Instrument[49]) project is a joint initiative of the Directorate-

49 In 2014, the European Neighbourhood and Partnership Instrument (ENPI) was replaced by the European Neighbourhood Instrument (ENI) (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0232&from=en)

General for European Civil Protection and Humanitarian Aid Operations (DG ECHO) and the JRC. It aims to establish active partnerships with European Neighbourhood countries for improving the effectiveness of chemical accident prevention and preparedness programmes. It includes bilateral collaboration, developing tools, and training workshops which give the countries access to information, tools and knowledge produced by the JRC and the vast network of government and industry stakeholders collaborating at the European level. It also provides a platform for sharing experiences and lessons learned.

Algeria and Tunisia both provided assessments of their chemical accident prevention and preparedness programmes in response to a JRC survey carried out in 2015, and participated in a workshop for Enlargement and EU Neighbourhood countries on Natech50 risk assessment and the Rapid Natech Risk Assessment (RAPID-N) tool51.

FIGURE 95: Images from the RAPID-N tool, which assesses the potential damage from natural hazard events at hazardous facilities

To assist European Neighbourhood countries, the JRC is also completing the development of tools to model and visualise the risk of damage resulting from accidents[52].

The JRC is establishing bilateral relationships with a number of European Neighbourhood countries to provide training and assistance, especially on consequence and risk assessment tools. It encourages more European Neighbourhood countries, including those in North Africa, to take advantage of this opportunity in 2018. Electronic forums will also be possible through the JRC's Minerva Communities web platform[53]. The site already hosts JRC technical activities for Seveso inspections, land-use planning, accident analysis, and tools to respond to a variety of risk-management challenges encountered by competent authorities.

Coordination with international partners

Structured and ad-hoc support is provided in CBRN risk mitigation to relevant international organisations (International Atomic Energy Agency, World Health Organization, World Customs Organization, Organisation for the Prohibition of Chemical Weapons, United Nations Office for Disarmament Affairs (UNODA), UN Environment Programme, UN Development Programme), regional (African Union, League of Arab States) and other multi-country fora (UN Security Council Resolution 1540 Committee, Global Initiative to Combat Nuclear Terrorism, Global Health Security Initiative, etc.), particularly when their geographical scope of action exceeds that of the EU CBRN CoE. This support aims to involve these organisations in capacity-building activities to mitigate CBRN risks, enhance complementarity and avoid duplication of effort.

2) Gaps, future actions and priorities to be considered

The Cotonou Partnership Agreement between the members of the African, Caribbean and Pacific (ACP) Group of States, on the one hand, and the EU and its Member States on the other, will expire in February 2020. Signed in 2000, it was based on three complementary pillars: development cooperation, economic and trade cooperation, and political cooperation. The EU favours the option of having three distinct regional partnerships under a common umbrella (European Commission, 2016). Negotiations are expected to start in August 2018. The three African regions of the EU CBRN Risk Mitigation CoE initiative have expressed their intention to collaborate and progress towards a more integrated approach to issues linked to CBRN governance, for cross-fertilisation purposes and a coherence of approach at the continental level. The JRC could study how these initiatives and the objectives of the EU CBRN Risk Mitigation CoE initiative for the African continent could be embedded in the discussions for the post-Cotonou negotiations concerning the EU's partnership with Africa.

50 Natech events are natural hazards triggering a technological disaster, including chemical accidents.

51 This workshop was organised within the framework of the JRC Enlargement and Integration Action, in Ispra, in March 2016.

52 These include the accident damage assessment management tool, the GIS-area risk assessment tool, and RAPID-N, which is a unique, web-based assessment and mapping tool with a natural-hazards module. RAPID-N is already available online to assess earthquake impacts: http://rapidn.jrc.ec.europa.eu

53 https://minerva.jrc.ec.europa.eu

Supporting references and web links

Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC (Text with EEA relevance).

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18.2. Nuclear safety and safeguards

1) Key findings

Assessment of the situation

Nuclear materials, ores and facilities (such as nuclear power plants, nuclear research reactors and uranium mines) are in use in the African continent.

Uranium mines

In the past 60 years, uranium has become one of the world's most important energy minerals. It is mined and concentrated in a similar way to many other metals. Uranium is a naturally occurring element with an average concentration of 2.8 parts per million in the Earth's crust. Traces occur almost everywhere. Uranium mining has a long history in Africa. Significant quantities of the mineral have previously come from the Congo (including the uranium used for making the first atomic bomb) and Gabon.

> “The production of uranium (one of the world's most important energy minerals) is an important part of the African economy, with Niger, Namibia and South Africa contributing up to 18 % of the world's annual production.”

Warning signs on laboratory door ©EU, by Josephine McCourt

Today, uranium production is an important part of the African economy, with Niger, Namibia and South Africa contributing up to 18 % of the world's annual production. Many African countries produce uranium or have untapped uranium ore deposits. Namibia has two large uranium mines capable of producing 10 % of world output. There are also several promising developments in Namibia, including the major Husab project close to Rossing, owned by a subsidiary of the China General Nuclear Power Group (China's largest nuclear power operator), which promises to become one of the world's largest uranium mines. Niger has two significant long-running mines which supply 7 % of the world's mined uranium. In South Africa, uranium production has generally been a by-product of gold or copper mining. In Malawi, Paladin Energy has developed the Kayelekera uranium mine, where production reached 1100 tonnes per year before being suspended in 2014 to await higher prices. Uranium ore exploration is, or has been, carried out in other African countries, such as Algeria, Botswana, Guinea, the Central African Republic, Equatorial Guinea, Mali, Mauritania, Morocco, Nigeria, Tanzania, Zambia and Zimbabwe.

Nuclear facilities

> “Today, there are 12 nuclear research reactors in the African continent, 10 of which are operational.”

In 2009, Africa passed a milestone of 50 years' involvement with nuclear technology, dating from the initial criticality of the DRC's TRICO[54] I research reactor at the University of Kinshasa (IAEA, 2011). Egypt and South Africa soon followed, signalling a continental commitment to providing researchers, scientists, students and industries across Africa with access to modern nuclear analytical techniques and capabilities. Twelve research reactors have been built in eight countries across the continent (IAEA, 2011). Aside from conducting research into nuclear data and improving our knowledge of the subatomic world, they provide the neutrons used to probe material structures for enhanced construction practices, to insert atomic impurities for the manufacturing of semiconductors, create radioisotopes for medical and industrial diagnostics and cancer treatments, examine environmental samples for tracking pollution, and assist farmers in crop selection and placement. Moreover, they are typically seen as the

54 'TRICO' is a portmanteau of the names TRIGA (Training, Research, Isotopes, General Atomics – the type of reactor) and Congo.

first step towards inaugurating a national nuclear-power programme. Today, there are 10 operating research reactors across the African continent (in Algeria, Libya, Morocco, Egypt, Ghana, the DRC, Nigeria and South Africa). South Africa is the only country in Africa with a commercial nuclear power plant. Two reactors located at the Koeberg nuclear power station account for around 4 % of South Africa's electricity production. Spent fuel is disposed of at Vaalputs Radioactive Waste Disposal Facility in the Northern Cape.

African Nuclear Weapon Free Zone – Pelindaba Treaty
The Pelindaba Treaty, covering the whole continent, was signed in 1996 and came into effect with the 28th ratification on 15 July 2009. The Treaty prohibits the research, development, manufacture, stockpiling, acquisition, testing, possession, control or stationing of nuclear explosive devices in the territory of parties to the Treaty and the dumping of radioactive waste in the African zone by Treaty parties. The Treaty also prohibits any attack against nuclear installations in the zone by Treaty parties, and requires them to maintain the highest standards of physical protection of nuclear material, facilities and equipment, which are to be used exclusively for peaceful purposes. All parties are required to fully apply International Atomic Energy Agency (IAEA) safeguards to all their peaceful nuclear activities. This implies the conclusion of comprehensive safeguard agreements with the IAEA, equivalent to the agreements required in connection with the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). Twenty-one countries in Africa have yet to bring such agreements into force. After entry into force of the Treaty, the parties plan to establish an African Commission on Nuclear Energy, not only as a compliance mechanism but also to encourage regional and sub-regional programmes to cooperate in the peaceful use of nuclear science and technology. It would also encourage African countries to take responsibility for their natural resources (in particular, nuclear material), and ensure protection against the dumping of toxic waste.

> “The Pelindaba Treaty requires all nuclear material, facilities and equipment in the African zone to be used exclusively for peaceful purposes, and prohibits the dumping of radioactive waste or attack against nuclear installations in the African zone.”

Challenges and opportunities

In Central and Eastern African countries, the major challenges in terms of radiological and nuclear risks are the mining, milling, processing and transportation of uranium. Uranium-mining activities are ongoing and developing in sub-Saharan African countries as part of their development policies. Past experience has shown that the sustainability of uranium mining must be considered right from the start, in particular through the application of best international standards in the regulatory process. In most countries, there is no harmonised framework regarding the licensing and inspection process of uranium mining and its related transport activities. One example concerns the current plans to transport uranium from Tanzania to the seaport of Walvis Bay in Namibia for export, which is a trip of more than 5 000 km through four different countries (Tanzania, Malawi, Zambia and Namibia).

African countries have a legal obligation under several treaties and international or regional instruments to ensure effective regulation of uranium production and export. This is essential for good governance and to maintain public confidence in the security and safety of the nuclear industry. For several countries, the export of uranium-ore concentrate requires cross-border transport through neighbouring countries and is therefore a regional issue. Border-crossing points and crucial nodal points (e.g. seaports) are possible routes for the illicit trafficking of nuclear and other radioactive materials. Modern detection equipment and appropriate training will help deter and counteract such trafficking. A high level of nuclear safety, security and radiation protection are relevant in countries where uranium exploration, mining and milling takes place, and often need substantial improvements to reach a level that is acceptable in the EU.

From the safety perspective, the mining and processing of radioactive ores (for which protection of the environment, workers and the general public must be regulated and enforced) is not always covered by proper legislation and licensing in line with international safety standards and best practices.

Some African countries have plans to embark on the development of nuclear power production, e.g. Egypt, Ghana, Kenya and Morocco; Egypt seems the most advanced in its planning. They will have to develop the necessary national infrastructure to launch and bring their nuclear-power programmes (legislative and regulatory framework, safety infrastructure, radioactive-waste-management capabilities, nuclear activities with the research reactor, training, etc.) up to international standards.

Several projects are funded under the DG DEVCO's Instrument for Nuclear Safety Cooperation. They focus on strengthening the capabilities of national regulatory authorities, in particular for capacity-building and enhancing the regulatory framework for nuclear and radiation safety in, for example, Morocco and Egypt.

For the first time, through a project aiming to "Strengthen the technical capabilities of the Tanzanian Atomic Energy Commission", the European Commission will become involved in the field of nuclear and radiation safety in sub-Saharan Africa. The project aims to upgrade the Tanzanian Atomic Energy Commission's radio-analytical laboratory with a view to ensuring proper radiation-protection duties and strengthening the regulatory capabilities related to mining, milling and transport.

In 2014, the EU organised a regional seminar to discuss how best to strengthen the peaceful use of nuclear energy by enhancing nuclear safety, security and safeguards. The objective was to engage the regulatory authorities (possibly on a regional basis), provide support, and promote the adoption of best international practices. The seminar gave African countries the opportunity to share their experiences with relevant international organisations active in the field. The exchange was designed, *inter alia*, to inform the development of regional support programmes that address needs or gaps at the national, regional or continental levels. This led to a follow-up regional seminar on uranium mining, milling and transport which involved four countries (Tanzania, Malawi, Namibia and Zambia), and to a project, financed through the Instrument for Nuclear Safety Cooperation. This aims to reinforce the capacity of African countries to develop an effective regulatory framework for domestic uranium production (including methods for effective accounting, control, and security of uranium products), and to assist these countries in implementing their obligations imposed by relevant UN Security Council resolutions.

The 'Transfer of EU nuclear safeguards methodology to third countries' project will include training based on the European Safeguards Research and Development Association (ESARDA) course on nuclear safeguards and non-proliferation. It will also support the relevant Southern African Development Community (SADC) working group. The project, which is linked to security aspects under the IcSP, will develop a regional case study and establish nuclear safety and safeguard provisions in each country for both the licensing and control of uranium-mining activities and transport in the above-mentioned four countries (Tanzania, Malawi, Namibia and Zambia). This case study will consider both the national and regional levels, in particular for transport that involves border crossings and information exchange for the transfer of responsibilities. It will identify discrepancies and provide recommendations for harmonisation, taking into account best practices in the corresponding areas. The project will further identify and address training needs, and will provide a web-based communication system for incidents, movement of nuclear materials, exchanging documents, etc.

Uganda National Bureau of Standards ©EU, by Josephine McCourt

2) Gaps, future actions and priorities to be considered

Activities in the nuclear safety area will continue to concentrate on the EU's Southern Neighbourhood countries, mainly Egypt and Morocco, giving support to their respective regulators within the Instrument for Nuclear Safety Cooperation. This will be combined with strengthening the control of uranium-mining activities in the rest of Africa, unless Ghana and Kenya will follow through on their stated commitments to install nuclear power plants. Efforts to support nuclear-safety activities in Egypt will increase following Egypt's expected signature of a contract for the construction of a nuclear power plant on the Mediterranean coast.

Supporting references and web links

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Regulation (EC) No 1717/2006 of the European Parliament and of the Council of 15 November 2006 establishing an Instrument for Stability (OJ L 327, 24.11.2006, p. 1).

Regulation (EU) No 230/2014 of the European Parliament and of the Council of 11 March 2014 establishing an Instrument contributing to Stability and Peace (IcSP) (OJ L 77, 15.03.2014, p. 1).

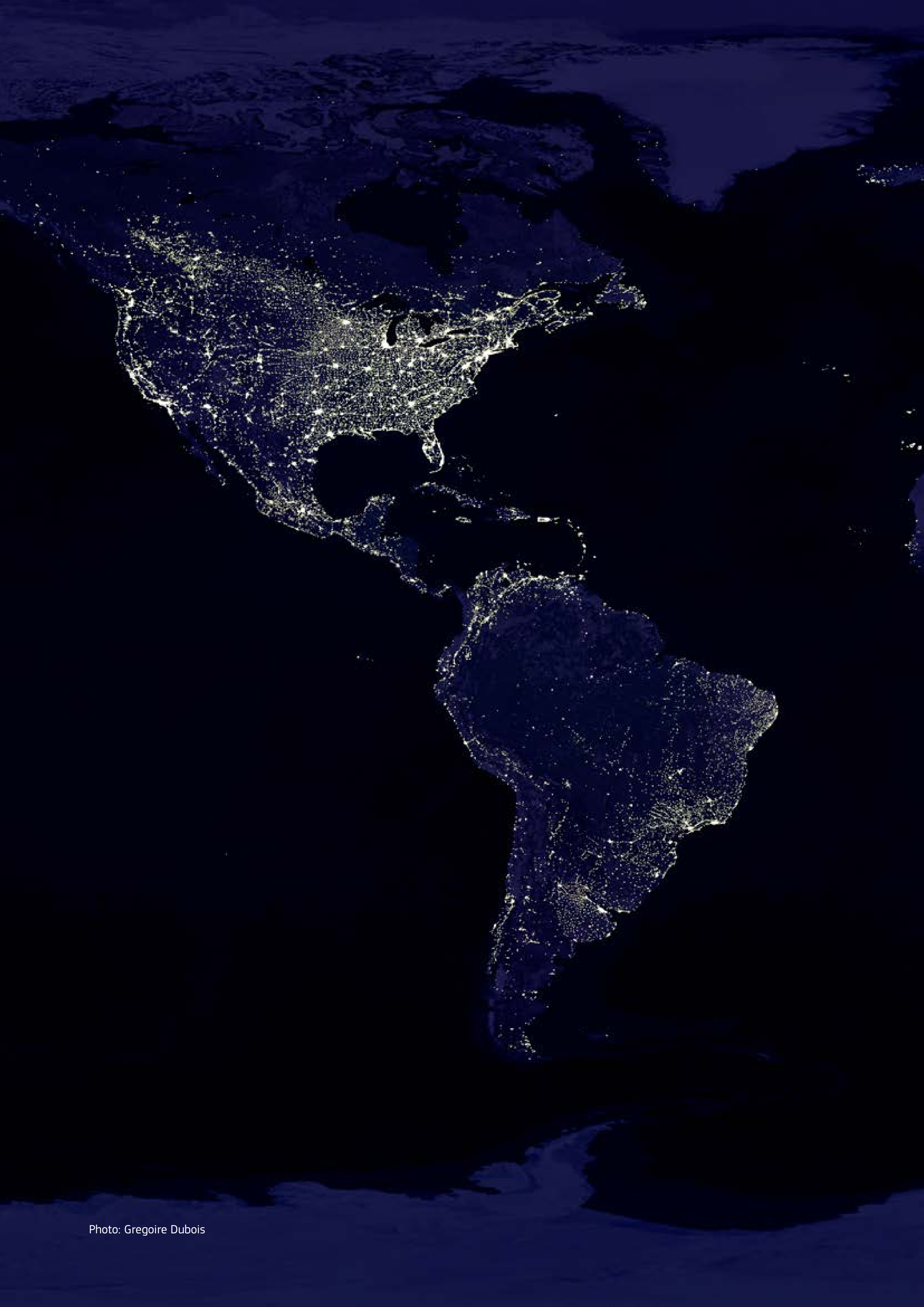


Photo: Gregoire Dubois

PART 2

Cross-cutting topics

1. Research and innovation

1.1. Research and innovation performance

1) Key findings

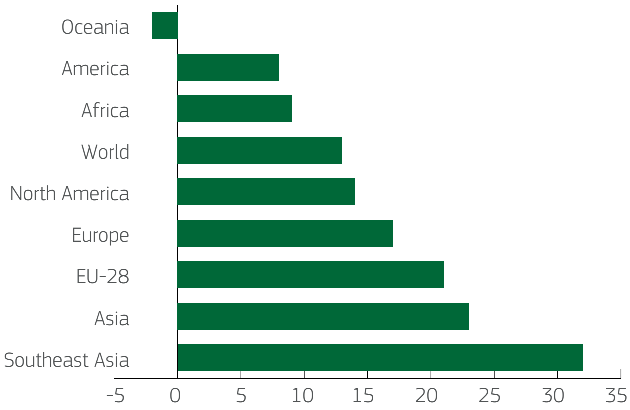
Assessment of the situation

The Science, Technology and Innovation Strategy for Africa – 2024 (STISA-2024) is one of the three pillars identified by the AU to achieve the global SDGs. Advances in science and innovation are crucial to provide solutions to the challenges faced by African communities and economies in various sectors (such as the food and agro-industry, energy, health and water supply), as well as for the functioning of enterprises (e.g. information and technology services) and the improvement of living conditions. The creation and commercialisation of novel goods, services, processes and methods need to be supported by targeted and sustained investments in human capital and infrastructure, as well as adequate funding for innovation.

During the last decade, African countries have engaged more actively in research and development (R&D) and innovation activities (where research involves discovery, development implies building on or strengthening known concepts and products, and innovation implies creation and diffusion of new ways of doing things – all three are closely linked). This engagement is reflected in, among others, the positive growth of African gross domestic expenditure on R&D (GERD) (Figure 96). In 2013, R&D expenditure as a percentage of GDP in Africa was 0.45 %, much lower than the global average and less than the AU's target of 1 %. However, the rate of increase between 2007 and 2013 was higher than in the Americas (North and South combined).

“Average African R&D expenditure is growing, but is still less than 0.5 % of GDP.”

FIGURE 96: Growth of GERD, 2007-2013 *(Source: based on data from UNESCO, 2015)*; EU-28 relates to the 28 Member States of the European Union.



About half of Africa's R&D investments rely on international funding, and most national R&D expenditure comes from the public sector.

Despite considerable variability between countries, Figure 97 shows the general upward trends in both R&D investments as a proportion of GDP in sub-Saharan Africa (+2.7 %) and the number of researchers (+11.24 %) between 2010 and 2014.

However, Africa has the lowest number of researchers per million inhabitants of all these regions – 87 in sub-Saharan Africa, compared to the global ratio of 1098 (UNESCO Institute for Statistics data for 2014, not shown in Figure 97). Despite this, Africa has managed to improve both its scientific output and the excellence of its publications over the period 2000-2014 (Figure 98).

FIGURE 97:GROWTH rates in GERD as a percentage of GDP as well as in the number of researchers by region, 2010-2014 *(Data from the UNESCO Institute for Statistics (UIS), extracted in March 2017)*

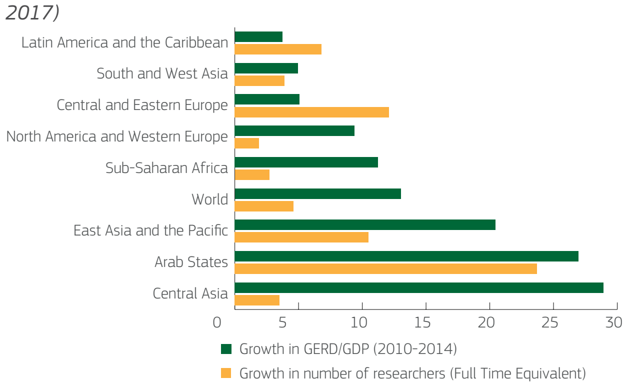
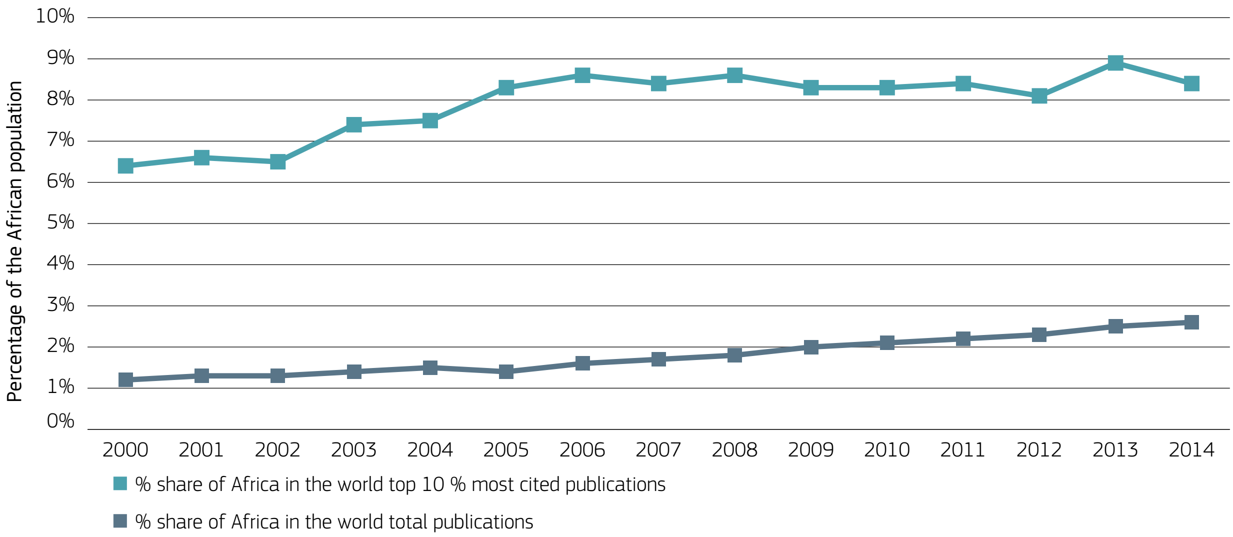


FIGURE 98: Growth in scientific output (share of total publications in the world – articles, book reviews and conference papers) and performance in the most highly regarded global publications (percentage share in the top 10 % most-cited publications worldwide) *(Source: Data from © 2017 Elsevier B.V., extracted from Scopus database in March 2017)*



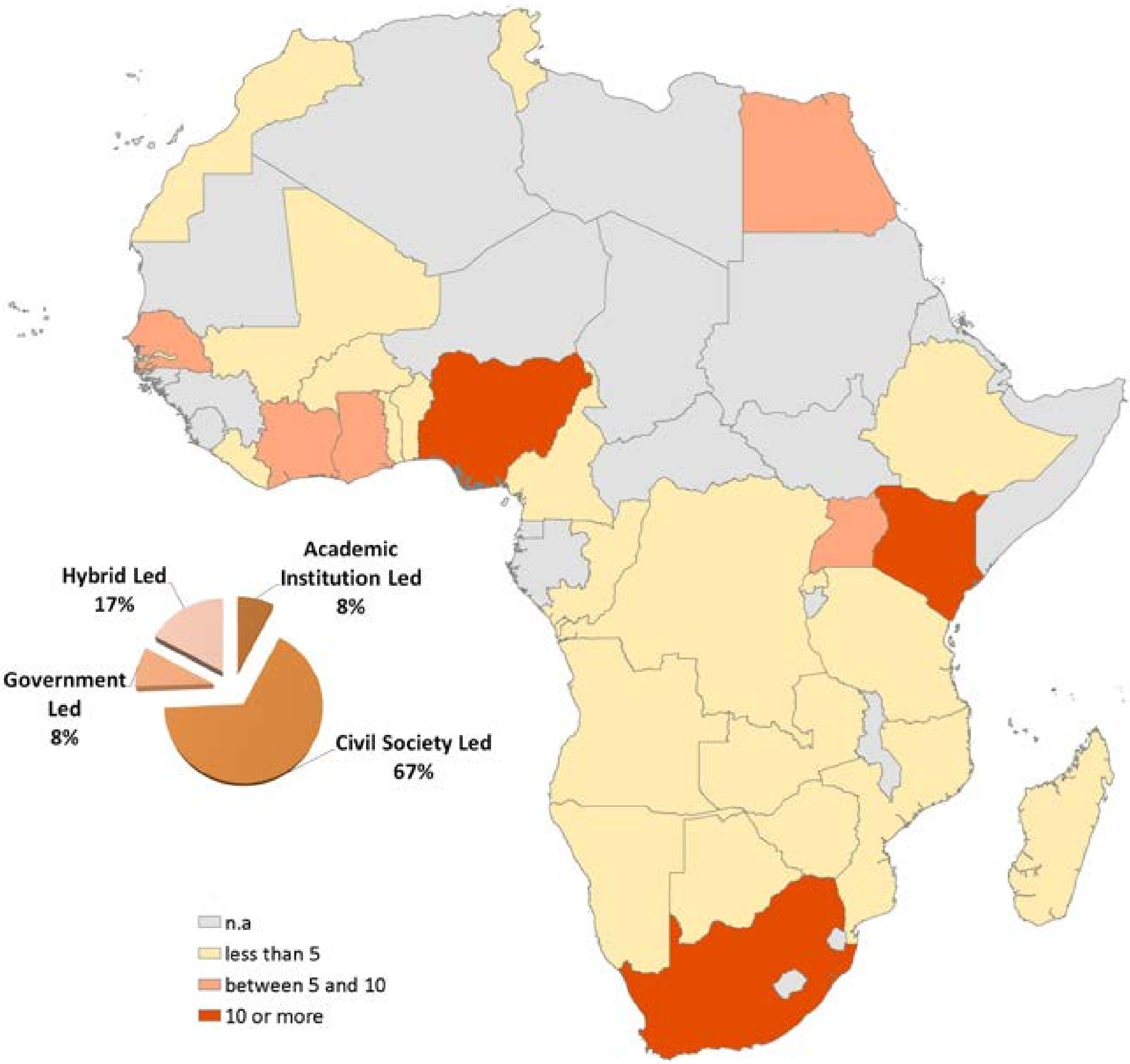
Low R&D expenditure in Africa does not mean a low level of commitment to innovation. Traditional R&D indicators may fail to capture the actual dynamics of innovation, especially for organisational and marketing innovation (e.g. changes in business practices, design, packaging, etc.), as well as in the service and informal sectors.

> “Several African countries (including Kenya, Rwanda and Mozambique) featured as 'innovation achievers' in 2015.”

Recent innovation surveys of 11 countries (Egypt, Gabon, Ghana, Kenya, Lesotho, Nigeria, Senegal, South Africa, Tanzania, Uganda and Zambia), carried out under the African Science, Technology and Innovation Indicators (ASTII) Initiative of the AU's New Partnership for Africa's Development (NEPAD), show that innovation rates are high. On average, more than 40 % of firms were found to be actively innovative (with more than 70 % in Ghana, Kenya and Uganda). This primarily involved the acquisition of machinery and software, followed by R&D investments (NEPAD, 2010). Most new products and processes were developed by local firms that rely significantly on interactions with users, suppliers, and competitors (African Innovation Outlook, 2014). In recent years, sub-Saharan Africa has slightly improved its ranking in the Global Innovation Index[55], and several countries (such as Kenya, Rwanda and Mozambique) featured as ‘innovation achievers’ in 2015 within their income group: they have improved both in terms of innovation inputs and outputs (Cornell University et al., 2016). However, the continental picture shows that the majority of African countries are still in the lowest ranks of the 2015 Global Innovation Index. In contrast, the vibrant development of tech hubs (incubators or common innovation spaces for entrepreneurs or start-up firms) in Africa may not have been systematically captured by standard R&D figures and innovation surveys. Mainly oriented towards the development of ICT applications, these interactive and co-creation spaces facilitate access to specific knowledge, peer support, mentoring and external seed funding, and act as accelerators for the development and commercialisation of local innovations. This may also explain their success with the new generation of African entrepreneurs involved in developing digital technology innovations.

55 The Global Innovation Index ranks economies according to their innovation inputs and outputs, within predefined income groups. ‘Innovation achievers’ designate economies that outperform their peers relative to their level of GDP.

FIGURE 99:MAPPING tech hubs in Africa



The map shows the estimated numbers of African digital-technology-oriented tech hubs for September 2015 (total of 117) *(Source: based on data from the World Development Report 2016 team (World Bank, 2016)*

Challenges and opportunities

Africa has the world's youngest population and a burgeoning entrepreneurial sector, especially in the ICT, wholesale and retail sectors (Kelley et al., 2015), which present both challenges and opportunities for the continent's development. A rapid upgrade of the education, business, research and innovation conditions would no doubt be beneficial, as would the active involvement of private actors (and others) in the exploitation of local research outcomes.

Although many African countries have developed science, technology and innovation policies, their outcomes and potential impacts are not yet visible in the statistics. The lack of appropriate funds (public and private for innovation) stands out as one of the greatest barriers to innovation in Africa. Governments would be well advised to step up public R&D and innovation investments to ensure viable options for future growth in an increasingly competitive world economy. Greater efforts are needed to support the training of researchers and the development of relevant technical, entrepreneurial and business skills for innovation.

> "The lack of public and private funding for innovation stands out as the greatest barrier to innovation in Africa."

Collaborative, multi-stakeholder initiatives that bring together government, industry and the research community are more likely to succeed and to be sustained in the long term. The rapid development in Africa of collective innovation spaces and places (tech hubs, living labs, open innovation spaces, fab labs (digital fabrication laboratories), local clusters, etc.) has led to low-cost solutions to local problems, which should continue to be supported.

Scientists from Europe and Africa collaborating in the field ©EU, by Andreas Brink

The EU-Africa High Level Policy Dialogue (HLPD) on Science, Technology and Innovation (adopted in 2010) is co-chaired by the EU and the AU. In practice, this task is carried out by the European Commission's Directorate-General for Research and Innovation (DG RTD), and the Member States chairing the African Ministerial Council on Science and Technology (AMCOST). The EU-Africa HLPD on Science, Technology and Innovation provides a platform for regular interactions on research and innovation policy, and aims to formulate and implement long-term priorities related to cooperation between Africa and Europe on science, technology and innovation. Within this framework, the Research and Innovation Network for Europe and Africa project is funded by the EU's Horizon 2020 research and innovation programme (see the Africa-EU Science, Technology& Innovation Portal).

Despite the increasing adoption of international standards, investment in and the impacts of research and innovation (R&I)[56] remain very difficult to measure in the African context. Without indicators and adequate local measurement sources (company-level data, local innovation surveys, national statistics on R&I performance) to monitor Africa's scientific and technological developments, governments will find it very difficult to formulate and implement R&I policies for the development of their territories. Recognising this need, the AU established the African Observatory for Science, Technology and Innovation (AOSTI). Among others, AOSTI is the technical office in charge of the design and collection of statistics and the development of monitoring and evaluation tools in the field of science, technology and innovation.

2) Gaps, future actions and priorities to be considered

Despite the creation of AOSTI, most R&I assessments are carried out by international organisations and triggered by AU institutions. Ideally, countries should develop systematic statistical frameworks and tools to monitor and evaluate their R&I capabilities at different geographical levels, and to monitor local, regional and global innovation and technology trends. Therefore, the continued uptake of international guidelines and standards should be combined with dedicated training courses to develop the expertise of researchers and government officials in the collection and interpretation of innovation data.

Furthermore, the analysis of creation and innovation processes in the informal sector is fundamental as it constitutes a major sector in many African economies, and employs mainly young people and women. In this perspective, the official registration of enterprises and employees should facilitate an effective monitoring of and support for innovation in the informal sector. The actions, combined with additional activities to better understand the learning and innovation processes, networking and knowledge-sharing practices in the informal sector, together with the provision of adequate means to acknowledge and protect their innovation, should all be considered an integral part of R&I strategies in Africa.

56 R&I includes both R&D activities (fundamental, and applied research as well as experimental development) and innovation activities (which involve the generation and diffusion of new ideas, methods or products). The distinction between R&D and R&I reflects the recognition that not all innovations derive from R&D efforts or investments, i.e. firms can adopt or create new ways of doing things without undertaking formal R&D activities, for instance through interactions with their customers.

Supporting references and web links

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1.2. Research and innovation policies for sustainable territorial development

1) Key findings

Assessment of the situation

Awareness of the importance of R&I for economic growth and development has led many governments to develop dedicated programmes and plans to support and promote R&I activities.

Innovation policies generally designate a set of public actions and programmes that aim to support the generation and diffusion of innovation with a view to stimulating economic development. They cover a wide range of instruments, including direct R&I funding, fiscal support to R&I investments, the provision of technical services and advice, science and innovation networks and the protection of intellectual property (e.g. patents, trademarks, designs, copyrights, geographical indications), as well as measures to stimulate the demand for innovation and to facilitate access to finance and venture capital for innovative start-ups and entrepreneurs. Sound public policy and governance for innovation can have a significant impact in terms of, for instance, increased R&I activities by local firms, enhanced provision of skills, access to expertise and relevant knowledge, and knowledge sharing and networks (such as the Compendium of Evidence on Innovation Policy, and the Innovation Policy Platform of the World Bank and the Organisation for Economic Co-operation and Development (OECD)).

Policies often focus on developing the innovation capabilities and performance of a given territory (i.e. country or region), through support to specific industries (vertical policies), across sectors (horizontal policies) or through mixed policy approaches. Also known as 'place-based' innovation policies, territorial innovation policies are usually developed at the national or regional levels, targeting the sustainability and effective functioning of national and/or regional systems of innovation, i.e. the system of organisations and institutions involved in the creation and diffusion of knowledge and innovation.

> “The New Economic Partnership for Africa (NEPAD) was created in 2001 to promote capacity building in the area of industrialisation, research and development and STI.”

At the continental level, the AU has been very proactive in science, technology and innovation (STI) policymaking with the aim of fostering regional economic integration and development. The New Economic Partnership for Africa (NEPAD, adopted in 2001), has an explicit mandate to promote capacity-building in the area of industrialisation, R&D and STI. More recently, the Science, Technology and Innovation Strategy for Africa – 2024 (STISA-2024), which was adopted in 2014, confirms African policymakers' awareness of the role of innovation.

The Joint Africa-EU Strategy (JAES) also recognises the role of STI policies in the attainment of several socio-economic development objectives. It highlights the need to reinforce "cooperation between research communities and the creation of joint academic research programmes, with a special focus on innovation and the productive sector, including research infrastructures". Key areas include food and nutrition, security, and sustainable agriculture.

> “A one-size-fits-all approach is often adopted when designing STI strategies, which does not take into account the specificities of local resources, challenges or needs.”

Observations on STI policymaking at country level present a heterogeneous picture, with widely differing calendars for strategy roll-out and implementation. Although some progress has been made, certain countries still depend heavily on funding from abroad (in 2014, over 50 % of GERD in countries such as Uganda, Mozambique and Burkina Faso was funded from abroad), or from the government sector (in 2014, more than 90 % of GERD in Egypt, Mali, Togo and Zambia was government funded (UNESCO Institute for Statistics, August 2016). Moreover, many countries also have limited expertise in STI policymaking and weak multi-level institutional coordination (African Union, 2014).

Scientists from the JRC and the Regional Centre for Mapping of Resources for Development (RCMRD) carrying out joint field measurements in Kenya ©EU, by Andreas Brink and Grégoire Dubois

A one-size-fits-all approach is often adopted for designing STI strategies, which does not take into account the specificities of local resources, challenges or needs. Moreover, national governments cannot always assess the costs of implementing STI policies, which hampers the monitoring, evaluation and the estimation of their outcomes (UNECA, 2016). Often, the selection of priorities is not backed up by the systematic collection of evidence and in-depth analyses of the R&I potential of local actors and industry. Priorities for innovation are mostly identified and defined in a centralised and top-down manner, with little or no involvement of other key actors, i.e. firms, universities, research centres and civil society.

Challenges and opportunities

Africa's growing youth population has embraced the innovation culture, as is shown by the rapid development of open innovation communities throughout the continent (see chapter II.1.1). However, policymakers should consider innovation as a cross-cutting dimension in their national plans supporting the development and sustainability of local innovation systems. Moreover, it is not enough just to design an innovation policy and governance. The implementation of such policies should rely on instruments, actions and institutions that are appropriate to the socio-economic characteristics of their territories and populations.

At the EU level, research and innovation strategies for smart specialisation (RIS3) have been promoted under EUCohesion Policy as insightful, flexible and step-based approaches for the conception and implementation of territorial innovation policies. Adopted by more than 100 EU regions, R&I strategies for smart specialisation are made up of place-based agendas that target knowledge- and innovation-led economic transformation. In this framework, territories are expected to concentrate their resources for innovation around a few selected priority areas. Priority territories should be identified with an inclusive and bottom-up approach, ensuring that directions for economic development are decided consensually between local actors, i.e. firms, universities, research centres, governments and civil society. This has already led to the emergence of novel and broader participatory processes and relevant benchmarking exercises for identifying priorities and designing territorial governance mechanisms (see the EU's Smart Specialisation Platform).In the African context, such a perspective may offer relevant opportunities to design and implement, where appropriate, place-based and inclusive territorial innovation policies[57] adapted to local needs, challenges and resources.

> "R&I strategies for smart specialisation could help design and implement place-based and inclusive territorial innovation policies adapted to local needs, challenges and resources in Africa."

Policy framework

The AU's STISA-2024 aims to accelerate the transition towards innovation- and knowledge-based economies. It identifies continental challenges in relation to entrepreneurship, innovation and an enabling environment for STI. In parallel, the AU is setting up continental institutions for the implementation of the STI strategy, such as AOSTI and the pan-African university continental network. AOSTI's responsibilities include collecting statistics to assess the innovation performance of African countries and the capacity-building and training of national experts in STI policymaking.

> "The Science, Technology and Innovation Strategy for Africa - 2024 (STISA-2024) aims to accelerate the transition towards innovation- and knowledge-based economies."

57 See Dosso (2017) for an early discussion document on the common challenges and opportunities of research and innovation strategies for smart specialisation (RIS3) in the sub-Saharan African context.

STISA-2024 addresses several SDGs, especially SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation.

2) Gaps, future actions and priorities to be considered

An enabling-innovation environment is crucial for the uptake of Africa-led innovations. Beyond the financial support, public intervention for innovation is also needed to build up and maintain knowledge creation and innovation infrastructure (e.g. laboratories, research centres and universities). Cooperation for innovation should be promoted, for instance by supporting the links between research and business, user-producer relations and collaborations between firms to address issues of local population and territorial development. In addition, effective information channels are also needed to promote a more pervasive culture of science and innovation in Africa, especially in resource-based economic sectors beyond the ICT industries. Failure to design territorial or place-based innovation strategies informed by reliable evidence will reduce the ability of African countries to maximise the innovative potential of their societies, thus limiting future growth opportunities and the long-term resilience of their economies.

Africa-EU collaboration on the design and implementation of territorial innovation policies would be a positive step towards extending the actions of the High Level Africa-EU STI policy dialogue under the Joint Africa-EU Strategy (JAES). In this perspective,the JRC is prioritising the development of international cooperation in the area of smart specialisation. Indeed, working outside of the EU can provide further inspiration for such exploration.

Pilot exercises on an initial selection of African urban and regional areas would lay the foundations for more concrete and wider collaboration and mutual learning between Africa and Europe on territorial innovation policies. These would also help to explore opportunities for setting up a joint JRC-AOSTI initiative with a view to identifying best international practices in the design and implementation of place-based innovation policies and the monitoring of innovation-led territorial development strategies.

Supporting references and web links

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Innovation Policy Platform: https://www.innovationpolicyplatform.org

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2. Knowledge sharing, education and training

Knowledge is essential for creating and sustaining competitive advantage, as well as for decision-making and management processes, at all levels. Generally speaking, knowledge sharing is the exchange of knowledge (including information and know-how) among individuals, communities or organisations. More specifically, it can be defined as "the provision of task information and know-how to help others and to collaborate with others tosolve problems, develop new ideas, or implement policies or procedures" (Wang and Noe, 2009). In the knowledge-based economy, the potential benefits of knowledge sharing, within organisations and networks and more broadly, have received increasing attention. Furthermore, the understanding of knowledge sharing has moved away from the traditional idea of a transfer from one party to another towards the concept of co-production of knowledge and mutual learning as a transformative process generating benefits for all parties (Martinez-Fernandez et al., 2011; OECD, n.d.).

In the context of development cooperation, the importance of knowledge sharing has been emphasised in different fora, and is reflected notably in the Multi-Year Action Plan on Development adopted by the G20 leaders in Seoul in 2010[58]. Knowledge sharing is one of the plan's nine pillars and should be mainstreamed in all other pillars, recognising that sharing development experiences, including through North-South, South-South and triangularcooperation, contributes to the adoption of the most relevant and effective development solutions. Furthermore, knowledge sharing is essential for addressing global challenges.

1) Key findings

The past few decades have seen dramatic growth in the amount of data, information and knowledge available to policymakers across all disciplines. The recent technological revolution has expanded enormously our ability to gather, analyse, produce and disseminate information more rapidly than ever before. The Internet of Things, wearable sensors and Earth-observation satellites further generate huge amounts of data that can serve a broad range of societal applications. Concurring trends at the global level are a specialisation of R&D and the diversification of knowledge and skills.

58 https://www.oecd.org/g20/summits/seoul/Annex2-Multi-Year-Action-Plan-Development.pdf

In the knowledge-based economy, human capital and R&I play an increasingly important role in social and economic development. However, there is a risk of a growing divide between countries that generate most of the latest scientific knowledge and those with lower capacities for knowledge production, access and use.

Although African countries have recently increased their investments in R&D, innovation and higher education (see chapter II.1), the strengthening of capacities in STI remains a major challenge. A recent report from the African Capacity Building Foundation (2017) highlights significant bottlenecks in human and institutional capacities, skills and expertise, infrastructure and equipment, and financial resources to promote STI, although the situation differs markedly across the continent. In an annual survey of African countries to assess capacity needs in STI, training emerges as the top priority area, being considered as a high or very high priority by 91 % of the countries (ACBF, 2017).Overall, African countries still face a major skills shortage: Africa has only 35 scientists and engineers per million inhabitants, compared to 168 in Brazil, 2457 in Europe and 4103 in the United States (Shizha & Diallo, 2015).

> "Africa has only 35 scientists and engineers per million inhabitants, compared with 168 in Brazil, 2 457 in Europe and 4 103 in the United States."

Knowledge sharing has a key role to play to help address some of these challenges.ICTs have provided a range of tools that complement the traditional instruments of knowledge sharing (face-to-face meetings, publications, etc.) and offer a vast potential to expand it. Greater use of the internet, with online communities, interactive web portals, etc., provide multiple opportunities that could be seized by African countries to promote the development of knowledge-sharing initiatives and practices. Moreover, for education and training, the greater availability of e-learning courses and tools also offers many possibilities (see education and training below). This implies, however, that the development of skills for using ICT is critical, as well as the provision of knowledge-sharing spaces and infrastructures/facilities such as physical libraries and fast internet access.

One area of particular importance is strengthening the science-policy interface. For public policies to be effective, transparent and consistent, they should be based on robust evidence. The efforts to promote evidence-informed policymaking contribute to accountability and to overall good governance. However, research findings must be translated into usable knowledge if they are to influence policy development and implementation. Scientific data are often complex and scattered, and not all the information available is reliable or policy-relevant. Information and its analysis need to be presented in structured ways and in a language that users can easily understand. Furthermore, many policy problems require interdisciplinary analyses and solutions and close science-policy interaction. Online information systems and decision-support tools, as well as institutions such as observatories and centres of excellence, can facilitate the integration of scientific evidence into policymaking.

Dedicated decision-support systems, developed through direct interaction with users, or internet platforms for knowledge sharing, can be useful tools for policy- and decision-makers from the global to the local scale. Over the past 15 years, the JRC has developed and made available online thematic platforms that address issues at the African and global scales (see chapter II.3.2). Such platforms gather, organise and process scientific information on specific topics, using international and regional scientific networks and thereby fostering cooperation. The information is presented in a way that can inform decision-making processes. These information systems help standardise approaches and make information comparable over time and space, they facilitate the elaboration of scenarios as well as integrated planning, and they can support crisis prevention and management. Their development and use can also help strengthen capacities in information technologies and geospatial analysis.

Training and capacity-building workshop on the use of remote-sensing to map deforestation ©EU, by Andreas Brink

Regional observatories and related networks (such as the Biodiversity and Protected Areas Management (BIOPAMA) pan-African network of Regional Observatories and the African Network for Basin Organizations) can also play an important role in providing decision-makers with relevant and reliable information and supporting strategic planning. They can develop their own information systems or make use of existing ones. They can also help overcome silos by targeting stakeholders from different sectors. Internalisation of the regional observatories within political institutions (such as the Regional Economic Communities) reinforces their mandate and is proven to be more effective in enhancing evidence-informed decision-making.

Centres of Excellence (CoEs), such as the Water CoEs established by the New Partnership for Africa's Development (NEPAD) (see Box 34),and the Africa Higher Education Centres of Excellence supported by the World Bank, promote scientific and technical expertise, support networks and provide leadership and capacity-building for research and education in specific areas. They can foster the development of local capacities and South-South scientific cooperation. Thematic centres like the Water CoEs can also play important roles in strengthening the interface between science and policy by promoting the development of decision-support tools and skills at the national and regional level.

BOX 34

The NEPAD Water Centres of Excellence

The AU, through NEPAD's African Centres of Excellence (CoEs)[59] on Water (ACE-Water initiative), brings together a network of higher education and research institutions to conduct scientific research and capacity-building activities in water-related sectors. In line with EU development policy on water and sanitation, the JRC and the United Nations Educational, Scientific and Cultural Organization (UNESCO) International Hydrological Programme support the establishment and operations of NEPAD networks of CoEs in Western, Southern and Eastern-Central Africa. Under the mandate of the African Ministers' Council on Water (AMCOW), and in cooperation with key stakeholders such as Regional Economic Communities and River Basin Organisations, NEPAD coordinates the activities of the CoEs, focusing on capacity-building, transboundary water-resources management, and research on climate variability and on the water-energy-food-ecosystems (WEFE) nexus (Donin et al., 2014; Ronco et al., 2017).

The initiative involves a wide range of international partners (UNESCO-IHE, UNESCO-IHP, Cap-Net, WaterNet, and development cooperation agencies) and African national partners. The Southern African Network of Water Centres of Excellence (SANWATCE) includes 10 universities and other scientific institutions from South Africa, Mozambique, Malawi, Zambia, Botswana, Namibia, Zimbabwe and Mauritius. The Western African Network of Water Centres of Excellence (WANWATCE) has five members from Senegal, Nigeria, Burkina Faso and Ghana. The Central Eastern African Network (CEANWATCE) is currently being established and has received applications from Uganda, Ethiopia, Kenya and Sudan.

Building scientific and technical capacities requires multilateral cooperative dialogue between scientists, key stakeholders and policymakers; for water management, the regional and river-basin scales have proven to be the most prominent levels of approach. In addition to setting up the networks, the activities include inter alia the development of scientific tools to support decision-making and assessment of the scientific and technical skills needed to address WEFE nexus issues in Africa.

59 http://nepadwatercoe.org/

BOX 35

The Covenant of Mayors in sub-Saharan Africa

Sustainable urban development is one of the main challenges facing Africa. In cities, greenhouse gas and air pollutant emission reduction, greater energy efficiency and the promotion of renewable energies are of particular importance. The 2015 Paris Climate Agreement has given a new impulse to local measures designed to mitigate or adapt to climate change. A range of programmes are being developed by city networks and at the national level, including international initiatives such as the Covenant of Mayors for Climate and Energy and the Compact of Mayors[60].

The Covenant of Mayors for Climate and Energy (CoM)[61] is a European movement involving local and regional authorities which voluntarily commit to increasing energy efficiency and the use of renewable energy sources on their territories. Signatories prepare Sustainable Energy and Climate Action Plans (SECAPs), which include concrete actions that are the subject of a monitoring report. Within the wider objectives of the decarbonisation of the economy and reducing the environmental footprint of human activities, especially in urban areas, the CoM includes activities to promote local renewable energy production (e.g. solar power and bioenergy) and other local measures to reduce carbon dioxide emissions. Since 2008, the JRC has provided scientific and technical support for the initiative.

Since the beginning of 2017, CoM activities are being extended to sub-Saharan Africa. Technical cooperation is also being established with the Global Covenant of Mayors for Climate and Energy, a recently launched worldwide umbrella organisation (with JRC participation in technical working groups). While the CoM activities in Europe initially focused on climate change mitigation, adaptation is receiving growing attention, and access to energy will be added for low-income countries and communities. The activities of the CoM in sub-Saharan Africa will be carried out in close cooperation with the AU, the European Commission's DG DEVCO, the Council of European Municipalities and Regions, the Sustainable Energy for All initiative, United Cities and Local Governments, United Nations Habitat, theEuropean platform of local and regional authorities for development(PLATFORMA project), United Cities and Local Governments of Africa (UCLGA), and the Global Covenant of Mayors for Climate and Energy.

The CoM's quantitative assessment (which has 6201 signatories, representing 213 million inhabitants and 315 monitoring inventories, and is estimated to have achieved a 23 % reduction in emissions (Kona et al., 2016)) was presented at the 22nd session of the Conference of the Partiesto the United Nations Framework Convention on Climate Change (UNFCCC, COP 22[62]) in Marrakech in November 2016. The CoM initiative in Africa currently embraces 6.63 million inhabitants, corresponding to approximately 1.3 % of the urban population. This figure will increase as other African cities join.

Pilot projects have been awarded to a first group of cities/municipalities in sub-Saharan Africa, including Kampala (Uganda), Lubumbashi (DRC), Dakar (Senegal), Bouaké (Côte d'Ivoire), Communauté de Communes du Zou (Benin), Nouakchott (Mauritania) and Tsévié (Togo). The first seven African cities to join the CoM initiative range from Lubumbashi (with a population of 1 790 000) to Tsévié (with a population of 54 000).

With the support of DG DEVCO, a series of activities are being prepared for the sub-Saharan African CoM. They include the provision of assistance for developing SECAPS, the development of criteria for multi-level governance and sustainable energy policies and plans, and the adaptation of the CoM methodology for SECAPs and emission inventories to take into account the specific needs of cities in sub-Saharan Africa and the development of reporting tools. It is expected that these efforts will enable the implementation and monitoring of the CoM initiative in sub-Saharan Africa, with a new timeframe (2030), and quantitative goals for reducing GHG emissions.

60 The Compact of Mayors is the world's largest cooperative effort among mayors and city officials to reduce greenhouse gas emissions and climate risks in cities; see https://www.compactofmayors.org/

61 http://www.covenantofmayors.eu/index_en.html

62 http://unfccc.int/meetings/marrakech_nov_2016/meeting/9567.php

Education and training

Education provides knowledge and skills, empowers people, helps strengthen civil society, and drives social and economic development. Higher education and training are crucial to enable countries to absorb and use technologies and take an active part in the global knowledge economy. However, the role of basic education remains essential as it lays the foundations for the further acquisition of skills.

Africa has the youngest population of all continents: 50 % of Africans are under the age of 19.5 years. African countries devote a substantial proportion of government expenditure to education (with a median share of 18.4 % in sub-Saharan Africa compared to a world share of 13.7 %, although this median value masks large variations among countries, from 7.8 % in Central African Republic to 33.1 % in Ghana) (Africa-America Institute, 2015). From 2000 to 2012, public expenditure on education in sub-Saharan Africa grew by 6.1 % per year, outpacing economic growth (4.0 %) (UNESCO, 2015). Although education is improving, it still has a long way to go to meet the targets set for example by Agenda 2030 and its SDG 4 to “Ensure inclusive and quality education for all and promote lifelong learning”.

The number of children enrolled in primary school in Africa rose from 62 million to 149 million between 1990 and 2012. Despite this massive expansion, 38 million children of primary school age were not enrolled in school in 2012 (UNESCO, 2015). Poverty, lack of access to basic social services such as water, sanitation and energy, as well as conflicts all affect enrolment rates, in particular for girls. Enrolment in secondary schools also increased strongly from 2000 to 2012 in Africa, although the enrolment rate still averages only 36 %. As access to education has increased faster than spending, the quality of education has been negatively affected (Africa-America Institute, 2015).

Education in the rural areas of Mozambique ©EU, by Paolo Ronco

In 2012, formal technical vocational education and training (TVET) accounted for only about 6 % of secondary enrolment in sub-Saharan Africa (UNESCO, 2015); however, skills are also largely acquired on-the-job, for which there is a lack of accurate data. Analyses have pointed to the need to improve the quality and relevance of TVET systems in Africa (Filmer and Fox, 2014). In recent years, TVET has moved higher up the global education policy agenda, andthe reform and revitalisation of TVET systemsis receiving greater attention(Marope et al., 2015).

> “Although enrolments have more than doubled since 2000, enrolment rates in higher education in sub-Saharan Africa are still among the lowest in the world.”

Enrolment rates in higher education in sub-Saharan Africa are among the lowest in the world (6 % of the relevant age group in 2012, compared to the global average of 26 %; Africa-America Institute, 2015). Efforts have been largely focused on primary education, with a decline in per-capita spending on higher education in the 1980s-90s. This low priority was reversed only recently: between 2000 and 2010, higher education enrolment more than doubled (from 2.3 million to 5.2 million; Africa-America Institute, 2015). While students are mainly enrolled at the bachelor level, there has also been a substantial increase in enrolments and graduations at the master’s level. In parallel, private higher education is a fast-growing sector. While all of this helps to increase the pool of skilled workers, the proportion of students engaged in doctoral studies is very low, due partly to inadequate incentive structures (Cloete et al., 2011). This has negative consequences in terms of scientific output and capacity to meet the recruitment needs of research institutes and the private sector. Furthermore, enrolment in science, engineering and technology remains insufficient, despite an increase in recent years: more than 80 % of student enrolments are in social sciences and humanities (ACBF, 2016).

Professional development training opportunities in Africa are still inadequate to respond to labour market needs, in particular for medium- and high-level scientific and technical skills. Surveys confirm that there is a demand for skills in science and engineering (ACBF, 2017). Consequently, Africa continues to rely on imported expertise. A study by ACBF has estimated that building the capacities needed to implement the STISA-2024 would imply a massive increase in the number of engineers and agricultural scientists (ACBF, 2016). Ad-hoc training courses for decision-makers are also regularly found to be insufficient to meet the needs.For example, in the water sector, a detailed survey on requirements in higher education and training for practitioners covering southern African countries (SADC) identified training needs for hydrologists, hydrogeologists, statisticians, environmental specialists, economists and planners, as well as for decision-makers and students at undergraduate and postgraduate levels (Ronco et al., 2017).

Training on the use of satellite images for land-cover mapping ©EU, by Andreas Brink

Vocational and continuous on-the-job training are needed to ensure that workers' skills are upgraded to meet the changing needs of the economy and adapt to technological progress. For example, the introduction of geospatial information technology demands a combination of traditional skills with those related to new technology and spatial-data handling. It has been estimated that the majority of professionals involved in geospatial information activities in Africa were trained in obsolete methods of map production, due notably to the fact that many institutions were not adequately equipped to provide efficient training courses (Kufoniyi et al., 2002). A critical mass of well-trained staff is needed to benefit from the current flow of geospatial data (much of it made available on a no-cost basis, such as satellite imagery from Europe's Copernicus programme).

The migration of highly skilled workers – the brain drain – further contributes to the shortage of educated and technically proficient professionals. In 2010-2011, one in every nine people who were born in Africa and have a university degree lived in one of the 34 member states of the Organisation for Economic Co-operation and Development (OECD), i.e. the world's most developed countries (UN-DESA and OECD, 2013).

Outlook

Africa is the world region with the largest expected growth in the number of young people, with the number of those aged 15-24 years (230 million in 2015) projected to increase by 44 % between 2015 and 2030 (United Nations, 2015b). Some 11 million young people are expected to enter the labour market every year over the coming decade (Africa-America Institute, 2015).

Because of the considerable progress made in the last 15 years in access to primary education, pressure to expand secondary education is growing. Based on current trends, 59 % of 20-24-year-olds will have completed secondary education in 2030, compared to 42 % today. This will translate into 137 million in that age range with secondary education and 12 million with tertiary education in 2030 (AfDB et al., 2012). Of course, the actual outcomes will depend on national education policies.

Educational attainment needs to be accompanied by building skills in order to benefit from a globalising economy and help address the challenge of youth employment. The development of human capital is essential even if not sufficient alone to ensure that the economy generates enough employment opportunities to absorb the growing labour force. Even if the formal private sector grows steadily, the household enterprise sector and the agriculture sector are expected to remain the main sources of new employment at least over the next decade (AfDB et al., 2012; Filmer and Fox, 2014). However, skills development can also play an important role for employment and productivity in these sectors (Filmer and Fox, 2014; UNESCO, 2015).

Challenges and opportunities

Africa's growing labour force, when populations in much of the world are ageing, and improvements in education provide considerable opportunities for economic growth and social development.

However, in the short-and medium-term, considerable challenges remain. Substantial efforts in terms of financial and human resources will be needed to maintain the growth in primary education and expand school enrolment in secondary education,while improving the quality of education. It is estimated that 1 million new teachers will have to be recruited to achieve the universal primary education target (Africa-America Institute, 2015); large shortages of qualified teachers will also have to be addressed to meet the needs of a growing secondary education sector.

The higher education and training sectors face the challenge of having to rapidly develop a specialised workforce and address shortages, taking into account the financial constraints of many African countries. As regards higher education, key issues include insufficient research funding in universities, a lack of support for postgraduate students, a fragmentation of initiatives and a lack of coordination among stakeholders, including international donors (Cloete et al. 2011).

Fostering South-South and North-South networks can play a role in strengthening research and education and increasing the availability of education and training programmes. Notably, such collaborations (involving universities and training institutions) can help overcome constraints, such as insufficient financial resources, obsolete or rigid curricula, and inadequate equipment (Kufoniyi et al, 2002).

Group photo of technical and scientific staff from West African institutions and the JRC ©EU, by Andreas Brink

However, national and pan-African policies and investments are essential. The development of CoE and initiatives such as the AUC's Pan-African University deserve particular attention and international support. This network of university nodes in Africa's five geographic regions aims to enhance the attractiveness of African institutions by providing quality postgraduate education and engaging in collaborative and development-oriented research programmes.

Policy framework

The importance of STI as key drivers of socio-economic development has been emphasised in Agenda 2063 and is reflected in the adoption of both the NEPAD and STISA-2024 (see chapter II.1).

At the global level, following the World Conference on Education for All in 1990, universal education objectives were reaffirmed in 2000 at the World Education Forum in Dakar (Senegal). SDG 4 calls for universal education and training ("Ensure inclusive and quality education for all and promote lifelong learning"). Agenda 2063 outlines the objectives of universal early childhood development, basic education, and sustained investments in higher education. The AU's Continental Education Strategy for Africa (CESA 2016-2025; African Union, 2016) provides a framework with strategic priorities for education and training systems in the coming decade.

Human development is one of the five priorities of the Joint Africa-EU Strategy (JAES) Roadmap for 2014-2017, which foresees reinforced cooperation between research communities and the creation of joint academic research programmes, with a special focus on innovation. The EU-Africa High Level Policy Dialogue (HLPD) on science, technology and innovation is the key platform for priority-setting and implementation design. The JAES Roadmap also calls for cooperation on higher education, including actions to facilitate student mobility and the development of CoE in Africa.

2) Gaps, future actions and priorities to be considered

The development of education and, more recently, the promotion of STI are major priorities for most African countries and will require sustained efforts. Some specific aspects that deserve attention include:

- promoting education and training initiatives in youth employment areas (such as computer and geospatial sciences and technologies);
- strengthening vocational training, in cooperation with the private sector;
- supporting mechanisms that make the link between education (notably curricula design) and training programmes and private-sector needs;
- developing incentives to mitigate the braindrain;
- supporting local and international knowledge-sharing initiatives, networks and practices;
- introducing skills for using scientific evidence in policymaking in administration- and research-oriented higher education curricula and developing targeted training for decision-makers;
- further improving the accessibility and dissemination of data and data products;
- developing ad-hoc thematic and integrated decision-support systems for decision-makers.

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3. Earth observation and geospatial information systems

3.1. Sharing Earth observation infrastructure

1) Key findings

Assessment of the situation

Reliable and systematic geospatial information at regional to continental scales is essential for the efficient monitoring of crop yields and food-security situations, marine resources, wildfires as well as forests and other climate drivers (affecting GHG emission scenarios). Detailed and regularly updated geospatial information is also required for assessing migration flows, anthropogenic pressures on protected areas, urban development, and roads and communication infrastructures. A growing need has been identified for geospatial-information mapping of the risks of extreme events and disasters (IPCC, 2012).

Observations from civilian Earth-orbiting satellites represent an essential, systematic and reliable source of information, which may be applied to different thematic contexts (such as water, fires, air quality, biodiversity, dust storms, heatwaves, human settlements, electrification, disaster risks, etc.), irrespective of political borders and geographic zones. Such information can be provided by early-warning systems, and can reduce the loss of lives and damage to property.

Recognising the relevance of Earth observation, funding bodies such as the United States Agency for International Development (USAID) (see the SERVIR initiative – the name comes from the Spanish for 'serve') and the Japan International Cooperation Agency (JICA) support development projects in Africa based on satellite data. These projects arose from international agreements such as the United Nations (UN) Millennium Development Goals and NEPAD.

> "As of 2017, fifteen African countries and organisations are members of the international Group on Earth Observations (GEO)."

The UN uses Earth observation in many of its agencies, including its Food and Agriculture Organization (FAO), the World Meteorological Organization (WMO), the United Nations Economic Commission for Africa (UNECA) and the United Nations Environment Programme (UNEP). The recently adopted 2030 Agenda on Sustainable Development[63] specifically mentions Earth observation as a tool for tracking progress in implementation of the Sustainable Development Goalsand their related targets.

A receiving station on the Bale mountains in Ethiopia ©EU, by Andreas Brink

The application of civilian Earth observation has been given a boost through the activities of the Group on Earth Observations (GEO). Currently, 80 nations and 58 organisations are members of the GEO, including 15 African countries and institutions. Over the period 2005-2015, the GEO built up the Global Earth Observation System of Systems (GEOSS) in view of achieving comprehensive, coordinated and sustained observations of the overall Earth system, with emphasis on the delivery of timely, quality-assured, long-term global information as a basis for sound decision-making in a variety of areas and for a broad range of users.

Within the GEOSS framework, the AfriGEOSS initiative aims to strengthen the link between current GEO activities and existing capabilities and initiatives in Africa. Its objective is to help countries and organisations to benefit from bilateral and multilateral Earth-observation-based initiatives across Africa. GEOSS has also established a near-real-time global network of satellite-based data-dissemination systems designed to distribute space-based, air-borne and *in-situ* data, metadata and products to diverse communities. This network, known as GEONETCast, is gradually being introduced into African organisations.

The African Association of Remote Sensing of the Environment (AARSE), founded in 1992, became a regional member of the International Society for

63 Transforming our world: the 2030 Agenda for Sustainable Development.

Photogrammetry and Remote Sensing (ISPRS) in 1994. The association's primary objective is to raise awareness of African governments and their institutions, the private sector and society at large about the benefits of developing and using responsibly the products and services of Earth-observation systems and geo-information technology. Since 1996, AARSE has held biennial international conferences across Africa, and conducted other awareness-raising and capacity-building activities. African universities also collaborate in the University Network for Disaster Risk Reduction in Africa (UNEDRA), which is dedicated to promoting collaboration and running training courses in this field.

Many of the African nations are directly involved in Earth observation, both as collectors and users of data. South Africa[64], Nigeria[65], Algeria[66] and Egypt each operate satellites with Earth-observation sensors.

The African Resources Management (see Mostert, 2008) satellite constellation is a joint satellite programme of South Africa, Nigeria, Kenya and Algeria and any other interested country in Africa. It is one of the key flagship projects of the NEPAD science and technology ministerial programme. It has been described as fulfilling the need for regular high-resolution data on Africa for resource-management applications.

Outlook

Civilian Earth observation is expected to play an increasing role in supporting policymaking in Africa, considering the need for synoptic and reliable information at the continental level and the technological development of the space and ICT sectors. For instance, it is estimated that around 420 civil and commercial satellites (>50 kg) will be launched worldwide between 2016 and 2025, generating US$35.5 billion, EUR 29 billion with 2017 exchange rates, in manufacturing revenues (Euroconsult, 2016).

During their 26th Ordinary Session in January 2016 in Addis Ababa, the AUheads of state and government adopted the 'African Space Policy and Strategy' as the first concrete step towards realising an African Outer Space Programme, which is one of the flagship programmes of the AU's Agenda 2063. They urged the AU member states, Regional Economic Communities, partners and the AU Commission to raise awareness on the central role of space science and technology in Africa's socio-economic development, and to mobilise domestic resources for implementing this policy and strategy. Adoption of the African space policy and strategy has set the pace for the collective revitalisation of African space activities, as a contribution to the goals of Agenda 2063.

Challenges and opportunities

More and more Earth observation datasets will become available in the coming decade, either as free or commercial products. Commercial-data providers play a significant role in Africa: it has been estimated that 62 agreements were in place in Africa in 2016 (compared to 181 in Europe and 84 in Latin America – see Euroconsult, 2016). Even more relevant is the possible role of free and open Earth-observation data, including the products delivered within the EU's Copernicus programme. However, these open datasets represent a significant burden in term of data volumes: it has been assessed (see SERCO, 2016) that,by the end of 2016, 1.23 PB (petabyte) of Sentinel-1 and Sentinel-2A products were generated and made available for users on the Open Access Hub – with a daily average volume of around 4.5 TB (terabyte) in November 2016.

Africa's telecommunications landscape has greatly evolved in recent years. This is characterised by the extension of submarine cable infrastructure linking Africa to the rest of the world (Many Possibilities,African Undersea Cables[67]) and expansion of the terrestrial infrastructure network within the continent. As a result of these ongoing initiatives, the total capacity of terrestrial cross-border routes in sub-Saharan Africa grew from 33 Mbit/s in 2005 to 30 960 Mbit/s in 2011. There has also been impressive growth in the use of mobile phones.

However, several challenges remain for conveying the datasets from European hubs to African institutions at regional and national level. Establishing continental hubs will be beneficial, as well as re-enforcing other dissemination systems, such as GEONETCast[68]. Additional challenges lie in deriving fit-for-purpose informationfrom satellite observations, and in embedding such information in the policymaking and monitoring processes.

64 The South African National Space Agency (SANSA) was established in 2010. Following a period of rapid growth and transition, the agency has made significant progress towards addressing its mandate of deriving greater value from space science and technology for the benefit of South African society (http://www.sansa.org.za/).

65 In 2001, the government of Nigeria approved its National Space Policy and Programmes and the establishment of a National Space Research and Development Agency (NASRDA) to conduct appropriate R&D activities and consolidate all activities related to space science and technology, in order to make a greater impact on developmental efforts in Nigeria.

66 The Algerian Space Agency (or 'Agence Spatiale ALgérienne' - ASAL) is a public national institution with legal personality and financial autonomy, established in 2002 (http://www.asal.dz).

67 https://manypossibilities.net/african-undersea-cables/ (accessed June 2017).

68 GEONETCast is a global network of satellite-based data-dissemination systems providing environmental data to a worldwide user community.

BOX 35

The PUMA, AMESD and MESA initiatives

The EU, the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) and the European Space Agency (ESA) have a long record of involvement in projects designed to support the reception and usage of Earthobservation products in Africa. For example, the 'Preparation for the Use of Meteosat Second Generation in Africa' project (PUMA, 2001-2005) provided training on meteorological receiving stations in 47 sub-Saharan countries. The 'African Monitoring of the Environment for Sustainable Development' programme (AMESD, 2007-2013), an initiative of the European Commission and the AUC (funded through the European Development Fund), extended the operational use of Earth-observation technologies and data to environmental monitoring applications. The 'Monitoring of the Environment and Security in Africa' (MESA, 2013-2017) initiative consolidated AMESD's results and developed operational services for monitoring the environment, including agriculture, rangeland, fisheries and water management.

The 'GMES and Africa' initiative (2017-2021) will build on the results achieved by the PUMA, AMESD and MESA projects and will significantly strengthen African capacity to monitor the environment and security using Earthobservation techniques in three priority themes: 1) long-term management of natural resources; 2) marine and coastal regions; and 3) water-resource management.

Participants in a MESA workshop at the Intergovernmental Authority on Development (IGAD) Climate Prediction and Applications Centre (ICPAC) in Nairobi, Kenya ©EU, by Andreas Brink

The provision of infrastructure and Earthobservation data to African institutions has been complemented by training programmes designed to ensure that the beneficiaries can make the best use of the tools and methodologies. This aspect constituted a major part of the MESA initiative, so much so that a training strategy was defined to develop the competencies required to achieve the project's overall objectives. About 25 distance education courses have been developed on technical and thematic topics, as well as 10 on communication and outreach and policy dialogue. These courses are given through the online learning platform for the MESA training programme (Training4MESA[69]), where all training resources are accessible. Onsite training courses on the maintenance and operation of satellite reception stations are also offered by the JRC and EUMETSAT.

Through the MESA projects, around 160 Earthobservation receiving stations (eStations) have been deployed in 47 countries, at the regional and national level, including in four training centres mandated by the World Meteorological Organization (WMO). More than 2200 African experts were trained on the maintenance and use of the eStations, andover 100 operational products were developed to meet the needs of the 18 application services (see also chapter I.5.2).

69 http://training4mesa.org/

FIGURE 100: Overview of the locations of eStation 2.0 in Africa, and of the available Earth observationproducts *(JRC MESA Project)*

	Spatial resolution	Data since	Time composite
RAINFALL			
MSG MPE	3km	2010	15' to 10 day
TAMSAT RFE	4km	1983	10 day to yearly
FEWSNET RFE	8km	1981	10 day to yearly
CHIRPS2.0 RFE	8km	1981	10 day to yearly
ARC2 NCEP	10km	1983	1 day to yearly
ECMWF OPE	25km	2008	10 day
TEMPERATURE			
Landsaf LST - METOP	1km	2007	15' to monthly
Landsaf LST - MSG	5km	2009	15' to monthly
VEGETATION			
SPOT VGT + PROBA V	1km	1998	10 day to monthly
FIRE			
MODIS	1km	2002	10 day to monthly
BURNT AREA			
MODIS	1km	2002	10 day to monthly
EVAPOTRANSPIRATION			
MSG - LSASAF	5km	2009	30' to monthly
ECMWF OPE	25km	2008	10 day
WATER BODY			
LANDSAT WATER BODY	30m	1983	monthly
MARINE			
MODIS SST	4km	2002	1 day to monthly
PML SST	1km	2012	3 day to monthly
SST FRONT	1km	2012	1 day to monthly
MODIS CHLA	4km	2002	1 day to monthly
PML CHLA	1km	2012	3 day to monthly
MODIS KD490	4km	2002	1 day to monthly
PML KD490	1km	2012	3 day to monthly
MODIS PAR	4km	2002	1 day to monthly
MODIS PP	4km	2002	3 day to monthly

Policy framework

The Maputo Declaration adopted in 2006 by African partners[70] explicitly called upon the EU to plan for an extension of the GMES programme (now Copernicus) to Africa.

During the Lisbon Summit (2007), African and EU heads of state agreed on an ‘Action Plan on GMES and Africa’ as part of the Joint Africa-EU Strategy (JAES). The main objective was to allow Africa to make full use of the potential of space systems for sustainable development, and to reinforce Africa’s ownership and capacity in using and developing remote-sensing applications.

More recently, the 4th Africa-EU Summit (Brussels, 2014) called for the “establishment of a coherent framework for the development of Earthobservation activities in Africa, so that space strategically contributes to Africa’s socio-economic development”. This is in line with the priorities of the African Space Policy and Strategy and AfriGEOSS, the African segment of the Group on Earth Observations, which aim to deliver services in priority domains for Africa, such as food security and health. As part of this framework, the 'GMES and Africa' initiative (2017-2021) will significantly strengthen African capacity to monitor the environment and security using Earthobservation techniques (see Box 36).

70 The African Union Commission, five Regional Economic Communities (RECs) of Sub-Saharan Africa, the Secretariat of the African, Caribbean and Pacific (ACP) Group of States and the World Meteorological Organization.

2) Gaps, future actions and priorities to be considered

Despite strong policy drivers at global, African and regional levels, major gaps still exist in the availability of Earth observation data for policymaking in Africa. Several satellites from various space agencies have the potential to provide data to Africa, but the scarcity of available infrastructure and capacity prevent African users from fully accessing them. The potential of the internet and other information technologies for the communication and dissemination of satellite data and information has not yet been fully exploited. Some past activities in these domains were entirely donor-dependent, and there has been a general lack of continuity since funding ended. Finally, few African governments have established or are supporting the utilisation of space-based technologies. However, this is changing and, to date (by 2017), Nigeria, Algeria, Egypt and South Africa have built and launched Earth observation satellites (see also Belward and Skøien, 2015).

The JAES 2014-2017 roadmap priority ‘Global and emerging issues’ specifically mentions the “establishment of a coherent framework for the development of Earth observation activities in Africa”, including MESA, GMES and Africa and AfriGEOSS. The 'GMES and Africa' initiative can also be seen as the African counterpart to the EU’s

Copernicus programme.The JRC is looking forward to continuing its partnership in GMES and Africa, and will put particular effort into ensuring Sentinel satellite data and derived information are available to users with free, full and open access.

Infrastructure is needed for the exploitation of Earth observation data and information systems based on geographic datasets. Initiatives are also under way that use satellite data for food security and agriculture (see chapters I.4 and I.12), road development and accessibility (chapter I.2), marine resources monitoring (chapter I.11), the assessment of desertification (chapter I.7.2), biodiversity and protected areas (chapter I.9), wildfire monitoring (chapter I.6.1), drought assessment (chapter I.10) and raw materials (chapter I.14).

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JRC Earth Observation Data and Processing Platform: http://cidportal.jrc.ec.europa.eu/imagearchive/

Learning Platform for MESA Training Programme: http://lms.training4mesa.org

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SERVIR initiative: https://www.servirglobal.net/

Training4MESA: http://training4mesa.org/

3.2. A growing role for geospatial information systems

1) Key findings

Assessment of the situation

Geospatial information systems play an increasing role in supporting research, planning, operations, management and decision-making across a wide range of disciplines. They can be defined as organised systems for the collection, organisation, storage and distribution of data and information. Although such information systems can combine data and information from a range of sources and disciplines, many have been developed and deployed over time to meet thematic or specific needs, for example for protected-area management (see chapter I.9). While these are highly effective decision-making tools, their use is not as widespread as it could be, partly because of infrastructure gaps (such as internet access, see chapter I.15.1), partly through a lack of awareness and capacity-building, partly because the geospatial information system required has not yet been developed, and partly because decision-making end-users were not involved in the conception from the beginning.

However, a few existing systems do provide reliable and neutral information that is standardised and comparable across multiple scales, integrates geospatial components and provides scientific assessments for evidence-based decision-making. Some even integrate ad-hoc 'science-policy interfaces' to support clearly identified parts of the decision-making process. Annex 2 of this report lists a number of such systems.

Outlook

One of the key elements of success and sustainability in building information systems is interoperability. Interoperability is defined as "the ability of computer systems or software to exchange and make use of information". This requires that information from various sources be integrated and standardised in such a way that it can be readily exchanged.

A number of such initiatives are underway in Africa,which require the standardisation of data content, harmonisation of data from heterogeneous sources, and delivery of data and information products via the internet and other channels, in line with recognised industry standard protocols. In Europe, one prominent initiative is the Infrastructure for Spatial Information in Europe (INSPIRE Directive), which is widely recognised as one of the best examples of inter-country cooperation on information exchange. At the global level, support is provided to the intergovernmental Group on Earth Observations (GEO), which is leading a worldwide effort to build a Global Earth Observation System of Systems (GEOSS). In these developments, focus on an open information and system architecture, the use of open-source software components and the promotion of web services all contribute to modular, reusable tools that are essential for modern information platforms. These approaches are widely shared with, and endorsed by, African partners.

Challenges and opportunities

Over the past decade, geospatial information systems operating at the global scale have advanced. Significant resources are being invested to further improve:

- existing capacities that rely on advanced technologies, particularly for big data processing, such as Google Earth Engine (a platform for petabyte-scale scientific analysis and visualisation of geospatial datasets), the Amazon Web Service (which also provides access to significant archives of geospatial data, and Hadoop (an open-source software framework used for distributed storage and processing of big data);

- the science-policy interface, to better address the needs of decision-makers. In this respect, special attention is given to the organisation of information and the development of interactive functionalities that allow the reuse of (both the metadata and geospatial) information, e.g. to repeatedly generate and customise maps, and to automatically generate reports on the basis of predefined queries. In addition, the latest generation of information systems is associated with specific training programmes for the decision-making community, which can be delivered online (e-learning), to improve uptake.

New-generation information systems aim to bring together the best-available science and knowledge, and make it easily accessible across a range of scales (often globally, scaling down through continental, regional, country and even site levels). Table 2 of Annex I of this report describes a number of existing information systems developed specifically to strengthen the science and policy interface, especially in the context of multidisciplinary development policymaking and implementation.

Policy framework

The intergovernmental Group on Earth Observations has developed a set of data-sharing principles endorsed by all of its 100+ member countries and 100+ participating organisations. These principles provide a foundation for interoperability and the building of databases in information systems that will point the way to multiscale systems. Sharing data and adopting common standards is particularly valuable when addressing transboundary issues, such as water-resource management and transport network management.

2) Gaps, future actions and priorities to be considered

In view of further improving integrated planning and decision-making processes, particular efforts should address the integration of information from different sources, different timescales and different thematic areas. The available technologies offer a range of new opportunities which should be explored and developed. The donor community should pay careful attention to such developments, as they would support policy coherence and overall consistency for development cooperation. Also, they would provide an excellent basisfor sustaining joint programming processes, together with national or regional beneficiaries.

Beyond technical aspects, it is essential to invest in the uptake of such systems and to ensure that development and (especially) analysis are carriedout in close partnership with beneficiary institutions or countries or regions. In the absence of these key elements of "partnership and internalisation", the probability that the information developed and displayed is actually used at country or regional level for decision-making is indeed limited.

Supporting references and web links

Amazon Web Services: https://aws.amazon.com/

Google Earth Engine: https://earthengine.google.com/

Group on Earth Observations (GEO): http://earthobservations.org

Hadoop project: http://hadoop.apache.org

4. Building resilience for sustainable development

1) Key findings

Assessment of the situation

Part I of this report describes many of the challenges facing African countries. Overall, the economy is improving steadily, with an average GDP growth rate of 3 % in 2015, and 2.6 % projected for 2017[71]. However, this masks significant heterogeneity from country to country and the fact that, at 41 %, the poverty rate was still very high and heterogeneous in 2013[72] (see Figure 101). Many African countries are affected by natural disasters, political instability and armed conflicts, and consequently struggle to unlock economic growth. In recent years, food-price spikes and financial shocks have added to the stressors that lead to a deterioration of living conditions. These stressors claim lives, negatively affect economic development, and can keep millions of people in extreme poverty.

> “Although the African economy is improving steadily, with a GDP growth rate of 2.6 % projected for 2017, poverty levels are still very high.”

Resilience thinking can offer a useful perspective from which to tackle persisting and emerging problems in Africa. Resilience is a multifaceted phenomenon which – in very generic terms – describes the ability to thrive despite adversity. Increased resilience can help people, households, communities, countries and global institutions better anticipate, prepare for, cope with and recover from shocks and stressors. It is central to disaster risk reduction, since disasters occur when a shock affects a society beyond its coping capacity (see chapter I.3).

However, resilience refersnot only to the capacity to recover from shocks, but also to a system's ability to move forward, adapt to dynamic conditions and put in place mechanisms that enable longer-term, systematic responses to the underlying causes of vulnerability. It is particularly important to address the drivers of fragility that affect the most vulnerable populations, and to help build resilience in order to develop lasting solutions to complex global challenges. This could help unleash the growth potential of African countries, and contribute to achieving the SDGs, particularly SDG 1[73] on poverty eradication.

Crop diversification in Ethiopia, supported by the Supporting Horn of Africa Resilience (SHARE) programme ©EU, by François Kayitakire

Resilience-based policies adopt a structural, multi-sectoral (systems-wide) and long-term perspective to address crises, fragility and vulnerability. They combine anticipation (early-warning systems), prevention, preparation and resolution (crisis-response) elements. Recognising that the sources of fragility and vulnerability are complex, they limit current damage and, at the same time, put in place long-term actions that aim to address the root causes, actions that can even include the creation of new institutions. Their focus goes beyond stability, bringing adaptation and transformation (i.e. the need to reform) centre stage.

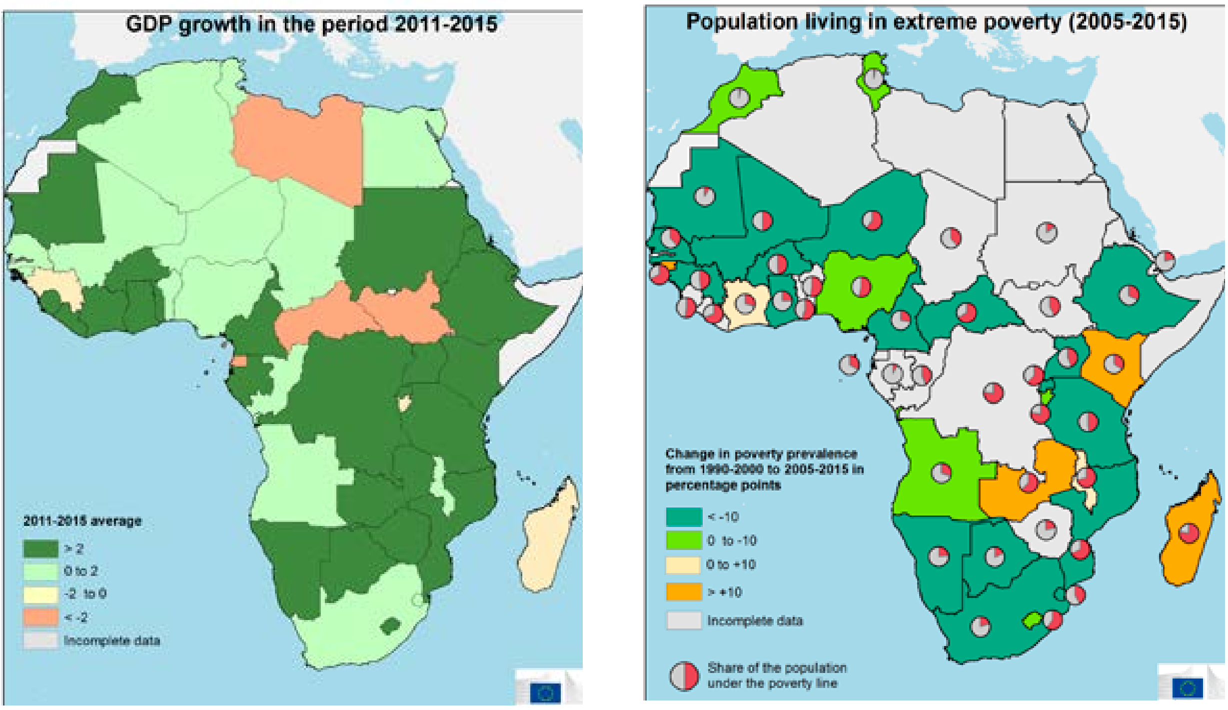
The potential of a resilience-based policy framework has been recognised by African and international policymakers who have already created many resilience-building initiatives. For example, several initiatives were launched in Africa to build resilience for food and nutrition security in the aftermath of the 2011-2012 food crises in the Horn of Africa and in the Sahel. Two major resilience initiatives, the Global Alliance for Resilience in the Sahel and West Africa (AGIR-Sahel and West Africa), and the Global Alliance for Action for Drought Resilience and Growth in the Horn of Africa, set as their main strategy the coordination of humanitarian assistance and longer-term development cooperation to provide long-lasting response to crises. The two initiatives are paving the way towards a broader resilience approach to food-crisis prevention and management.

71 The numbers refer to sub-Saharan Africa. The 2015 GDP growth rate is from the World Development Indicators (last available year). For the 2017 forecast, see World Bank (2017), page 7.

72 Source: Poverty and Equity Database of the World Bank. 2013 is the most recent year available.

73 SDG 1: End poverty in all its forms everywhere.

FIGURE 101: GDP growth (left) and change in poverty rates (right) in African countries *(Source: World Bank)*. The left panel shows average GDP growth by country from 2011 to 2015. The right panel shows the share of the population in a country living on less than US$1.90 a day, and how this has changed from 1990-2000 to 2005-2015 (in percentage points). The share refers to the average value of the data for all available years in the two periods.



In 2014, the African Development Bank issued its 'Strategy for Addressing Fragility and Building Resilience in Africa, 2014-2019', which guides its engagement in fragile situations, i.e. in countries or regions affected by crises. It identifies three focus areas: (i) strengthening state capacity and establishing effective institutions; (ii) promoting resilient societies through inclusive and equitable access to employment, basic services and shared benefits from natural resource endowments; and (iii) enhancing the bank's leadership role in policy dialogue, partnerships and advocacy regarding issues of fragility.

BOX 37

Details of initiatives that aim to build resilience

The Global Alliance for Resilience (Alliance globale pour la résilience, AGIR) roadmap (adopted in April 2013) proposes complementary actions at three levels (AGIR, 2013): first, supporting local communities and endogenous initiatives and mechanisms; second, supporting investment programmes and existing consensus-building mechanisms at the national level; and third, supporting the regional plans and mechanisms put in place by the Economic Community of West African States (ECOWAS), the Union Economique et Monétaire Ouest Africaine (UEMOA), and the Comité Permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (CILSS) regional organisations. Underpinning these actions are AGIR's strategic objectives, namely to: (i) improve social protection for the most vulnerable households and communities to secure their livelihoods; (ii) strengthen the nutrition of vulnerable households; (iii) sustainably improve agricultural and food production, as well as the incomes of vulnerable households and their access to food; and (iv) strengthen governance in food and nutritional security.

The EU-funded Supporting Horn of Africa Resilience (SHARE) programme focuses on country-level programmes, and encourages some cross-border initiatives for managing natural resources. Its core principle is the joint, multi-sectoral programming of actions in agriculture and food security, water, hygiene and sanitation, health and nutrition, and disaster risk management. It aims to improve the nutritional status of populations in areas with high rates of chronic and acute malnutrition.

> *"* The resilience approach has triggered better organisation of disaster risk management in most African countries, and has led to a significant reduction in loss of life.*"*

The Sendai Framework for Disaster Risk Reduction 2015-2030, like its predecessor (the Hyogo Framework for Action 2005-2015), aims to prevent the occurrence of new disaster risks and reduce existing ones. The African Peace and Security Architecture has similar objectives; its focus also extends to the coping capacity of the society, i.e. its resilience.

Overall, the resilience approach has triggered better organisation of the national authorities responsible to disaster risk management in most African countries. A significant reduction in the number of lives claimed by natural disasters, in particular by drought-induced food crises, has been noticed in recent years[74], although the number of people suffering from hunger remains too high.

Challenges and opportunities

Integrating the resilience approach into the policymaking cycle is still a challenge, in particular because of its complexity, the length of time it needs to become established, and the current entrenched sectoral approach (as opposed to a multi-sectoral, system-wide perspective). Another obstacle to using the resilience framework in policy and programme design is the lack of clear indicators for assessing the level of resilience of a household, a community, a country or a system. Measurable indicators ensure accountability in the planning, monitoring and evaluation of programmes and projects. A systematic dashboard (a unified way of visualising data and indicators) of resilience would broaden the standard policy design toolkit, introducing the ability to assess both the intended and unintended impacts of policies on resilience.

Fishermen in Mozambique ©EU, by Paolo Ronco

A first synthesis analysis of resilience for Europe was presented at a high-level conference in 2015 (Building a resilient Europe in a globalised world). One of the main conclusions of the conference was that resilience is a complex and multidimensional phenomenon that needs to be addressed by moving towards a common framework using a systems approach. This challenge has been taken up by the Commission-wide Research Network on Measuring Resilience[75], established in 2016 by the JRC and the European Political Strategy Centre (EPSC), which has developed a common framework for thinking about resilience in a policy context.

> *"* A resilient society can deliver individual and societal well-being in an intergenerationally fair distribution, even amidst shocks or persistent changes.*"*

74 For instance, a reversal in the increasing trend of acute malnutrition during the lean season was noted during the El-Niño-induced food crisis in Zimbabwe. An assessment conducted in January 2017, during the lean season that followed the bad crop season of 2015-2016, found that the acute malnutrition rate was lower than in April-May 2016 (see ZimVAC, 2016; 2017).

75 The Research Network on Measuring Resilience was jointly established by the JRC and the EPSC in 2016. Together with policy DGs participating in the network, the JRC has designed a common framework for resilience. The main elements are explained in Manca et al. (2017).

According to this framework, a society is resilient if, when facing shocks or persistent structural changes, it can maintain its ability to deliver individual and societal well-being in an inter-generationally fair distribution, i.e. ensuring current well-being without seriously compromising that of future generations. Such an approach very much underpins the 2030 Agenda and its SDGs. Societies that are more resilient to disturbances will also be able to ensure a higher level of well-being, as the shock will impact them less severely. The absorptive and adaptive capacity of resilience means that, despite some initial inevitable losses after a shock, a resilient society tends to return to its original level of well-being and functionality. When the situation becomes unbearable and a transformation is necessary, the original level of well-being and functionality can no longer be sustained. However, these transformations should lead to a new, sustainable path with acceptable levels of well-being.

Policy framework

Although resilience is becoming an increasingly used term in EU policies, there is no common resilience framework for the EU yet. However, resilience plays a key role in EU external policies. Most importantly, the EU Global Strategy features strengthening state and societal resilience as one of its main strategic elements. The Joint Communication on a strategic approach to resilience in the EU's external action (European Commission, 2017)develops this further. Although the main focus of resilience may depend on the country or region, it is important to ensure coherence between different approaches. Resilience is also implicit in the 2030 Agenda.

2) Gaps, future actions and priorities to be considered

Data availability is one major issue, particularly at the individual or household level. For example, the World Bank's poverty estimates are based on consumption surveys that are only available in some countries, covering between half and two-thirds of the continent. This problem is not specific to Africa, but availability and compatibility issues are particularly acute there. Although there are some potentially useful datasets and initiatives[76], data availability must be improved to inform policy- and decision-making.

Systems are being developed to measure and monitor resilience within the EU, and collaboration on developing similar systems for Africa could be envisaged. The outcome of this activity would be a dashboard of resilience characteristics, i.e. features of various entities (individuals, communities, cities, regions or countries) that are influential and robust determinants of their resilience.

This dashboard would allow for: 1) continuous monitoring of the resilience of the society within a certain country; 2) an assessment of the intended or unintended impacts of policies on resilience; and 3) based on such information, the development of guidance for new policies that directly or indirectly improve resilience.

Existing sector-specific approaches could be further developed and integrated into such a system-wide approach through the Africa-EU Partnership framework, interinstitutional agreements between the AUC and the European Commission, and by teaming up with scientific initiatives such as the ResilientAfrica Network (RAN). Measurable criteria and correlations could then be jointly developed based on this approach, collecting data and establishing reliable networks of data suppliers.

The various aspects of the resilience dashboard would have to be adjusted and tailored to the specific needs of the various African contexts. The role of culture, the socio-economic context, and the nature of the interdependence between individuals and society[77] in shaping decisions with regard to risk must be understood.

Ethiopia is hit by recurrent droughts ©EU, by Grégoire Dubois

76 For example, the Integrated Survey on Agriculture of the World Bank's Living Standards Measurement Study (LSMS_ISA) has collected information on shocks experienced by households, and their impacts on well-being and coping strategies in many countries, including Africa. This has been used (for example, by Tefera and Kayitakire, 2015) to analyse resilience for food and nutrition security. The existing administrative infrastructure of the EU's CBRN Risk Mitigation Centres of Excellence Initiative, which investigates and helps build preparedness for CBRN and explosive threats worldwide, could also be used to reach out to the population of African countries.

77 This includes, for example, the concept of an informed society (one where citizens have the resources, education and skills to access and participate in the free flow of reliable and useful information through a diverse range of platforms and media organisations that empower them to make considered decisions about their economic, social and political lives – as defined by the World Economic Forum). It can be assessed using the Africa Media Barometer tool by fesmedia Africa www.fesmedia-africa.org/

Supporting references and web links

Africa Media Barometer: www.fesmedia-africa.org/

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Photo: Gregoire Dubois

PART 3

Towards sustained partnership

1. Strengthening implementation and revitalising the Africa-EU Partnership for sustainable development

The 2030 Agenda for Sustainable Development (2030 Agenda), adopted unanimously by the United Nations General Assembly in 2015, is based on the idea that economic prosperity, environmental protection and social well-being are interconnected elements that cannot be addressed separately. This holistic approach is expressed in a set of objectives, the SDGs.

The SDGs provide a global framework for guiding the policy agendas of all countries towards sustainable development. They cut across all aspects of the EU's Global Strategy, and provide a framework for EU development policy (European Commission, 2016a). Sustainable development is also a key pillar of the AU's Agenda 2063 (2015), as stated in the first of its Aspirations[78].

Children are the main beneficiaries of the UN's 2030 Agenda and the AU's Agenda 2063 ©EU, by Andreas Brink

The joint priorities of the Africa-EU Partnership, as outlined in the JAES Roadmap for 2014-2017,resonate strongly with the 2030Agenda. The JAES Roadmap for 2014-2017 focuses its implementation on the following five priorities:peace and security; democracy, good governance and human rights; human development; sustainable and inclusive development and growth, and continental integration; and global and emerging issues. The development framework proposed in the 2030 Agenda covers all of these priority areas, as it supports: (i) the promotion of equity and equality; (ii) the inclusion of multiple cultural values; (iii) prosperity and development; (iv) human rights; and (v) environmental conservation. The successful implementation of the SDGs could therefore be extremely well supported by the Africa-EU Partnership.

The trends, challenges and opportunities for the partnership between Africa and the EU, as highlighted in this report, can be framed within the context of the five pillars of the 2030 Agenda: People (SDGs 1, 2, 3, 4 and 5); Prosperity (SDGs 7, 8, 9, 10 and 11); Planet (SDGs 6, 12, 13, 14 and 15); Peace (SDG 16); and Partnership (SDG 17). How the respective topics of the present report relate to the SDGs is depicted in Table 5. This highlights key links, although many others are evident –the goal 'No Poverty' is particularly cross-cutting, and links may be found throughout this report.

78 "Aspiration 1: A prosperous Africa based on inclusive growth and sustainable development" (African Union Commission, 2015).

TABLE 5: Relationship between the chapters in this report and the SDGs

Relationship between the chapters in this report and the SDGs	
SDG	**Report chapter**
SDG 1: No Poverty	Part I - Chap. 3 on Disaster risk Part I - Chap. 12 on Agriculture and fisheries
SDG 2: Zero Hunger	Part I - Chap. 4 on Food security Part I - Chap. 12 on Agriculture and fisheries
SDG 3: Good Health and Well-being	Part II - Chap 8 on Soils Part II - Chap 10 on Water-resource management
SDG 4: Quality Education	Part II - Chap. 2 on Knowledge sharing, education and training
SDG 5: Gender Equality	Part II - Chap. 2 on Knowledge sharing, education and training
SDG 6: Clean Water and Sanitation	Part I - Chap. 10 on Water-resource management
SDG 7: Affordable and Clean Energy	Part I - Chap. 13 on Energy
SDG 8: Decent Work and Economic Growth	Part II - Chap. 1 on Research and innovation Part II - Chap. 2 on Knowledge sharing, education and training
SDG 9: Industry, Innovation and Infrastructure	Part I - Chap. 2 on Urbanisation andaccessibility Part I - Chap. 3 on Disaster risk Part I - Chap.15 on Digital Infrastructures Part II - Chap. 1 on Research and innovation
SDG 10: Reduced Inequalities	Part I - Chap. 1.2 on Migration Part II - Chap. 2 on Knowledge sharing, education and training
SDG 11: Sustainable Cities and Communities	Part I - Chap. 2. on Urbanisation and accessibility Part I - Chap. 3 on Disaster risk Part II - Chap. 2 on Knowledge sharing, education and training
SDG 12: Responsible Consumption and Production	Part I - Chap. 14 on Raw materials Part I - Chap. 17 on Maritime security
SDG 13: Climate Action	Part I - Chap. 3 on Disaster risk Part I - Chap. 5 on Climate and climate change Part I - Chap. 6 on Forests Part I - Chap 10 on Water-resource management Part I - Chap. 7.2 on Land Part II - Chap. 2 on Knowledge sharing, education and training
SDG 14: Life below Water	Part I - Chap. 9 on Biodiversity and protected areas Part I - Chap. 11 on The marine environment
SDG 15: Life on Land	Part I -Chap. 6 on Forests Part I - Chap. 7 on Land Part I - Chap. 8 on Soils Part I - Chap. 9 on Biodiversity and protected areas
SDG 16: Peace, Justice and Strong Institutions	Part I - Chap. 16 on Conflict prevention and early warning Part I - Chap. 18 on Chemical, biological, radiological and nuclear security and nuclear safety Part I - Chap. 17 on Maritime security Part II - Chap. 2 on Knowledge sharing, education and training
SDG 17: Partnerships for the Goals	Part II - Chap. 1 on Research and innovation Part II - Chap. 2 on Knowledge sharing, education and training PartII - Chap. 3 on Sharing Earth observation Infrastructure and information systems Part III - Chap. 1 on Strengthening implementation and revitalising the Africa-EU Partnership for sustainable development

This chapter focuses on partnerships, particularly in the context of SDG 17, since high levels of inclusion and cooperation within and across countries are required to meet the goals and targets set out in the 2030 Agenda. SDG 17 aims to "strengthen the means of implementation and revitalise the Global Partnership for Sustainable Development". The 19 targets set for this goal are categorised under five topics: finance, technology, capacity, trade and systemic issues, the last of which is subdivided into: policy and institutional coherence, multi-stakeholder partnerships and data, and monitoring and accountability[79]. In this chapter, these topics are examined to give different perspectives on the Africa-EU Partnership and frame it as a global partnership towards sustainable development and the 2030 Agenda. A few of the indicators used to globally monitor the SDGs are discussed.

1) Finance

As stated in the AU's Agenda 2063, the people of Africa and the Africandiaspora aspire to the following: "By 2063, Africa shall be fully capable and have the means to finance her development". African resources to finance its development are considered to be among the critical enablers for the country's transformation. One of the main commitments of the JAESRoadmap for 2014-2017 is to help transform Africa's economy through investment and access to finance. Accordingly, developed countries should speed up their mobilisation of public finances to achieve the joint commitment of mobilising US$100 billion, EUR 83 billion at 2017 exchange rates, per year by 2020 from a wide variety of sources. The Pan-African Programme, launched in 2014 with a budget of EUR 845 million for the period 2014-2020, is an EU funding instrument for Africa that focuses on the joint priorities of the Africa-EU Partnership.

> "To achieve all the SDGs, an estimated US$ 1.4 trillion a year will have to be invested in low- and lower-middle-income countries, most of which are located in Africa."

These priorities are complementary to the achievement of the 17 SDGs. To meet all the goals and their targets, Schmidt-Traub (2015) estimates that over US$1.4 trillion, EUR 1.16 trillion at 2017 exchange rates, a year will have to be invested in low- and lower-middle-income countries, most of which are located in Africa. Different sources of finance from the current development finance landscape should be used to achieve sustainable development. In 2015, the Addis Ababa Action Agenda, which provides the basis for implementing the SDGs, stressed the need to achieve a positive socio-economic transformation in a way that addresses the diverse needs and challenges facing African countries. The Agenda recognises that investing in sustainable and resilient infrastructures is a prerequisite for achieving many of the SDGs. Indeed, in Africa there is a great need for long-term quality investments for infrastructure. According to the G20 Development Working Group, the estimated infrastructure needs in sub-Saharan Africa,by sector, are divided as follows: 43 % forenergy, 27 % for water and sewage, 20 % for transportation, and 10 % for communication (United Nations, 2017).

Plantain market in Uganda ©EU, by Andreas Brink

In Africa, development finance has several peculiarities[80]. Nowadays, transport, water, energy and communications are financed almost exclusively with public funds (Infrastructure Consortium for Africa). With reference to institutional investors, national pension funds in Africa have invested directly in national and regional infrastructures and in domestic sovereign debt. According to the UN Report of the Inter-agency Task Force on Financing for Development 2017 (United Nations, 2017), East and Southern Africa have enjoyed greater foreign direct investment (FDI) flows in recent years through the integration of global value chains, although these flows are still limited to and concentrated in extractive industries. Domestic bond markets in Africa are also underdeveloped.

Development aid is an important source of financial inflows for Africa. According to the Organisation for Economic Co-operation and Development (OECD, 2017), Official Development Assistance (ODA) reached US$56.6

79 Goal 17 and its targets are available athttp://www.un.org/sustainabledevelopment/sustainable-development-goals/

80 Investment, remittances, aid, debt forgiveness and natural resource exports are addressed in many different SDG targets. Actual figures vary widely across African countries and are strongly context-dependent, so they should be analysed on a case-by-case basis.

million, EUR 50.7 million at 2015 exchange rates, in 2015 in Africa in terms of net disbursements, and US$72.9 million, EUR 65.3 million at 2015 exchange rates, in terms of commitments.The EU and its Member States are collectively the world's largest providers of development assistance, providing almost 60 % of global ODA. However, net ODA per capita in 2015 fell compared to the previous year, due to the high population growth. Aid effectiveness is frequently reduced by the fragmentation of aid, namely the proliferation of projects and of donors giving too little aid to too many countries. In 2013, African countries ranked eighth among the top 10 developing countries receiving fragmented aid (Buscaglia and Garg, 2016). The effectiveness of aid in these countries is hampered by a lack of donor coordination, a lack of commitment from beneficiary countries and a lack of recipient resilience.

Another example of additional financial resources for Africa is remittances, namely personal transfers and the compensation of employees from foreign sources. It is important to note that, while the 2030 Agenda for Sustainable Development includes commitments to reduce transaction costs of migrant remittances to less than 3 % (SDG 10, target 10.c), sub-Saharan Africa remains the region with the highest costs, with an average remittance cost of 9.5 % in 2015 (United Nations, 2017) (see also chapter I.1.2).

Implementation of the SDGs requires considerable financial means. In order to engage further private-sector finance, the EU has launched the External Investment Plan (European Commission, 2016d). In addition, the recently launched European Fund for Sustainable Development aims to mobilise public and private investments of up to EUR 44 billion in the coming years, based on an initial EU contribution of EUR 4.1 billion. It will offer guarantees and use blending mechanisms to encourage the private sector to invest in more risky contexts, such as fragile states or conflict-affected areas. These funds are primarily intended to help Africa and the EU's Neighbourhood region achieve the 2030 Agenda, reducing poverty and eradicating it in the long term, while addressing the root causes of migration.

To acquire a comprehensive understanding of financial flows within and into Africa, the considerable illicit financial flows must also be accounted for. The importance of tackling illicit financial flows (which are estimated at up to US$50 billion, EUR 41.5 billion at 2017 exchange rates, annually) is emphasised by the follow-up to the Addis Ababa Action Agenda and the inclusion of illicit financial flows in target 16.4 of the SDGs[81].

2) Technology and capacity

Europe is one of the leading innovation hubs in the world. Innovation, increased efficiency and the creation of a circular economy are prerequisites for achieving the SDGs. The Africa-EU Partnership is an excellent vehicle for sharing knowledge and diffusing technology.

Access to technology and the promotion of innovation will help drive the transformation of Africa's economy. The Africa-EU Partnership aims to promote human development by increasing investments in research, science, technology and innovation. These investments will help unlock the entrepreneurial potential of people, particularly of women and young people[82].

Cooperation between the EU and Africa on STI is cross-cutting in nature as it contributes to the attainment of different socio-economic development objectives. It also aims to develop a long-term, jointly funded and managed R&I partnership under the umbrella of the EU-Africa High Level Policy Dialogue (HLPD) on STI, with financial support from the European Research and Innovation Programme and the EU Framework Programme for Research and Innovation 2014-2020 (Horizon 2020).

SDG target 17.6 aims for cooperation on and access to STI, enhanced knowledge sharing, and improved coordination through a global technology-facilitation mechanism. The UN has selected two indicators for the global monitoring of this target: the number of science and technology cooperation agreements and programmes between countries, and fixed internet broadband subscriptions per 100 inhabitants. While the number of cooperation agreements between countries is not readily available, the indicator ofinternet broadband subscriptions is depicted in Figure 102.

3) Policy and institutional coherence

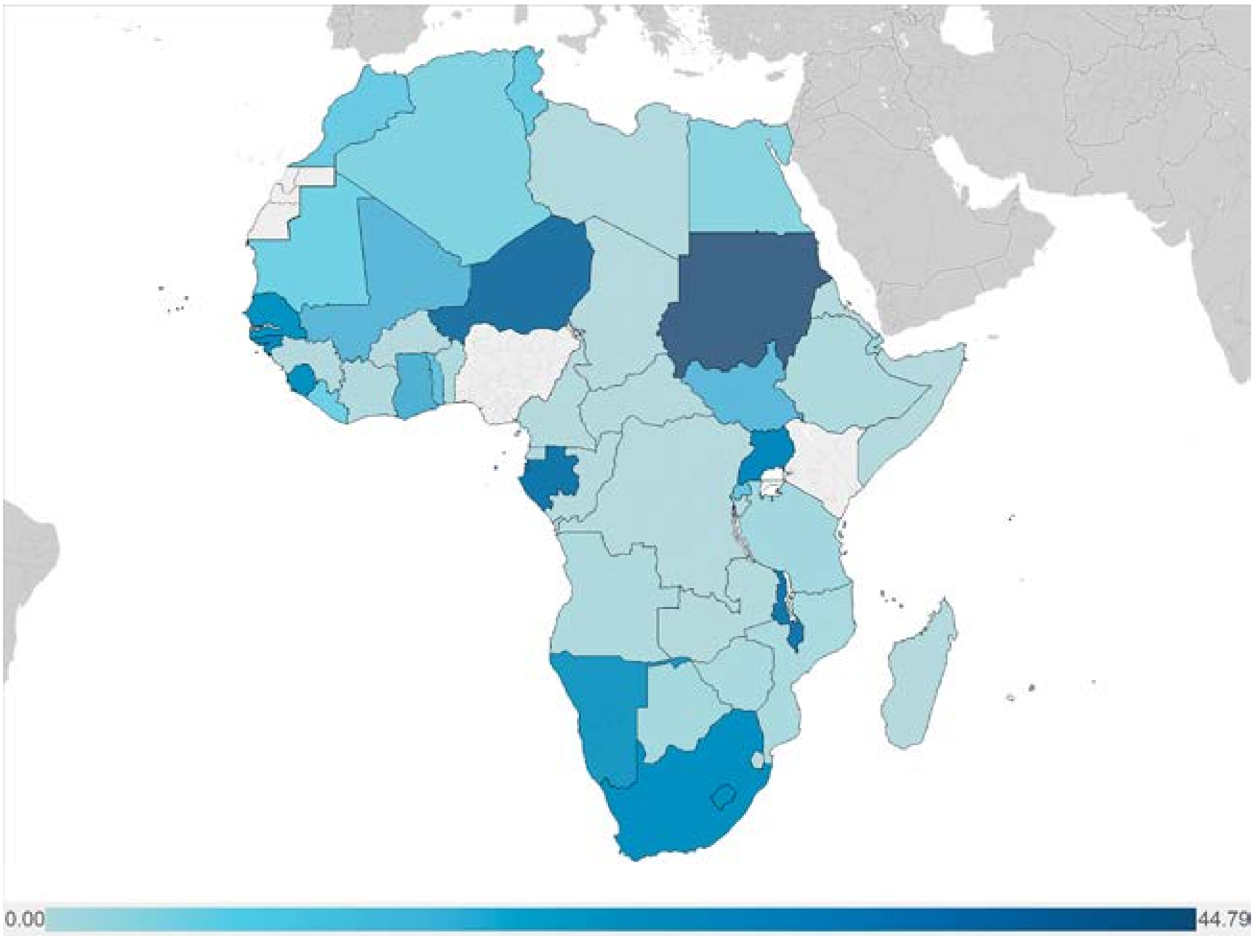
Policy coherence means that a given policy is suitable for attaining its desired objective while not offsetting other policy consequences. The holistic nature of the SDGs is a central element of the 2030 Agenda, since it emphasises the need to account for interactions across policy fields. Accordingly, policy coherence requires a broad perspective, simultaneously taking into account policy effects on all objectives.

The Africa-EU Partnership promotes policy coherence in at least two ways:

81 Target 16.4: By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organised crime.

82 Aspiration 6 of the Africa 2063 Agenda: "An Africa whose development is people-driven, relying on the potential of African people, especially its women and youth, and caring for children".

FIGURE 102: UN Official Sustainable Development Goal Indicator 17.6.2: Fixed internet broadband subscriptions per 100 inhabitants (data for last available year for each country) *(Source: UNStats)*



- first: policy coordination between political entities increases policy coherence. This is true both for policy coordination between the AU and EU at country level, and for the policy coordination between Africa and the EU;

- second: given the EU's accumulated institutional experience, the Africa-EU Partnership allows for institutional learning, knowledge transfer and capacity-building. The EU's 'better regulation' agenda is one of the latest examples of efforts to increase policy coherence.

Improved institutional quality, coherence and capacity will help improve policy coherence. Institutional coherence refers to an institutional structure which helps achieve the institution's objective and where the institution's elements are aligned so as to complement each other.

The AU has initiated a reform process to realign its institutional structure to better deliver on key priorities (Kagame, 2017). Improving institutional coherence and capacity is also an issue for the Africa-EU Partnership. The current JAES Roadmap 2014-2017 defines "Democracy, Good Governance and Human Rights" as one of its five priority areas. This includes economic, social, cultural, civil and political rights. The strategic objective of this priority is to ensure transparent, democratic and accountable governance, based on human rights and the rule of law.

Within the Africa-EU Partnership, the EU has contributed to a number of activities that aim to improve institutional coherence and capacity. These include efforts to enhance the capacity of African policymakers and planners to design, implement and monitor policies on all scales; to increase capacity for the sustainable management of natural resources based on the use of Earth-observation data and derived information; and to strengthen the institutional capacities of national and sub-regional bodies to develop climate-sensitive policies.

Post 2020, the European Parliament and the Council foresee a political partnership with Africa "based on mutual responsibilities and supported by rules", which is implemented by a "multi-layered and flexible institutional architecture that promotes and facilitates dialogue" and uses "the principles of subsidiarity and complementarity to define engagement with relevant institutional and non-institutional actors at different levels" (European Commission, 2016c).

4) Multi-stakeholder partnerships

The SDGs are explicit in their emphasis that successful implementation requires stronger partnerships between all sustainable development stakeholders, and novel and more cooperative forms of global governance. The different targets and goals have been specifically designed to have a global, multi-dimensional, interrelated and intergenerational focus. The Africa-EU Partnership is a governmental partnership. However, both the AU and the EU use many tools to facilitate stakeholder participation. That is not to say that those government unions are fully inclusive, but they generally acknowledge the value of subsidiarity and inclusiveness.

Local people in Lesotho ©EU, by Paolo Ronco

The Africa-EU Partnership mission statement explicitly reiterates its inclusive approach: "Facilitate and promote a broad-based and wide-ranging people-centred partnership by ensuring the effective participation of civil society and the private sector and by delivering direct benefits for African and European citizens". In a similar vein, the EU emphasises human rights, the rule of law, good governance, effective and independent justice, sound public finance management and dialogue with relevant human rights institutions from bothcontinents, with relevant national institutions (e.g. national parliaments), civil society and local authorities (European Commission, 2016c, p. 16).

The Africa-EU Partnership will also be important in creating post-2020 EU partnerships with Africa, the Caribbean and the Pacific regions. A recent Communication (European Commission, 2016c) assesses several options for renewed partnerships after 2020. It proposes one option that comprises "three distinct regional partnerships with Africa, the Caribbean and the Pacific, with an opening for a closer involvement of other countries, under a common umbrella. The umbrella would define the common values, principles, essential elements, and interests that underpin the cooperation between the parties [...]. The three regional partnerships would build on and integrate existing ones (e.g. Joint Africa-EU Strategy) and set the priorities and actions focused on the specificities of the agenda of the partnership with each of the three regions. This will allow the EU and partner countries to set initiatives at the most appropriate level" (European Commission, 2016c, p. 25).

The future partnership should be based on a number of principles and implemented as a multi-level system of governance. The guiding principles should be dialogue, mutual accountability, broad participation of state and non-state actors, and ownership. Employing a multi-level system of governance enables actions to be taken at the appropriate level, according to the principles of subsidiarity, complementarity, differentiation and regionalisation. "The partnership should also build on a multi-stakeholder approach, going beyond governments which cannot handle the challenges alone" (European Commission, 2016c, p. 27).

5) Data, monitoring and accountability

A set of 230 indicators has been chosen by the Inter-Agency and Expert Group on SDG Indicators (IAEG-SDGs) to monitor the global implementation of the SDGs. Since actions will mostly be implemented at the national and regional level, national and sub-national indicators must also be identified. Since different countries have different characteristics (e.g. in terms of economic development, access to natural resources, and their cultural and political environment), the implementation strategies would need to be designed accordingly, and the usefulness of indicators must be evaluated against the specific contexts.

This monitoring framework should be based on reliable and comparable data. This concept is highlighted by SDG targets 17.18 and 17.19 which call for a significant increase in the availability of high-quality, timely and reliable disaggregated data. African countries have already set up a statistical plan. However, according to the Africa-EU Partnership, there is an urgent need to enhance cooperation between European and African statistical systems to produce a high-quality statistical service.

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2. Building a knowledge base for the Africa-EU Partnership

Substantial economic, political and societal changes are taking place across the African continent. Most countries experienced sustained economic growth over the past decade (with annual GDP growth rates often above 5 %), and improved political and economic governance. The world's youngest, fastest-growing and rapidly urbanising population, combined with technological development (in particular ICT expansion), offers the potential to create dynamic new economic sectors and to drive further positive socio-economic transformations.

Kigali in Rwanda is one of the fastest growing cities in Africa ©EU, by Andreas Brink

However, the economic slowdown experienced across Africa in 2016 brings a number of issues into focus, despite some recovery in 2017 (World Bank, 2017): indicators on sanitation, food security, energy access, transport infrastructure, education, science and research, and global indicators such as the Human Development Index, show that progress is not uniform. Economic structures (such as reliance on commodity exports and minimal value-adding chains), sensitivity to shocks (from climate change, extreme weather events and conflicts), population growth (bringing increased demand for jobs, housing, health and education) and the need for sustainable management of natural resources still pose considerable challenges to inclusive poverty reduction and sustainable, healthy development.

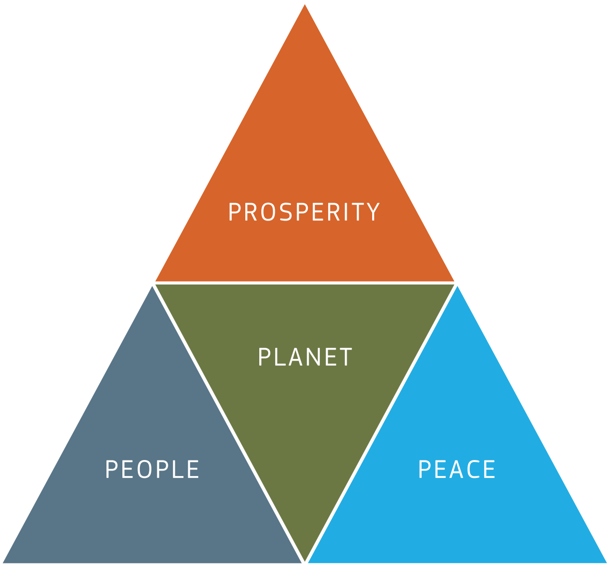
Sharing African and European experiences can help identify sustainable options and facilitate access to them. In many sectors, recent scientific knowledge and technological tools can make a difference, both for policy design and implementation. Scientific cooperation in such areas could therefore be a key component of a strengthened Africa-EU Partnership. From the findings presented in this report, three main directions emerge: i) the need for integrated approaches to science and policymaking; ii) the importance of spatial information; and iii) the critical role of knowledge sharing.

1) Interdependencies and the need for integrated approaches

The policies in one area often impact on others. Ideally, these interlinkages are synergistic, but they can involve trade-offs and, in the worst cases, policies determined in isolation can have conflicting effects. For example, efficient urban planning and better roads improve market access, facilitate trade, reduce agricultural waste, boost productivity, provide jobs, and save lives because of fewer accidents. But better roads and urban expansion also increase threats to natural capital and bring new challenges in terms of energy demands, water needs and the sealing of productive, fertile soils.

More broadly, the priority areas of the 2030 Agenda are interdependent: people, planet, prosperity and peace cannot be treated in isolation. There are different ways of representing the multiple interlinkages, but the evidence presented in this report highlights, *inter alia*, the links between the natural environment (i.e. the planet pillar) and healthy, prosperous and peaceful societies (the people, prosperity and peace pillars) (see Figure 103). Indeed, the need for integrated approaches and policy coherence is becoming ever more urgent because of increasing pressures on natural resources, which exacerbate interdependencies between sectors that use these resources in different ways, and ultimately have a broader range of impacts on the economy and society. This is typically the case for the water-energy-food-ecosystems nexus. For example, Ethiopia's water towers depend on the continued presence of forests, which intercept rainfall, reducing the risk of flash floods in the wet season and regulating river flows in the dry season. However, pressure on land availability is forcing land-use shifts which threaten the integrity of the forests, with consequences on water availability, soil erosion, food security and climate. Many social crises in Africa are triggered by water- and soil-management issues.

FIGURE 103: A view of the interdependence of development pillars that puts planet (the natural environment) at the core; if this collapses, then peace, prosperity and the well-being of people suffer. *(Source: DG DEVCO)*



While the advantages of an integrated approach to science and policymaking are clear (to maximise synergies, resolve trade-offs and minimise counteracting effects), such an approach is all too uncommon; science develops in disciplines, and policymaking is sectoral. As knowledge develops, research tends to become even more specialised and research specifically designed to address policy-relevant interlinkages must be pursued. Without appropriate quantification through integrated assessments, the impacts of, and constraints arising from, such policy-relevant interdependencies are often overlooked. Similarly, policy coherence for development is an acknowledged priority, but much still needs to be done to put this into practice, and mechanisms are needed to promote such integrated approaches.

Resilience-based policies take a multi-sectoral and long-term (years to decades) approach to crises, fragility and vulnerability. They combine forecasting (early warning), prevention, preparation and resolution (crisis response). Recognising that the sources of fragility and vulnerability are complex, they aim to limit current damage while, at the same time, putting in place long-term actions and institutions that address the root causes. This report highlights the potential of resilience-based policy frameworks in domains including food and nutrition security (the Global Alliance for Resilience in the Sahel and West Africa (AGIR-Sahel and West Africa), and the Global Alliance for Action for Drought Resilience and Growth in the Horn of Africa) and climate change (the Global Climate Change Alliance plus). Building resilience (the ability to thrive in the face of adversity) can help people, households, communities, countries and institutions to forecast, prepare for, cope with and recover from shocks and stressors.

Producing knowledge – with well-characterised quality statements attached to such knowledge – that crosses scientific disciplines, sharing the same information with decision-makers from different sectors, carrying out integrated assessments, and having institutions that bring together scientists and decision-makers can all help. The International Network for Government Science Advice (INGSA), in particular its Africa Chapter (which has the goal of raising awareness about science-policy advice and helping to build a community of practitioners across Africa), has a role to play here. This report also highlights examples of structures set up to develop and share knowledge, such as water CoEs, forest regional observatories, and observatories used for wildlife management and the conservation of biological diversity.

Shared commitments to international global governance initiatives (including the UNFCCC, the CBD, the UN Convention to Combat Desertification (UNCCD), the Sendai Framework for Disaster Risk Reduction and the SDGs of the 2030 Agenda) also present opportunities to improve information exchange. Sharing scientific knowledge between the conventions should be further explored. This could deliver savings and allow for shared capacity-building and outreach activities, and would focus the demands made on knowledge providers.

2) Knowledge providers for assessment and planning

Knowledge providers undoubtedly have a role to play in informing the integrated approach outlined above. Because of the strong time and location specificity of many of the problems addressed, spatial information, local knowledge and models are all important.

Spatial information

Aggregate numbers and maps of the continent can helpto identify the main trends and challenges, and put them into perspective by comparing them with other world regions. At the same time, the explosion in the availability of contemporary spatial data from satellites (which are being acquired more frequently than ever, and at increasingly high levels of spatial resolution), free and open access to historical archives stretching back over decades, together with increasingly geo-located socio-economic data, make it possible to document diversity between and within countries. This is a great support for policy design and implementation at national and local levels, while providing a basis for addressing transboundary and global issues.

For example, accurate information about water availability and its changes over time is needed to prevent water conflicts and promote stability, to plan urban, industrial and irrigation supply, to address food security, nutrition and public health issues, to orient agricultural choices and livestock and wildlife management, to cope with seasonal rainfall anomalies, and to enable the monitoring of possible disease outbreaks.

To reap the full benefits of free data, of data available with higher geographical detail and increased frequency, and of better data-processing techniques, access to all these data must be further improved, analytical tools need to be provided, and people must be educated so that they have the skills to use them. It is also useful to build services – such as climate services – that address the specific information needs of different communities (be they policymakers, those more immediately involved in resource management or, indeed, the public).

This report describes spatial information and analysis tools tuned to issues ranging from transport infrastructure, urban expansion and intensification, rural settlement patterns, energy infrastructure and production capabilities, to soil types and land condition, crop yields, land cover, surface-water resources, maritime security, and the status and value of protected areas on land and in the oceans. The geospatial information systems described help assess, map and monitor vital resources and support their better management.They are also very useful for planning infrastructure development, and for assessing risks (natural disasters, security risks, etc.) so as to be better prepared and to develop more effective interventions. When combined with modelling tools, they also enhance predictive capabilities and can be adapted to the specific conditions of a region or country.

Local knowledge and data needs

While remote-sensing data has huge potential, it is generally complemented or contextualised by other data, in particular data collected at the local level and combined with local expertise. This *in-situ* knowledge is valuable in its own right, notably with regard to social, institutional, political and economic aspects, in order to understand the complex interaction of societies, economies and the environment. Data from *in-situ* sources also help calibrate and interpret the remote-sensing information, adding to its overall reliability and value. Collaboration with local partners thus benefits everyone.

Sharing local knowledge ©EU, by Andreas Brink

For example, detailed soil surveys would be needed, in combination with socio-economic and institutional data (e.g. on land tenure), to assess the suitability of land for different uses and to develop guidance for sustainable soil management. In the agricultural sector, disaggregated data and information on inputs (such as fertilisers) and investments, and information on trade in agricultural commodities and livestock, are often lacking. There are also gaps in information about agricultural production and food security in countries affected by conflicts; these often coincide with situations of high food-security risk.

Models

Better models will result in improved predictive capabilities regarding natural systems (both long-term projections, e.g. for climate, and short-term forecasting, e.g. for floods) and socio-economic and political systems (e.g. violent conflicts, population growth and economic development). Improved models will also yield reduced or better quantified uncertainties, which in turn will help better assess the impacts of change (related to climate, water, land or vegetation) and build the necessary capacity for forecasting such impacts.

Spatial data, local knowledge and models combined

A number of existing resources developed by the JRC and involving African partners (such as the Global Human Settlement Layer, the Global Surface Water Explorer, the Photovoltaic Geographical Information System, the Digital Observatory for Protected Areas, and agricultural yield models) are already available to users across both continents (and anywhere in the world). Such systems currently operate as stand-alone, independent means of knowledge dissemination. Combining them would make them stronger. Further collaborations could be developed to best address the needs of African partners and ensure the effectiveness of targeted capacity-building. The combination of existing systems would not only encourage synergies but would also provide a realistic knowledge-management platform to support new avenues, such as a common charter embodying key principles for the sustainable management of natural resources.

3) The critical role of knowledge sharing, education and training

Progress in education enrolment and attainment will be a major factor influencing the pace of transition. A concerted effort towards capacity-building and knowledge sharing (including across policy areas and at the science-policy interface) has a role to play in the overall education landscape. In the immediate term, this maximises the benefits of new infrastructure (such as the knowledge-management platforms outlined in the section above) and will also ensure the availability of a more informed workforce over time (months and years).

Many training activities are ongoing, often in the context of scientific collaboration and networks. However, a more coherent approach should be developed, building on the activities outlined in this report and also exploring synergies with capacity-building activities carried out by other organisations. For example, this could optimise the use of existing structures and networks such as the CBRN and the MESA networks, both of which are already established in a large number of countries and include infrastructural elements, such as the MESA programme's eStations. Stronger links with initiatives such as the Pan-African University, as well as national universities, should also be established. Such links could include student exchange programmes, co-supervised PhD studies, and collaboration on curriculum development, course design and teaching.

4) Conclusions

Scientific knowledge and technological tools can make a difference in many sectors and priority policy areas that are critical for development – both for policy design and implementation. Scientific cooperation in these areas can be a valuable component of a strengthened Africa-EU Partnership.

This introduces the question of how to prioritise. This report is based on JRC expertise in many thematic areas, but does not cover all dimensions of Africa's development or Africa-EU cooperation (even though some new areas of JRC activities, in which collaboration is just being explored, have been included).

However, the compilation of information and assessments across such a wide range of topics does bring insights. There are significant gaps in the evidence base in a number of areas that need to be addressed, as they are limiting sound analysis in support of policymaking. These include, *inter alia*, a lack of up-to-date consistent and comparable data on climate, soils, the quality of roads, the marine environment, and water resources, as well as disaggregated socio-economic data. More knowledge sharing through a reinforced Africa-EU Partnership can also help fill these gaps and build knowledge.

Wealth, if you use it, comes to an end; learning, if you use it, increases.

~ African proverb

Supporting references and web links

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AFRICA REPORT ANNEXES

Annex 1: Key JRC partners, scientific tools, databases, and knowledge-sharing activities

Most of the activities described in this report are carried out in collaboration with African or other international partners. The range of activities carried out by the JRC includes the compilation of a large number of databases, the development of software, information systems and other scientific tools, and dedicated training and capacity-building activities. These freely available resources are outlined below. Table 1 identifies key African and international partners of the JRC. Table 2 presents existing information systems and tools. Table 3 provides an overview of JRC knowledge-sharing activities, in particular training activities, and indicates web links and contacts. The information is presented according to the chapters in the main report.

Table 1: Key JRC partners

I.1 Population and migration

Centre of Expertise on Population and Migration
In 2016 the JRC and the International Institute for Applied Systems Analysis (IIASA) established collaboration in the area of demography and set up the Centre of Expertise on Population and Migration placed at the IRC. The Centre takes a multi-dimensional demographic approach to assess the consequences of alternative future population and migration trends in Europe and in the main regions of origin for migration into Europe. The Centre studies push and pull factors, different kinds of migration streams as well as the impact of migration flows for Europe in terms of population aging and the productivity of Europe's labour force over the coming decades.

I.2 Urbanisation and accessibility

Urbanisation and human settlements
The JRC is leading the Human Planet Initiative of the Group on Earth Observations (GEO), which is committed to developing a new generation of measurements and information products that provide new scientific evidence and a comprehensive understanding of the human presence on the planet, and that can support global policy processes with agreed, actionable and goal-driven metrics. The core partners involved in the production of global baseline data are the JRC, the University of Southampton WorldPop project, Columbia University and the Center for International Earth Science Information Network (CIESIN). The extended partnership involves more than 150 individual scientists and policymakers who belong to 85 different organisations, including academies, international stakeholders, governmental bodies and private firms.

Since 2013, the South African National Space Agency (SANSA) and the JRC have been collaborating on the high-resolution mapping of settlements in South Africa to produce consistent and up-to-date human-settlement data for various policy domains. These maps are used in initiatives such as the Upgrading of Informal Settlements Programme (UISP, which aims to upgrade existing informal settlements and create new low-cost housing), the Statistics Act (helping to support census planning), and the Disaster Management Act, which needs information on human settlements for post-disaster verification, and disaster risk profiling and assessment.

Urban-rural connectivity
The JRC has a well-established global network of partners working on accessibility issues. At the European level, international JRC activities are supported by the European Parliament and the Directorate-General for Climate Action (DG CLIMA). Through its partnership with the Malaria Atlas Project, the JRC has links to the University of Oxford and its network of international health research organisations, and is working with some of the leading institutions investigating the interactions between transportation infrastructure development and the environment, including the Centre for Tropical Environmental & Sustainability Science at James Cook University, and the Center for International Forestry Research (CIFOR). On the technology side, in order to gather and process the vast amounts of road and related data at the global scale, the JRC works closely with several partners offering big-data processing capability, including the Google Earth Engine team.

I.3 Disaster risk

The JRC works closely with the United Nations Office for Disaster Risk Reduction, the World Meteorological Organization and international scientific partners. African partners include the African Union Commission AUC) and the Southern African Development Community (SADC). The Index for Risk Management (INFORM) was developed in collaboration with the United Nations (UN) Inter-Agency Standing Committee Reference Group on Risk, Early Warning and Preparedness. Partners include 23 organisations from the UN, national governments, and non-governmental organisations, including the UN Office for Coordination of Humanitarian Affairs, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Children's Fund (UNICEF), the World Bank Global Facility for Disaster Risk Reduction, humanitarian agencies of the United Kingdom and the United States, and the World Health Organization (WHO).

I.4 Food security

Key partners in Africa include the AUC, the five Regional Economic Communities, the Permanent Interstate Committee for Drought Control in the Sahel (CILSS), and national authorities and institutions. The JRC also has partnerships with international organisations, including the FAO, the World Food Programme (WFP), the United Nations Children's Fund (UNICEF), the World Bank, the Organisation for Economic Co-operation and Development (OECD), the Oxford Committee for Famine Relief (OXFAM), Save the Children, Action Contre la Faim (ACF), Cooperative for Assistance and Relief Everywhere (CARE) and the Famine Early Warning Systems Network (FEWS NET).

I.5 Climate and climate change

The Africa initiative of the Coordinated Regional Climate Downscaling Experiment (CORDEX) involves the main climate-modelling groups worldwide (including the United Kingdom's Met Office, the Climate Limited-area Modelling community, the Danish Meteorological Institute, the Swedish Meteorological and Hydrological Institute, the International Centre for Theoretical Physics, the Royal Dutch Meteorological Institute and the Centre National de Recherches Météorologiques) in the production of climate-change projections by means of state-of-the-art climate models, and a network of (mostly) African scientists coordinated by the System Analysis Group of the University of Cape Town (South Africa) for analysing the results. The JRC contributes to the CORDEX initiative through both the production and analysis of climate-change projections.

National meteorological services in Africa and Europe have made climate observations over many years. International coordination is provided through the World Meteorological Organization. Climatological and hydrological networks (including the Agrometeorology, Hydrology, Meteorology Regional Centre (AGRHYMET) in Niger and the African Centre of Meteorological Applications for Development in Kenya), provide additional coordination nodes. These can be reinforced through partnership with African and European networks, as in the Monitoring of the Environment and Security in Africa (MESA) programme. The evolution of the MESA programme, in line with the development of the Global Framework for Climate Services in Africa and the Copernicus services, provides additional networking opportunities.

Funded by the Government of Norway, the Global Framework for Climate Services has set up the 'Climate Services Adaptation Programme in Africa'. This involves the World Meteorological Organization, the Consultative Group on International Agricultural Research (CGIAR) Research Program on Climate Change, Agriculture and Food Security, the Center for International Climate and Environmental Research – Oslo, the Chr. Michelsen Institute, the International Federation of Red Cross and Red Crescent Societies, the WFP and the WHO.

Other partners include the International Energy Agency, the FAO, the Global Emissions InitiAtive (GEIA), and the Task Force on Hemispheric Transport of Air Pollution.

I.6 Forests

Since 2006, the JRC has contributed significantly to implementation of REDD+ (Reducing Emissions from Deforestation and forest Degradation, including the conservation of forest stocks, sustainable management of forests, and enhancement of forest carbon stocks), including by providing support to partner countries in the tropics. This has been backed up by scientific publications and contributions to the Global Terrestrial Observing System's Global Observation of Forest and Land Cover Dynamics Sourcebook on REDD+, which is a methodological guidebook for measuring, reporting and verifying anthropogenic forest-related emissions and removals (GOFC-GOLD, 2015).

As part of the Global Forest Resources Assessments programme led by the FAO, the JRC carried out a remote-sensing survey on global forest cover and cover change over the period 1990-2005 (FAO and JRC, 2012), which was then complemented by a survey of the tropical belt covering that period 1990-2010 (Achard et al., 2014).

With the European Commission's DG DEVCO, the JRC provides technical and methodological support to regional forest observatories in Central and East Africa. These observatories rely totally on the buy-in of national agencies at the highest level. In Central Africa, this is effected through the Observatoire des Forêts d'Afrique Centrale (OFAC), which is owned by the regional Council of Forest Ministers from the Commission des Forêts d'Afrique Centrale (COMIFAC). The COMIFAC secretariat in Yaoundé, Cameroon, hosts OFAC and the technical staff who manage the database and website, with technical support from the JRC.

At the end of 2016, the JRC launched a pilot East African Forest Observatory (OFESA), which is hosted by the intergovernmental Regional Centre for Mapping of Resources for Development (RCMRD) in Nairobi, Kenya. It helps to define the logical framework for forest observatories, and provides a structure for their databases and web-interfaces, so that all partner institutions can enter, query and analyse data in the system. It provides technical support for developing the regional databases and websites, and hosts mirrors thereof to guarantee the long-term durability of the data.

The regional partners (COMIFAC and the RCMRD) are the owners of their own regional observatories, their functionalities and future developments.

Every two years, OFAC publishes the 'State of Forests' report on the Congo Basin (e.g. de Wasseige et al., 2014). These publications serve to provide decision-makers with a single information source, and to give national and regional agencies and institutions the opportunity to share the results of their projects and research.

The JRC supports African forest agencies through a series of measures that aim to help generate reliable, repeatable and transparent information on forest-cover dynamics, specifically for the assessment of forest degradation. The main partners in the project on Reinforcement of Capacities for REDD+ (ReCaREDD) are: the Ministry of Forestry and Wildlife, Cameroon; Centre national d'inventaire et d'aménagement des ressources forestières et fauniques, Republic of the Congo; the Directorate of Inventory and Forest Management, Democratic Republic of the Congo; Centre Universitaire de Recherche et d'Application en Télédétection, Côte d'Ivoire; the Kenya Forest Service; and the Tanzania Forest Service. These measures also enable the national forest agencies to monitor the exploitation of forest reserves at the national level, and are a major contribution to the EU's Forest Law Enforcement, Governance and Trade Action Plan, which aims to reduce illegal logging by strengthening sustainable and legal forest management, improving governance and promoting trade in legally produced timber.

In cooperation with the FAO Silva Mediterranea network, the JRC has expanded its European Forest Fire Information System (EFFIS) to monitor fires in the Middle East and North Africa, covering all the North African countries subject to wildfires. Morocco, Algeria and Tunisia are official members of this expanded network. Through their participation in EFFIS, North African countries have good links with southern European countries and participate in joint activities related to fire-prevention and firefighting activities (e.g. Morocco supported firefighting operations in Portugal during the 2016 wildfire season).

Since 2015, as part of the intergovernmental GEO and the EU's Copernicus programme, the JRC has been leading the development of the GWIS, which aims to provide information for the continuous monitoring of wildfire regimes and impacts at the global level.

In cooperation with the UN's Office for Disaster Risk Reduction, the FAO and other international organisations, the JRC helps reduce the impact of wildfires globally, providing guidance and tools on wildfire-monitoring activities, and thereby also contributing to implementation of the UN SDGs.

I.7 Land

In collaboration with the European Commission's DG DEVCO, the World Bank, the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) and the Land Matrix project, the JRC is testing the use of high-resolution Earth observation systems for monitoring the dynamics and (where possible) consequences of large land transfers.

The JRC also collaborates with:

- The MESA programme and the upcoming Global Monitoring for Environment and Security and Africa (GMES and Africa) programme on the monitoring of land-cover dynamics within the natural habitat domain;
- GIZ, the World Bank and the Land Matrix project in monitoring large land transfers in Ethiopia;
- DG DEVCO, the Biodiversity and Protected Areas Management (BIOPAMA) programme and the EU Delegations in Africa in monitoring land cover and land-cover change in protected areas and key landscapes targeted for conservation activities.

It also provides support to the intergovernmental GEO through the AfriGEOSS initiative, particularly the Land Cover Working Group.

Preparation of the World Atlas of Desertification relies on a network of international experts and institutes, including the following:

- United Nations Convention to Combat Desertification (UNCCD), secretariat based in Germany
- United Nations Environment Programme (UNEP), Kenya
- Observatoire du Sahara et du Sahel (OSS), Tunisia
- The Arab Center for the Studies of Arid zones and Dry lands (ACSAD), Jordan
- Hebrew University of Jerusalem, Israel
- Cheikh Anta Diop University, Senegal
- Desert Research Foundation of Namibia, Namibia
- Council for Scientific and Industrial Research, South Africa

I.8 Soils

The JRC maintains a well-established network of soil science partnerships within numerous African research (e.g. the World Agroforestry Centre) and academic (e.g. the University of the Free State) organisations, and has close links with both the AUC and the Africa Soil Science Society. The FAO and the African organisations and institutions registered under the Global Soil Partnership are also major partners of the JRC.

In addition, the JRC collaborates closely with the FAO, whereby it supports the European Commission's commitment (led by DG DEVCO and the Directorate-General for the Environment (DG ENV)) in the design and implementation of the Global Soil Partnership (GSP), which aims to improve the global governance of soil. The JRC currently chairs the GSP's Intergovernmental Technical Panel on Soils, which recently published an assessment of the state of soils in Africa (FAO, 2015). In 2016, the JRC launched the first-ever Global Soil Biodiversity Atlas (Orgiazzi et al., 2016), with contributions from African researchers. It is currently developing a continental-scale assessment of soil erosion in Africa, and provides guidance to European Commission services on the development of research agendas and harmonised data-collection schemes.

I.9 Biodiversity and protected areas

Currently, the JRC is working with the European Commission's DG DEVCO on the implementation of the EU strategic approach to wildlife conservation in Africa (European Commission, 2015).

The JRC has a well-established network of partners in the field of biodiversity and protected areas within organisations such as the Africa Caribbean and Pacific (ACP) Secretariat, the AUC and several African Regional Economic Communities: the East African Community (EAC), the Economic Community of West African States (ECOWAS), the Intergovernmental Authority on Development (IGAD), the Indian Ocean Commission (IOC), the SADC and the West African Economic and Monetary Union (UEMOA). Other critical partners include regional organisations with a dedicated biodiversity and protected-area management remit, such as the Observatory for Central African Forests (OFAC), the Network of Protected Areas of Central Africa (RAPAC) and the Regional Network of Marine Protected Areas in West Africa (RAMPAO). The cooperation of relevant national ministries and agencies is also vital for implementation. International entities, including the United Nations Environment Programme (UNEP), the FAO, the Convention on Biological Diversity (CBD) and the International Union for Conservation of Nature (IUCN) provide the global context and also help in pan-continental coordination.

I.10 Water resource management

The JRC collaborates with a wide range of African and international partners, in particular with regard to the work on the water-energy-food-ecosystems (WEFE) nexus and water cooperation:

- political institutions: African Ministers' Council on Water and Technical Advisory Committee of the African Ministers' Council on Water; the AU; the NEPAD and its Water Centres of Excellence (WCoE); and several Regional Economic Communities: ECOWAS, SADC, Economic Community of Central Africa States (ECCAS), Intergovernmental Authority on Development (IGAD);

- research Institutions: the National Research Centre on Water from Egypt, Khartoum University, the Climate Prediction and Application Centre of IGAD, and the Agrometeorology, Hydrology, Meteorology regional centre (AGRHYMET);

- river basin authorities: Organisation pour la mise en valeur du fleuve Sénégal, Autorité du Bassin du Niger, the Zambezi Watercourse Commission, and African Network of Basin Organisations, among others;

- national hydrological services in Africa.

International partners include the UNESCO-IHE, UNESCO-IHP, Cap-Net, Water Net, national cooperation agencies (Institute for Development Research (IRD), Department for International Development (DfID), Stockholm International Water Institute (SIWI), GIZ, USAID, French National Research Agency, the European Space Agency's (ESA) TIGER programme, MESA, Centre for Research on Ecology and Forestry Applications (CREAF) in Spain, the Institut National de Recherche en Sciences et Technologies pour l'environnement et l'agriculture (IRSTEA) and the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) in France, the West African Science Service Center on Climate Change and Adapted Land Use (WASCAL) – AfriAlliance, the Global Water Partnership (GWP), Google Earth Engine, space agencies and other geospatial data providers across Europe (especially the Copernicus programme), Africa, and internationally, such as the United States Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA).

I.11 The marine environment

The JRC has organised training courses in partnership with international bodies (e.g. the intergovernmental GEO, the Global Ocean Observing System), African organisations and universities (e.g. the Kenya Marine and Fisheries Research Institute, the University of Cape Town, the Western Indian Ocean Marine Science Association), and in collaboration with European projects.

Under a partnership with the Centre for Remote Sensing Applications at the University Felix Houphouet-Boigny in Côte d'Ivoire, the JRC has supervised an Ivorian PhD student in the analysis of satellite data in order to improve understanding of ecosystem variability in the Gulf of Guinea and how coastal waters can be affected by land use.

The MESA project has a number of scientific partners across Africa for the marine environment, including the Mauritius Oceanography Institute and the University of Ghana.

I.12 Agriculture and fisheries

Several partner networks have been developed. For activities related to the agricultural sector, the main partners are:

1. at the United Nations level, the FAO and the WFP;
2. at the pan-African level, the MESA programme and its follow-up project: Global Monitoring for Environment and Security (GMES) and Africa;
3. at the regional level, the SADC, the Permanent Interstate Committee for Drought Control in the Sahel, the Intergovernmental Authority on Development (IGAD), the Regional Centre for Mapping of Resources for Development in East Africa, and the AGRHYMET regional centre in West Africa;
4. at the national level, agricultural researchers, meteorological institutes and national research institutes.

The JRC's near-real-time monitoring of agriculture at the global scale directly informs multi-agency information initiatives, such as the monthly Global Agricultural Monitoring Initiative (GEOGLAM) Crop Monitor bulletins of the Group on Earth Observations (GEO). Collaboration on food prices has also been established with the Agricultural Market Information System (AMIS), the Statistics Division of the FAO (FAOSTAT) and the University of Rome.

For activities related to fisheries, the main partners are the General Fisheries Commission for the Mediterranean, FAO, the Scientific, Technical and Economic Committee for Fisheries (STECF), and the Indian Ocean Tuna Commission.

I.14 Raw materials

In this area, the JRC works with the World Bank, the United Nations Environment Programme (UNEP) and the International Resources Panel (IRP).

I.15 Digital infrastructures

The main partners include:

- spectrum regulators in the EU Member States;
- the European Telecommunications Standards Institute (ETSI);
- the International Telecommunications Union (ITU);
- the Conference of European Postal and Telecommunications Administrations (CEPT).

The JRC is working with the Directorate-General for Communications Networks, Content and Technology (DG CONNECT) on challenges in the EU context. The results of this work are equally applicable in Africa.

The JRC is a pioneer in Europe for the exploration of the experiences of young children (0-8 years) and their families with new technologies. Through this research and interactions with the United Nations Children's Fund (UNICEF) Office of Research, the JRC is also in close contact with the Global Kids Online project. This project looks at children's and teenagers' use of the internet by creating a global network of researchers and experts. The project team works to connect the new evidence with the ongoing international dialogue regarding policy and practical solutions for children's well-being and rights in the digital age, especially in the global south, starting with South Africa among the pilot countries.

I.16 Conflict prevention and early-warning

Since 2005, the JRC has been providing scientific and technical support on conflict diamonds to the former Directorate-General for the External Relations, now the Service for Foreign Policy Instruments (FPI). The JRC is contributing to the Kimberley Process working groups on monitoring and statistics.

The Global Conflict Risk Index was developed with a contribution from a methodology working group of experts in quantitative conflict modelling. The following organisations were involved: the Uppsala Conflict Data Program, the Peace Research Institute Oslo, Dartmouth College (USA), the Political Instability Task Force, the Institute for Economics and Peace, the Heidelberg Institute for International Conflict Research, the UN's WFP and University College London. These institutes publish annual reports on worldwide conflict and peace, which provide reference data and indicators for the Global Conflict Risk Index (GCRI).

I.17 Maritime security

The Piracy, Maritime Awareness & Risks (PMAR) projects were partly funded by the European Development Fund under the Programme to Promote Regional Maritime Security, which put a number of African Regional Economic Communities in charge of the implementation – in the case of PMAR, this was the Indian Ocean Commission.

II.1 Research and innovation

The AU's African Observatory of Science Technology and Innovation (AOSTI) is a specialised technical office serving as the continental repository of statistics and a source of policy analysis in support of evidence-based policymaking in Africa.

Table 2: Existing JRC databases, information systems and tools

Development and humanitarian aid to Africa from the EU and its Member States

EU Aid Explorer
https://euidexplorer.ec.europa.eu

The EU is collectively the biggest donor in the world, providing over EUR 40 billion (Official Development Aid) a year to help overcoming poverty and advance global development. It is committed to implementing the international agreements on aid effectiveness and to being accountable to EU citizens who make solidarity initiatives possible. EU Aid Explorer is part of fulfilling the specific transparency commitments within the Paris Declaration on Aid Effectiveness 2005, the European Consensus on Humanitarian Aid 2007, Accra Agenda for Action 2008, and Busan Partnership for Effective Development Cooperation 2011. By making data easily accessible, countries, beneficiaries, EU citizens and implementing partners can examine the use of donor funds and donors themselves can improve coordination and effectiveness.

EU Aid Explorer, a web tool developed by the JRC, provides easy access to clear, complete and accurate data on development and humanitarian aid around the world. Maps and graphs are used to visualise which donor is active where, which sectors and countries receive how much assistance and how funding changes over time.

A European Commission corporate tool for information on aid, EU Aid Explorer facilitates donor coordination, transparency and accountability to citizens. All donors who report their aid data to international standards are covered. The data used in this tool is taken from a range of sources: the OECD, UN OCHA (United Nations Office for the Coordination of Humanitarian Affairs), EDRIS (the European Commission's European Disaster Response Information System) and the IATI (International Aid Transparency Initiative) registry. The added value of EU Aid Explorer is that, independently of where the data is coming from, it is made available to users through a standardised web interface. EU Aid Explorer is designed to help anyone with an interest in the figures behind aid: policymakers looking for evidence, civil society activists holding donors to account, journalists. The website contains detailed information on development and humanitarian projects which have been funded in African countries by the European Commission, the EU Member States, and other major donors in the world over the last decade. For example, via the website it is possible to access information on the funding amounts and sectors to which aid has been provided in each of the African countries in the past 10 years.

Contact at the JRC: Anjula GARG (anjula.garg@ec.europa.eu)

I.1 Population and migration

The European Commission's Knowledge Centre on Migration and Demography (KCMD) has recently developed two tools to support EU policymakers in preparing for future opportunities and challenges linked to longer-term global demographic and migration trends:

Migration Data Catalogue
(https://bluehub.jrc.ec.europa.eu/catalogue) is an inventory of about 120 existing datasets related to migration and demography. For each dataset, the catalogue gives key information, e.g. on its content, methodology of collection, geographical and temporal coverage and frequency of updating. By providing insight into the usability of the datasets for analysis, the catalogue gives guidance on available migration-related data, not only to EU policymakers but also to other interested parties.

Contact at the JRC: Marlene ALVAREZ (marlene.alvarez@ec.europa.eu)

Dynamic Data Hub
(https://bluehub.jrc.ec.europa.eu/migration/app/) is a web-based application which, through interactive mapping, gives direct access to migration-related datasets. It enables policymakers to undertake analyses to enhance awareness and deepen understanding of migration flows to Europe, related trends and impacts. In addition to migration data, it covers time series of selected demographic and socio-economic data (e.g. population growth, GDP, labour force and other World Development Indicators). In the future, it will also include long-term demographic projections produced by the Centre of Expertise on Population and Migration (CEPAM) project.

Contact at the JRC: Michele VESPE (michele.vespe@ec.europa.eu)

Knowledge Centre on Migration and Demography
(https://ec.europa.eu/jrc/en/migration-and-demography)

In 2016, the European Commission created the Commission-wide initiative of the Knowledge Centre on Migration and Demography (KCMD) and entrusted its day-to-day operation to the JRC. The primary goal of the KCMD is to provide better and more timely policy-relevant knowledge and evidence-based analysis of migration and demography to EU policymakers. Much of its activities are dedicated to the opportunities and challenges of longer-term global migration and demographic developments.

kcmd@ec.europa.eu

I.2 Urbanisation and accessibility

Global Human Settlement Layer
http://ghsl.jrc.ec.europa.eu

The Global Human Settlement Layer provides free and open access to global, high-resolution built-up area and population data. Current layers are available for 1975, 1990, 2000 and 2015. Regular updates are planned for the future.

Contact at the JRC: Thomas KEMPER (Thomas.kemper@ec.europa.eu)

Roadless Forests
www.roadlessforest.eu

Looking at tropical forests worldwide, the Roadless Forest project is creating a time-series analysis to assess the current status of forest degradation and to examine its evolution over the past 30 years using satellite imagery. In Africa, the focus is on up-to-date mapping of road infrastructure and logging roads which are rendering previously remote areas accessible.

Contact at the JRC: Stephen PEEDELL (stephen.peedell@ec.europa.eu)

I.3 Disaster risk

Disaster Risk Management Knowledge Centre
http://drmkc.jrc.ec.europa.eu

In 2015, the JRC launched a European-Commission-wide initiative to bridge science and policy in the field of disaster risk. The European Commission's Disaster Risk Management Knowledge Centre aims to make science available to policymakers through improved partnerships, shared knowledge and increased innovation.

Global Disaster Alert and Coordination System (GDACS)
http://www.gdacs.org/

The Global Disaster Alert and Coordination System (GDACS) is a cooperation framework between the UN, the European Commission and disaster managers worldwide to improve alerts, information exchange and coordination in the first phase following major sudden-onset disasters. GDACS provides automated, science-based alerts for earthquakes, tsunamis, tropical cyclones and floods.

Partners: UN and European Commission

Contact at the JRC: Alessandro ANNUNZIATO (alessandro.annunziato@ec.europa.eu)

Global Flood Awareness System (GloFAS)
http://globalfloods.jrc.ec.europa.eu/

The Global Flood Awareness System (GloFAS) is independent of administrative and political boundaries. It couples state-of-the-art weather forecasts with a hydrological model, and with its continental scale set-up it provides downstream countries with information on upstream river conditions as well as continental and global overviews. It is funded by the Copernicus Emergency Management Service.

Partners: European Commission and the European Centre for Medium-Range Weather Forecasts

Contact at the JRC: Peter SALAMON (peter.salamon@ec.europa.eu)

Global Wildfire Information System (GWIS) - see Forests

Index for Risk Management (INFORM)

http://www.inform-index.org/

INFORM is a global, open-source risk assessment tool for humanitarian crises and disasters. It can support decisions about prevention, preparedness and response. Partners include the European Commission and Inter-Agency Standing Committee Reference Group on Risk, Early Warning and Preparedness, the World Bank, the Federation of the Red Cross Red Crescent and specific entities in the USA and UK.

Contact at the JRC: Jesus SAN-MIGUEL (jesus.san-miguel@ec.europa.eu)

Global Drought Observatory (GDO)

http://edo.jrc.ec.europa.eu/gdo

The Global Drought Observatory is an online decision-support system that provides for the continuous monitoring of drought events and (in the future) temperature extremes across the globe, based on an assessment of the dynamic drought hazard and the exposure and vulnerability of different economic sectors and the environment. Early warnings are issued for different sectors (e.g. agriculture, public water supply, inland water transport, and energy production) every eight days. The system includes high-level alert indicators for decision-makers, as well as specific indicators for experts. The GDO also delivers summary information on the affected administrative regions (typically sub-national administrative units), including the population and land-use types affected, as well as key indicators for the country level. It allows for the automatic generation of summary reports for decision-making. More detailed analytical reports, including expert interpretations, are produced during severe events in collaboration with the Directorate-General for European Civil Protection and Humanitarian Aid Operations (DG ECHO), the main customer.

Contact at the JRC: Jürgen VOGT (juergen.vogt@ec.europa.eu)

African Drought Observatory (ADO)

http://edo.jrc.ec.europa.eu/ado

The African Drought Observatory provides specific drought-monitoring and seasonal forecasts as well as information on drought vulnerability and risk at the sub-basin level. The ADO Pan-African Map Viewer has been developed at the JRC within the framework of the DEWFORA (Improved Drought Early Warning and FORecasting to Strengthen Preparedness and Adaptation to Droughts in Africa) project, based on the experience of the European Drought Observatory. The online map viewer contains information provided as maps of drought indicators derived from different data sources (e.g. precipitation measurements, modelled meteorological variables, satellite measurements of vegetation vigour, and socio-economic indicators). The products are made freely available through the map viewer, and are a complementary source of information for stakeholders who would like to use them to monitor and forecast droughts in Africa, and to understand which areas are more vulnerable and at risk. The system has the potential to provide added value to existing and future African drought early-warning systems. The ADO is expected to be fully incorporated into the GDO.

Contact at the JRC: Paulo BARBOSA (paulo.barbosa@ec.europa.eu)

I.4 Food security

African Postharvest Losses Information System
www.aphlis.net

The African Postharvest Losses Information System (APHLIS) provides details on the post-harvest loss (PHL) of cereals. It has special relevance to the current situation, where agriculture needs to produce ever more food for a rapidly growing world population in the face of limited physical resources and the negative impacts of climate change. This is because reducing the losses that occur in the post-harvest chain for cereals offers a resource-efficient means of increasing food availability without further use of land, water and other agricultural inputs. Reliable PHL figures are essential for the better targeting of loss-reduction programmes, monitoring the success of these programmes and estimating food availability in countries threatened by food insecurity.

Contact -at the JRC: Felix REMBOLD (felix.rembold@ec.europa.eu)

Time series analysis software and data distribution
http://spirits.jrc.ec.europa.eu/download/software/

Software for the Processing and Interpretation of Remotely sensed Image Time Series (SPIRITS) is a free software environment for analysing satellite-derived time series of images to monitor crop and vegetation growth. With this software, users can process and examine time series of low- and medium-resolution sensors. It can be used to perform and automate many spatial and temporal processing steps on time series, and to extract spatially aggregated statistics. Vegetation indices and their anomalies can be rapidly mapped, and statistics can be plotted in seasonal graphs to be shared with analysts and decision-makers. The website also makes available numerous time series of spatial data directly in SPIRITS format, including meteorological data from the European Centre for Medium-Range Weather Forecasts (ECMWF) model, rainfall estimates from TAMSAT (Tropical Applications of Meteorology using SATellite data and ground-based observations) project and CHIRPS (Climate Hazards Group InfraRed Precipitation with Station data) dataset, as well as the EMODIS (EROS Moderate Resolution Imaging Spectroradiometer) vegetation index.

Contact at the JRC: Felix REMBOLD (felix.rembold@ec.europa.eu)

Anomaly hot Spots of Agricultural Production (ASAP)
https://mars.jrc.ec.europa.eu/asap/

ASAP is an online decision-support system for early warning about hot spots of agricultural production anomalies (crop and rangeland), developed by the JRC to help prevent food-security crises and inform response planning.

ASAP provides information at two levels:

1. Monthly identification of agricultural production hot spot countries and summary narratives by JRC experts for agriculture and food security analysts, for example in DG DEVCO and the EU Delegations;

2. Ten-day automatic warnings at province level and weather and Earth-observation-based vegetation indicators for JRC and external technical experts.

Contact at the JRC: Felix REMBOLD (felix.rembold@ec.europa.eu)

I.5 Climate and climate change

Air emissions
http://edgar.jrc.ec.europa.eu

The Emissions Database for Global Atmospheric Research (EDGAR) provides global past and present anthropogenic emissions of greenhouse gases and air pollutants by country on a spatial grid. EDGAR aims to inform scientists and policymakers on the evolution of emission inventories over time for all countries worldwide, and to provide the scientific community with grid maps that represent the emission sources, as input for atmospheric chemistry and climate models. The emissions are compiled from the bottom-up using a technology-based emission factor approach, consistently applied for all countries. With a complete global set of activity data, EDGAR calculates emissions of greenhouse gases, air pollutants and aerosols, which are important for the United Nations Framework Convention on Climate Change and the Convention on Long-range Transport of Air Pollution, and to address the co-benefits of air quality and climate policies. EDGAR inputs include international annual statistics that are collected from 1970 until year x-1 for CO2 and with two to four years' delay for air pollutants and particulate matter. Sector- and region-specific monthly profiles are applied for the latest available year, to generate global monthly emission grid maps.

The JRC evaluates emissions of black carbon and mercury into the atmosphere from all key emitting sources for all countries. Contact at the JRC: Greet JANSSENS-MAENHOUT, jrc-edgar@ec.europa.eu

Global Climate Change Alliance Plus (*GCCA+*) *Index*
http://knowsdgs.jrc.ec.europa.eu/gcca/gcca-index

The Global Climate Change Alliance Plus (GCCA+) Index is an index of climate-resilient development developed by the JRC in line with the SDGs. It is an open source index that aims to boost the efficiency of response to climate change for the most vulnerable countries. It has been developed to support the EU's Global Climate Change Alliance Flagship Initiative (GCCA+) and aims to provide knowledge to support the reconciliation of climate change policy objectives with development goals, by ensuring that climate change is systematically integrated into development strategies. This index allows for an *ex-ante* evaluation of the key features of vulnerability to climate change. It consists of four components that classify 34 country-level indicators. A JRC web platform serves as an interface between science and policy. It provides transparent, reliable, accurate and open source information on the indicators, data and methodology related to the index. It allows users to examine the factors behind the index and the indicators.

Contact at the JRC: Apollonia MIOLA apollonia.miola@ec.europa.eu

I.6 Forests

Observatory for Central African Forests (L'Observatoire des Forêts d'Afrique Centrale - OFAC)
www.observatoire-comifac.net

The Observatory for Central African Forests (OFAC) provides a common repository for data related to forests in Central Africa (inventories, spatial data, forest codes and laws, information on concessions, etc.), with an open and regulated single entry point for partners, decision-makers, funding agencies, researchers and civil society. OFAC also publishes research and findings relevant to the Central African region's forests, as well as regular reports on the 'State of the Central African Forests'.

OFAC is owned by the regional council of forest ministers from the Central African Forests Commission (La Conférence des Ministres en charge des Forêts de l'Afrique Centrale, COMIFAC). The COMIFAC secretariat in Yaoundé, Cameroon, hosts OFAC and the technical staff who manage the database and website, with technical support from the JRC.

Contact at the JRC: Frédéric ACHARD (frederic.achard@ec.europa.eu)

East African Forest Observatory (OFESA)
Web link: *to be created by end of 2017*

At the end of 2016, the JRC launched a pilot East African Forest Observatory (OFESA), which is hosted by the intergovernmental Regional Centre for Mapping of Resources for Development (RCMRD) in Nairobi, Kenya. The website will be made public at the end of 2017.

OFESA helps define the logical framework for forest observatories, and provides a framework for their databases and web-interfaces, so that all partner institutions can enter, query and analyse data in the system. It provides technical support for developing the regional databases and websites, and hosts mirrors thereof to guarantee the long-term durability of the data.

Contact at the JRC: Hugh EVA (hugh.eva@ec.europa.eu)

European Forest Fire Information System (EFFIS)
http://forest.jrc.ec.europa.eu/effis/

In cooperation with the FAO Silva Mediterranea network, the JRC has expanded its European Forest Fire Information System (EFFIS) to monitor fires in the Middle East and North Africa, covering all North African countries that are subject to wildfires.

Morocco, Algeria and Tunisia are official members of the expanded EFFIS network. Through their participation in EFFIS, North African countries have good links with southern European countries and participate in joint activities related to fire-prevention and firefighting activities.

Contact at the JRC: Jesús SAN-MIGUEL (jesus.san-miguel@ec.europa.eu)

Global Wildfire Information System (GWIS)
http://gwis.jrc.ec.europa.eu/static/gwis_current_situation/public/index.html

Since 2015, as part of the international Group on Earth Observations (GEO) and the Copernicus programme, the JRC has been leading the development of the Global Wildfire Information System (GWIS), which aims to bring together existing information sources at regional and national level to provide a comprehensive view and evaluation of fire regimes and fire effects at global level.

Partners include the European Commission, Group on Earth Observations, GTOS (GOFC-GOLD), Canadian Forest Service (CFS), South Africa's Council of Scientific & Industrial Research (CSIR), entities in USA, China and Japan, the European Space Agency and NASA. In the near future, GWIS will provide tools for wildfire monitoring at national and regional levels, specifically for the African continent.

As part of its development of GWIS, the JRC is currently reaching out to wildfire managers throughout Africa by establishing close cooperation with African networks such as AfriGEOSS (an initiative to reinforce the Global Earth Observation System of Systems in Africa) and the regional networks of the Global Observation of Forest Cover Fire Implementation Team.

Contact at the JRC: Jesús SAN-MIGUEL (jesus.san-miguel@ec.europa.eu)

Sentinel-2 web platform for REDD+ monitoring
https://cidportal.jrc.ec.europa.eu/forobs/sentinel.py

The recent availability of time series of Sentinel-2 imagery represents a significant technological step in the use of Earth observation data for forest-cover monitoring. To facilitate the use of Sentinel-2 imagery by national forestry services in the tropics (in particular in relation to Reducing Emissions from Deforestation and forest Degradation including the conservation of forest stocks, sustainable management of forests, and enhancement of forest carbon stocks (REDD+) activities), the JRC has developed the Sentinel-2 web platform, an online system for browsing, exploring and processing the full dataset of Sentinel-2 imagery available over the tropical belt.

Contact at the JRC: Dario SIMONETTI (dario.simonetti@ec.europa.eu)

I.7 Land

World Atlas of Desertification (WAD)
http://wad.jrc.ec.europa.eu/

The digital version of the JRC's World Atlas of Desertification (WAD) is due to be launched at the COP13 of the United Nations Convention to Combat Desertification (UNCCD) in China in early September 2017. The online WAD information system will provide access to the digital data in the printed version of the Atlas. An interactive mapping application will display the maps of the Atlas and provide access to the information used at pixel level. The main partner is the United Nations Environment Programme (UNEP). The printed version of the WAD will be a one-off paper publication. However, an interactive website providing regularly updated data on desertification is expected to be developed after publication of the report in September.

Contact at the JRC: Michael CHERLET michael.cherlet@ec.europa.eu

Copernicus Global Land Data distribution
http://land.copernicus.vgt.vito.be/PDF/portal/Application.html#Home

The Global Land Service is a component of the Copernicus Land Service which provides a series of bio-geophysical products on the status and evolution of land surface at global scale at mid- and low spatial resolution. The parameters are produced and delivered in a timely manner, and are complemented by long-term time-series data. The products are used to monitor the vegetation, the water cycle and energy budget.

Contact at the JRC: Michael CHERLET michael.cherlet@ec.europa.eu

I.8 Soils

Soil Atlas of Africa
http://esdac.jrc.ec.europa.eu/content/soil-map-soil-atlas-africa

Understanding the evolution of soils and associated vegetation patterns in relation to their use by society is fundamental to fully assess the impacts of processes that drive change in Africa. This applies equally to key challenges such as climate change, population growth and food security. Building on existing cooperation with researchers from Africa, EU Member States and international organisations, the JRC brings together experts of different nationalities and different technical and political backgrounds to address this key issue and to communicate science to the wider society. The Soil Atlas of Africa aims to raise awareness about the key role of soil in Africa as a non-renewable resource that is essential to human existence. In doing so, it supports the development of protective measures to safeguard soils for current and future generations. The atlas compiles existing information on different soil types in easy-to-understand maps that cover the entire African continent. While it is intended primarily for the educational sectors and policymakers, the atlas aims to bridge the gap between soil science and society at large. It is freely available in French and English at the European Soil Data Centre. Related data and maps can also be downloaded. Contact at the JRC: Arwyn JONES (arwyn.jones@ec.europa.eu)

Global Soil Biodiversity Atlas
http://esdac.jrc.ec.europa.eu/content/global-soil-biodiversity-atlas

The Global Soil Biodiversity Atlas describes soil as habitat for the vast diversity of organisms that live under our feet. At the same time, it draws attention to the threats to soil biodiversity, such as invasive species, pollution, intensive land-use practices and climate change. The atlas provides current solutions for the sustainable management of soils. It was coordinated by the JRC with more than 70 contributing organisations and several hundred individual contributions, including researchers from Africa. It illustrates the diversity of soil organisms, explains their geographical and temporal distribution, and the ecosystem functions and services provided by soil biota. Most importantly, it draws attention to the myriad threats to soil biodiversity. The atlas shows that mismanaging soils could exacerbate the effects of climate change, jeopardise agricultural production, compromise the quality of groundwater and worsen pollution. It proposes solutions for safeguarding soil biodiversity through the development of policies that directly or indirectly target soil health, leading to more sustainable use. The atlas is freely available in English at the European Soil Data Centre. Related relevant data/maps can also be downloaded.

Contact at the JRC: Alberto ORGIAZZI (alberto.orgiazzi@ec.europa.eu)

I.9 Biodiversity and protected areas

Digital Observatory for Protected Areas (DOPA)
http://dopa.jrc.ec.europa.eu/en

The Digital Observatory for Protected Areas (DOPA) is a set of web services and applications that can be used primarily to assess, monitor, report and possibly forecast the state of and pressures on protected areas at multiple scales. The data, indicators, maps and tools provided by DOPA are relevant to various end-users, including policymakers, funding agencies, protected-area agencies and managers, researchers and the Convention on Biological Diversity (CBD).

Contact at the JRC: Grégoire DUBOIS (gregoire.dubois@ec.europa.eu)

eConservation
http://econservation.jrc.ec.europa.eu/

The eConservation tool provides critical information in an interactive mapping interface on biodiversity conservation projects funded by large public donors worldwide. The service provides a means to collect, share and search project information. The aim is to better understand who is funding what and where, with a view to improving decision-making on biodiversity conservation.

Contact at the JRC: Grégoire DUBOIS (gregoire.dubois@ec.europa.eu)

BIOPAMA Reference Information System
http://rris.biopama.org

In the framework of the Biodiversity and Protected Areas Management Programme (BIOPAMA), a network of Regional Observatories on Biodiversity and Protected Areas is being established in partner organisations, including relevant Regional Economic Communities. The observatories facilitate access to critical information and knowledge to support protected-area management, and decision-making and policy processes in national and regional agencies and institutions. The JRC develops and deploys to each observatory a regional reference information system (RRIS) that integrates a diverse range of relevant data, tools and information, customised to regional information needs and priorities.

Contact at the JRC: Stephen PEEDELL (stephen.peedell@ec.europa.eu)

Africa, Caribbean and Pacific (ACP) Environmental Observatory for sustainable development
http://acpobservatory.jrc.ec.europa.eu/

The Africa, Caribbean and Pacific (ACP) Environmental Observatory is an information portal that supports European Commission services and the ACP Group of States in their decision-making on development policies and programmes that promote sustainable development in the ACP countries. Managed by the JRC, it is a web portal that provides access to information on themes related to sustainable development in the ACP Group of States. The portal helps the European Commission and other users to evaluate, monitor and report on the status and trends of environment and development in the ACP countries. The portal is a pilot website, developed in 2008-2009 and renewed in 2016, that aims to bring together in a single portal relevant environmental information on ACP countries concerning sustainable development.

Contact at the JRC: Stephen PEEDELL (stephen.peedell@ec.europa.eu)

I.10 Water resource management

LISFLOOD Water simulation model
https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/lisflood-distributed-water-balance-and-flood-simulation-model-revised-user-manual-2013

The **LISFLOOD water resources simulation model** is a state-of-the-art water resources and river-routing model that can simulate in detail the daily water balance over long periods and areas, at a user-specified level of spatial detail. It simulates water demand and consumption, lakes and reservoirs, groundwater abstraction, as well as extreme river flows. It produces indicators related to floods, droughts and water scarcity.

The main partners associated with LISFLOOD involved in providing technical support and feedback are the European Centre for Medium-Range Weather Forecasts (ECMWF), Utrecht University and several national hydrological institutes in Europe. LISFLOOD is used as the underlying model in the operational warning systems of the European Flood Awareness System (EFAS), the EDO and the Global Flood Awareness System (GloFAS).

Contact at the JRC: Ad DE ROO (ad.de-roo@ec.europa.eu)

Global Flood Awareness System (GloFAS)
http://globalfloods.jrc.ec.europa.eu/

The Global Flood Awareness System (GloFAS) was jointly developed by the European Commission and the European Centre for Medium-Range Weather Forecasts (ECMWF). It couples state-of-the art weather forecasts with a hydrological model and with its continental scale set-up it provides downstream countries with information on upstream river conditions as well as continental and global overviews. GloFAS has been producing daily flood forecasts in a pre-operational manner since June 2011. It has shown its potential during the floods in Pakistan in August 2013 and in Sudan in September 2013.

Contact at the JRC: Ad DE ROO (ad.de-roo@ec.europa.eu)

Global Surface Water Explorer
https://global-surface-water.appspot.com/

Scientists from the JRC recently partnered with Google to create interactive digital maps that show quantitative changes in surface water over the period 1984-2015. This massive effort used more than 3 million images that were analysed by 10 000 computers to produce a set of global maps at 30-m horizontal resolution. Anyone can access the maps and data on the European Commission's interactive site. Choose a location and select from various options to show, for example, total surface water over the 32-year period, or changes in water, such as permanent gain or loss. The maps (and accompanying data) provide a wealth of information about surface processes, changes in water availability, changes in seasonality, or the potential positive/adverse effects of human activity on surface water systems (rivers, lakes, diversion canals, etc.).

Contact at the JRC: Jean Francois PEKEL (jean-francois.pekel@ec.europa.eu)

Aquaknow
http://aquaknow.jrc.ec.europa.eu/

Aquaknow is a collaborative work space and content management system dedicated to technical and scientific knowledge for the sustainable development of the water sector. It is a dynamic platform designed for sharing knowledge on water-sector issues by gathering scientific and technical information and providing dynamic tools to manage it. These tools are a powerful means for sharing documents, data, information, ideas and experiences, and supporting and working with other stakeholders involved in the water sector.

The Aquaknow platform is oriented towards experts and practitioners at the institutions involved in the water sector, such as governmental and non-governmental organisations, universities and research centres, international organisations, the private sector, water utilities, river basin agencies, etc.

As with other interactive web platforms, users are central, becoming the providers of information and sharing it online through a user-friendly interface.

Aquaknow is organised around two axes:

- knowledge management, organising information through thematic indexes and within the following sections: news, events and library (where documents or links are stored in various formats); the capacity-building section (which provides users with an inventory of training courses, workshops, seminars and methodological tools); and the tools and data section (which contains databases and supporting tools for the water sector). These indexes are directly updated by members;

- building a community with interactive and user-friendly tools designed to facilitate distance working and networking. The working groups section is specifically designed to develop collaborative work;

Contact at the JRC: Cesar CARMONA MORENO (cesar.carmona-moreno@ec.europa.eu)

AquaSurvey
http://aquaknow.jrc.ec.europa.eu/aquasurvey-software

As data availability is a common issue in Africa, the JRC developed the AquaSurvey application to collect water-energy-food-ecosystems (WEFE) field data in areas where internet and space-based radio navigation (such as via the Global Positioning System (GPS)) reception is poor or intermittent, thereby maintaining the advantage of using advanced IT tools even in remote regions.

Contact at the JRC: Cesar CARMONA MORENO (cesar.carmona-moreno@ec.europa.eu)

e-NEXUS
The e-NEXUS module is a decision support tool (DST) being developed by the JRC together with African partners to help transboundary populations foster sustainable growth. The e-NEXUS integrates biophysical and socio-economic tools to provide multi-sectoral integrated development options to generate development scenarios for consideration by stakeholders during transboundary dialogues. Combined modelling tools simulate crop production according to different agricultural options, water availability and climate scenarios, irrigation, fertilisation provided, the availability of reservoirs, etc. The integrated economic assessment carried out and the related modelling provide economic estimations/projections of a water supply service, of the natural assets and agricultural production. At the request of the Niger River Basin Authority (NBA), the DST module will be installed at the Niger Environmental Observatory, and therefore replicated for the other nine countries that share the NBA as a support to the national authorities on WEFE Nexus management. Other river basin organisations (such as the Zambezi Watercourse Commission) have also expressed an interest. The portal is under development (prototype) and will be soon accessible via the Aquaknow platform.

Contact at the JRC: Cesar CARMONA MORENO (cesar.carmona-moreno@ec.europa.eu)

I.11 The marine environment

Environmental Marine Information System (EMIS)
http://mcc.jrc.ec.europa.eu/emis/

Through the analysis of satellite data and modelling outputs, the Environmental Marine Information System (EMIS) supports effective and long-lasting marine and coastal stewardship by providing scientific and technical added-value products to assist in monitoring and assessing water quality, biodiversity, and ecosystem health status in Europe and globally. The EMIS spatial data infrastructure and web-based GIS viewer enable users to retrieve, navigate and browse through the data, based on different levels of spatial resolution, variables to be analysed, and time periods. Another set of applications was developed to query the data and perform statistical analysis on the region of interest. Additional functions enable the users to download datasets in different formats, print maps and to download results directly on ready-to-use PDF files.

The EMIS Marine Analyst provides simple methods to explore any pre-defined areas of the European seas and of the oceans to assess the pressures to which they are exposed. It helps inform marine protected areas management and sustains the implementation of environmental directives, by generating environmental information and indicators of relevance for decision-makers.

Contacts at the JRC: Nicolas HOEPFFNER (Nicolas.hoepffner@ec.europa.eu);
Jean-Noel DRUON (jean-noel.druon@ec.europa.eu)

I.12 Agriculture and fisheries

The Data portal of agro-economics Modelling – DataM
https://datam.jrc.ec.europa.eu

The DataM portal provides interactive factsheets and raw datasets from the JRC's scientific activities relating to the economics of agriculture. The website combines traditional scientific articles and reports with interactive graphics which illustrate key facts and statistics. The areas of agricultural economics covered include trade and productivity, technology (e.g. genetically modified organisms, fertilisers), the bioeconomy, climate change, food security, nutrition, farms and rural development. The platform currently focuses on Europe, but is also expected to produce relevant information for Africa in the near future. This will include: i) a dashboard on investment and nutrition; ii) an interactive factsheet 'Food and nutrition security in long-term projections'; and iii) interactive infographics on agro-economic factsheets about developing countries. The work is developed in partnership with the European Commission's Directorate-General for Agriculture and Rural Development (DG AGRI) and DG DEVCO. Infographics on food and nutrition security are developed in partnership with the FOODSECURE consortium (which includes the Wageningen University and Research Centre, the International Institute for Applied Systems Analysis, and PBL – the Netherlands Environmental Assessment Agency). In the medium term, it is expected to produce a global report on food crises, in partnership with the FAO and the WFP.

Contact at the JRC: Bettina BARUTH (Bettina.baruth@ec.europa.eu)

I.13 Energy

AFRETEP
https://europa.eu/capacity4dev/afretep/

The African Renewable Energy Technology Platform (AFRETEP) is a JRC project, partly financed by the DG DEVCO, which aims to help understand the potential for using renewable energy options in Africa to increase access to electrification in rural areas. AFRETEP-developed geographical datasets have been made publicly available on DG DEVCO's 'Capacity4dev.eu' website, managed by DG DEVCO but initially developed by the JRC. AFRETEP provides African academia with a platform on which to access and exchange data and research material on renewable energy technology.

Contact at the JRC: Sandor SZABO (sandor.szabo@ec.europa.eu)

PVGIS
http://re.jrc.ec.europa.eu/pvgis/

It is planned to extend the EU's Photovoltaic Geographical Information System (PVGIS) to Africa. The PVGIS provides solar-irradiation data based on satellite images in freely downloadable format, and is widely used by industry and project developers, both in the framework of private and public investment and within development programmes. Its maps repository is designed to be used by policymakers and for research analysis.

Contact at the JRC: Thomas HULD (thomas.huld@ec.europa.eu)

RE2nAF tool
http://iet.jrc.ec.europa.eu/remea/re%C2%B2naf

The interactive tool RE^2nAF (**R**enewable **E**nergies for **R**ural **E**lectrificatio**n** of **Af**rica) enables geographically based exploratory analysis for off-grid electricity production options in Africa. It overlays population features (settlements), infrastructure (electricity grids, roads), national boundaries and renewable energy resources (currently limited to solar-energy resources, but will be extended to include other renewable resources). The user can easily get a first impression of the spatial distribution of the demand, density of the road network, estimated travel time to major cities, and the status of the existing power plants in a particular area/region. The RE^2nAF tool offers analyses at the continental scale, and is therefore suitable for defining policy strategies. Researchers can interact with the tool and also further adopt its functionalities in their own research. An app version of RE^2nAF is available, which gives updates on RE^2nAF results: http://re.jrc.ec.europa.eu/re2naf.html

Contacts at the JRC: Irene PINEDO PASCUA (irene.pinedo@ec.europa.eu);
Sandor SZABO (sandor.szabo@ec.europa.eu)

I.14 Raw materials

The Raw Materials Information System (RMIS)
http://rmis.jrc.ec.europa.eu/

The JRC has developed the RMIS in support of the European Commission's policy on raw materials, in particular in the context of the Raw Materials Initiative, the European Innovation Partnership (EIP) on Raw Materials, and as a specific action of the Circular Economy Action Plan. The RMIS aims at providing data and information on non-energy, non-food materials (e.g. metals, industrial and construction materials, and biomass) from primary and secondary sources, to inform policymakers and support international cooperation. It uses a variety of EU and international sources, including on specific raw materials and countries, from economic/trade, environmental, and social perspectives.

The Raw Materials Scoreboard (http://rmis.jrc.ec.europa.eu/Scoreboard/) provides an overview of global competitiveness, innovation and framework conditions for mining, the circular economy and recycling, including environmental and social sustainability considerations.

Contact at the JRC: Constantin CUPAGEA (constantin.cupagea@ec.europa.eu)

I.15 Digital infrastructures

A Radio Spectrum Atlas
The JRC has developed the EU Radio Spectrum Inventory which provides information on radio spectrum in EU countries. It gives a homogenous view of the allocation and use of radio waves in different EU countries. The Inventory helps to identify opportunities for harmonised decisions on the allocation of new spectrum for mobile broadband and other wireless services that enable the digital infrastructure in the European Digital Single Market.

Contact at the JRC: Pravir CHAWDHRY (pravir.chawdhry@ec.europa.eu)

Monitoring the Quality of Experience – netBravo app
For mobile as well as fixed broadband networks, monitoring the quality of service on a continuous basis is a key challenge. When a broadband network comes into service, the user experience initially tends to be good. With more and more users, the network starts to become congested and the quality of the user experience begins to deteriorate. Different operators respond to the market evolution differently in terms of price and capacity enhancement. For the users, reliable information on the quality of experience is as important as the price of the service. The JRC netBravo app provides information on users' experiences for different mobile and broadband networks.

Contact at the JRC: Georg PETER (georg.peter@ec.europa.eu)

Happy Onlife: digital media education and awareness raising
https://web.jrc.ec.europa.eu/happyonlife

Happy Onlife is an edutainment toolkit that promotes the safe and responsible use of information and communications technology (ICT) among adults and children. It comprises a set of paper-based and digital resources and best practices to raise awareness about the ethical and educational challenges of ICT, including online safety risks in terms of privacy, cybersecurity and cyberbullying. Happy Onlife is released under open-source European Union Public Licence 3 (EUPL3).

Contact at the JRC: Jean-Pierre NORDVIK (jean-pierre.nordvik@ec.europa.eu)

I.16 Conflict prevention and early warning

Continental Early Warning System (CEWS)
http://www.peaceau.org/en/page/28-continental-early-warning

The Continental Early Warning System (CEWS) is based on a number of tools developed in partnership with the JRC, including the Africa Media Monitor (AMM), Newsdesk, **Conflict Alerting and Analysis System** (CAAS) and Event Moderator, which combine within the CEWS to give the African Union Peace and Security Division a powerful monitoring, analysis and reporting capability.

The partnership involves JRC in building the CEWS technical capacity and know-how, in particular the AU Situation Room, by training CEWS staff and the Regional Economic Communities. A series of technical workshops held at the JRC Ispra site, the AU headquarters and at other locations determined by the AU Peace and Security Department help uptake. These training activities and further developments of the early-warning system will continue in the future.

Contacts at the JRC: Brian DOHERTY(brian.doherty@ec.europa.eu) and Martin ATKINSON (martin.atkinson@ec.europa.eu)

Global Conflict Risk Index (GCRI)
http://conflictrisk.jrc.ec.europa.eu/

The JRC's Global Conflict Risk Index (GCRI) is an index of the statistical risk of violent conflict over the next one to four years. It is exclusively based on quantitative indicators from open sources. With the assumption that the occurrence of violent conflict is linked to a country's structural conditions, the GCRI collects 24 variables under five themes (social, economic, security, political, geographical/environmental) and uses statistical regression models to calculate the probability and intensity of violent conflict.

Contact at the JRC: Matina HALKIA (matina.halkia@ec.europa.eu)

I.18 Chemical, biological, radiological and nuclear security and nuclear safety

EU CBRN Risk Mitigation Centres of Excellence
http://www.cbrn-coe.eu/

This website promotes the EU CBRN Risk Mitigation Centres of Excellence (CoE) initiative, gives visibility to its activities and provides a communication platform for the network's members. It is regularly updated, taking into account the latest news and achievements concerning the initiative. It describes the background to the CoE Initiative, states its objectives, presents the main stakeholders and official partners, raises awareness on CBRN-related issues and possible solutions, includes information about CoE projects and their current status, provides access to the newsletter and publicises information on events and meetings with partner countries and international organisations.

Contact at the JRC: Margarida GOULART (margarida.goulart@ec.europa.eu)

CBRNE Glossary
Website: http://opencbrne.jrc.ec.europa.eu/main

App Android: https://play.google.com/store/apps/details?id=eu.europa.publications.cbrne

App IOS: https://itunes.apple.com/us/app/eu-cbrne-glossary/id1123578719?mt=8

One important step in developing cross-border cooperation is to build a common understanding of key terms. This website provides an online glossary of terms in the area of chemical, biological, radiological, nuclear and explosives (CBRNE) in all EU official languages, and is accompanied by an application for smartphones and tablets, which could be used by first responders and the general public as an awareness-raising tool. It is to be used both within the EU and outside its borders, e.g. in the implementation of the EU CBRN Risk Mitigation Centres of Excellence Initiative. For this reason, it will soon be available in other languages (including Arabic), enabling broader use.

Contact at the JRC: Margarida GOULART (margarida.goulart@ec.europa.eu)

II.1 Research and innovation

The Smart Specialisation Platform
http://s3platform.jrc.ec.europa.eu

The JRC's Smart Specialisation Platform provides advice to EU countries and regions on the design and implementation of their research and innovation strategies for smart specialisation. A seminar held in Seville in 2017 on 'Smart specialisation and organisational development in enlargement and H2020 associated countries' focused on providing methodological advice on the opportunities to develop R&I strategies for smart specialisation to representatives from Tunisia and five neighbouring countries. The JRC will provide advice to the Tunisian authorities on introducing smart specialisation in a number of selected pilot regions.

Contact at the JRC: Manuel PALAZUELOS MARTINEZ (manuel.palazuelos-martinez@ec.europa.eu

II.3 Earth observation and geospatial information systems

Community Image Data (CID) portal
http://cidportal.jrc.ec.europa.eu/imagearchive/main/

The Community Image Data (CID) portal is an online catalogue and archive of satellite remote-sensing data. It was established by the JRC to improve the acquisition, pre-processing, access, storage and dissemination of satellite and aerial remote-sensing data. It contains over 100 TB of data, including satellite remote-sensing data of 0.5-m resolution to a time series of 1 000-m resolution (European and global coverage). Datasets on the common agricultural policy (CAP), Global Security and Crisis Management, and selected Copernicus datasets, among others, are stored here.

Contact at the JRC: Armin BURGER (armin.burger@ec.europa.eu)

Environmental station (eStation)
http://estation.jrc.ec.europa.eu/

The eStation is a processing system developed by the JRC to automatically deal with the acquisition, processing, visualisation and analysis of key environmental parameters derived from remotely-sensed data. In addition to the processing services, the eStation offers a highly customised web client, made available to different end-users for computing ad-hoc thematic products and environmental indicators. The eStation has been distributed to the national points of contact in all sub-Saharan African countries involved in the MESA project.

Contact at the JRC: Marco CLERICI (marco.clerici@ec.europa.eu)

Copernicus portals of relevance for Africa
Copernicus is an EU programme that aims to develop European information services based on satellite Earth observation and *in-situ* (non-space) data.

Copernicus Global Land Service
http://land.copernicus.eu/global/

The Copernicus Global Land Service provides a series of bio-geophysical products on the status and evolution of the land surface at a global scale at medium and low spatial resolution. The parameters are produced and delivered in a timely manner, and feed into long-term time-series data. The data are used to monitor the Earth's vegetation, water cycle and energy budget. Within the Global Land Service, the high-resolution hot-spot monitoring activity provides detailed land information on specific areas of interest, in response to ad-hoc requests. It concentrates mainly on the sustainable management of natural resources, with an initial focus on protected areas and key landscapes for conservation in Africa.

Contacts at the JRC: Mark DOWELL (mark.dowell@ec.europa.eu), Michael CHERLET (michael.cherlet@ec.europa.eu), Andreas BRINK (andreas.brink@ec.europa.eu)

Copernicus Emergency Management Service
http://emergency.copernicus.eu

The Copernicus Emergency Management Service (EMS) provides information for emergency response in relation to different types of disasters, including meteorological hazards, geophysical hazards, deliberate and accidental man-made disasters and other humanitarian disasters, as well as prevention, preparedness, response and recovery activities. Since 2012, the Copernicus EMS has provided support to African emergency response through the provision of rapid mapping in 16 activations for floods, storms, refugee and internally displaced persons camps and the Ebola crisis. It has also provided support to preparedness, prevention and recovery activities in four risk and recovery mapping activations for population estimation, environmental degradation and reconstruction projects.

Contacts at the JRC: Annett WANIA (annett.wania@ec.europa.eu), Peter SPRUYT (peter.spruyt@ec.europa.eu), Marco BROGLIA (marco.broglia@ec.europa.eu)

IMPACT Tool
http://forobs.jrc.ec.europa.eu/products/software/

The JRC's IMPACT (Image Processing and Classification Tool) Toolbox offers a combination of remote sensing, photo interpretation and processing technologies in a portable and stand-alone GIS environment, allowing non-specialist users to easily accomplish all necessary pre-processing steps while providing a fast and user-friendly environment for visual editing and map validation. No installation or virtual machines are required.

Contact at the JRC: Dario SIMONETTI (dario.simonetti@ec.europa.eu)

3. 1. Strengthening implementation and revitalising the Africa-EU Partnership for sustainable development

Sustainable Development Goals

knowSDGs (Knowledge base for the Sustainable Development Goals) platform
http://knowsdgs.jrc.ec.europa.eu/

The 2030 Agenda, unanimously adopted by the Member States of the United Nations in 2015, has been proposed to address some of the main challenges that affect both developing and developed countries. The Agenda contains the SDGs and is based on the idea that economic prosperity, environmental protection and social well-being are interconnected elements that cannot be addressed separately. The European Commission, which has worked towards sustainable development for a long time, is now working towards the implementation of the 17 SDGs and their 169 targets. This is laid out in the Communication 'Next steps for a sustainable European future - European action for sustainability' (COM/2016/739). The successful implementation of this framework requires a coordinated and coherent response, for which novel knowledge-management tools are required. The JRC's knowSDGs (Knowledge base for the Sustainable Development Goals) platform provides management tools and information on policies, indicators, methods and data to support the evidence-based implementation of the SDGs. This online platform facilitates interactive and easy-to-use access to data and information related to the SDGs.

Contact at the JRC: Apollonia MIOLA (apollonia.miola@ec.europa.eu)

Table 3: JRC training and capacity-building activities

I.2.1 Urbanisation

The JRC collaborates closely with the United Nations Human Settlements Programme (UNHABITAT) on the use of Earth-observation data for the mapping of human settlements. In recent years, together with the Global Urban Observatory (GUO) of the UNHABITAT, the JRC has organised training courses for African countries national statistical offices in Dakar (Senegal) and Beirut (Lebanon) for Arabic and North African countries. The JRC is also collaborating with the South African National Space Agency (SANSA), and has installed the JRC settlement mapping tools at the SANSA premises. Annual training sessions are given on using these tools.

Contact at the JRC: Thomas KEMPER (thomas.kemper@ec.europa.eu)

I.4 Food security

http://www.fao.org/elearning/#/elc/en/course/FRS

http://spirits.jrc.ec.europa.eu/

www.aphlis.net

The JRC collaborates closely with the main UN agencies for agriculture and food security (namely the FAO, the WFP and the World Meteorological Organization (WMO)) on agricultural monitoring and capacity-building activities. For instance, a joint JRC-FAO e-learning course (in English and French) on the use of remote sensing for crop monitoring has been created for African stakeholders; general training courses on the use of satellite products for monitoring agriculture were delivered in countries of West Africa (Ouagadougou, 2014), East Africa (Addis Ababa, 2015) and Southern Africa (Harare, 2016). More technical training sessions on JRC software, namely Software for Processing and Interpreting Remote sensing Image Time Series (SPIRITS) for crop monitoring, and the Crop Statistical Tool (CST) for forecasting crop yield, were organised in Africa (see SPIRITS website for a list of past training sessions). For instance, SPIRITS training was organised for the Kenyan National Drought Management Authority, as well as for the Bahir Dar University and the National Met Agency (2015), a 'train the trainers' training course on CST was given to the Southern African Development Community (SADC) in Botswana (2016). Building and consolidating national and regional capacities on the analysis of agricultural policies relies on the development and use of food-security information systems. At the regional level in West Africa, the JRC supports the Economic Community Of West African States (ECOWAS) Agricultural Regional Information System (ECOAGRIS) project, which aims to address food crises and to strengthen household resilience to food and nutrition insecurity. The JRC also supports agro-meteorological monitoring in Southern Africa, and the scientific network on post-harvest losses (Africa Post-Harvest Losses Information System – APHLIS). The JRC actively shares knowledge with the Permanent Interstate Committee for Drought Control in the Sahel (Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel - CILSS) on topics ranging from measurement to resilience to food crises.

Contact at the JRC: Felix REMBOLD (felix.rembold@ec.europa.eu)

I.6 Forests

http://forobs.jrc.ec.europa.eu/recaredd/

In the frame of the ReCaREDD project (Reinforcement of Capacities for REDD+ (Reducing Emissions from Deforestation and Forest Degradation and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries)), regional and national training workshops are organised with partner countries (Côte d'Ivoire, Cameroon, Republic of the Congo, Democratic Republic of the Congo and countries from the Intergovernmental Authority on Development (IGAD) region[83]). The project's main objective is to enhance the capacity of national institutions to report on forest degradation, in a reliable and cost-efficient manner. National services are strengthened in forest-monitoring techniques to improve reporting on forest degradation (one of the five REDD+ activities focusing on the mapping and monitoring of disturbed forests through remote-sensing imagery, relying on the Sentinel-2 satellite from the EU's Copernicus programme.

Contact at the JRC: Hugh EVA (hugh.eva@ec.europa.eu)

I.8 Soils

http://esdac.jrc.ec.europa.eu/themes/erosion-modelling-workshop

The JRC Soil Team is planning a two-day workshop on soil erosion modelling to be given in Morocco in 2018-2019. The workshop will follow a similar structure to the one organised in Ispra (VA), Italy in March 2017. Hosting around 100 participants from African countries, the focus will be on improving knowledge on the modelling of soil erosion in Africa.

Contact at the JRC: Panos PANAGOS (panos.panagos@ec.europa.eu)

83 The Intergovernmental Authority on Development (IGAD) region comprises the countries of Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, Sudan and Uganda.

I.9 Biodiversity and protected areas

BIOPAMA capacity-building programme
www.biopama.org

The BIOPAMA (Biodiversity and Protected Areas Management) Programme includes a knowledge-management and capacity-building component to improve the use of information and analysis in decision-making for conservation and development planning and management. This ranges from field-level data collection to regional analysis through the BIOPAMA observatories, with a particular emphasis on the use of advanced geospatial technologies. Work is also ongoing to compile sources of information on relevant training opportunities across Africa, from short courses on specific software tools to higher education and professional qualification opportunities.

Contact at the JRC: Stephen PEEDELL (stephen.peedell@ec.europa.eu)

Integrated Management Effectiveness Tool (IMET)
www.biopama.org

Protected-areas management is particularly complex because of the number and diversity of aspects, pressures and constraints to be addressed. Incomplete and unstructured information make it even more challenging. The Integrated Management Effectiveness Tool (IMET), developed by the JRC, the Observatory for Central African Forests (OFAC) and the Network of Protected Areas of Central Africa (RAPAC) as part of the BIOPAMA programme, directly supports managers at field and central level. It consists of three modules: context of intervention, management effectiveness, and visualisation of the results (decision support systems). The use of IMET entails a strong capacity-building dimension. It allows for the definition of strategic and management objectives, as well as of indicators and reference values (benchmarks) to ensure follow-up over time. To date, more than 60 protected areas in 14 different countries (mostly in Central and West Africa) have been assessed, and requests for IMET training courses and assessments have been made by staff in other protected areas on an individual and national level. The second phase of the BIOPAMA project (2017-2022) is expected to meet these demands and to further expand the use of a systematic approach towards biodiversity conservation.

Contact at the JRC: Paolo ROGGERI (paolo.roggeri@ec.europa.eu)

I.10 Water-resource management

http://aquaknow.jrc.ec.europa.eu/

Many capacity-building initiatives were implemented as part of the African Centres of Excellence on Water (ACE-Water) initiative. During phase I, 13 training courses (eight in West Africa and five in Southern Africa) were delivered, focusing on knowledge gaps, response strategies, knowledge management for science and data sharing, water management at transboundary river-basin level and climate variability. During phase II, other training courses were organised on climate change risk, vulnerability assessment and early warning.

In the framework of the Mékrou project, training courses were delivered to key stakeholders on the Soil and Water Assessment Tool (SWAT) and its calibration on the Mékrou and Niger rivers, household surveys, climate variability modelling SWAT, crop modelling and socio-economic assessment.

Contact at the JRC: Cesar CARMONA MORENO (cesar.carmona-moreno@ec.europa.eu)

I.11 The marine environment

https://mesa.au.int/

The JRC has organised a series of training sessions on 'Methods and Applications of Ocean Colour Remote-Sensing in African Coastal and Regional Seas' (2007: Mombasa, Kenya; 2009: Zanzibar, Tanzania; 2012: El Jadida, Morocco). This training provided the theory behind ocean-colour satellite measurements, and introduced key applications for monitoring and managing the coastal zone and protecting marine ecosystems and their resources. Training courses were organised in partnership with international bodies (including the GEO, the Intergovernmental Oceanographic Commission's Global Ocean Observing System (IOC-GOOS), the International Geosphere-Biosphere Programme's Land Ocean Interactions in the Coastal Zone (IGBP-LOICZ)), African organisations and universities (including the Kenya Marine and Fisheries Research Institute (KMFRI), the University of Cape Town (UCT), the Western Indian Ocean Marine Science Association (WIOMSA), and the Moroccan Association of Remote Sensing of the Environment (MARSE)), and in collaboration with European projects. A partnership with the Centre for Remote Sensing Applications (CURAT) at the University Felix Houphouet-Boigny in the Côte d'Ivoire resulted in an analysis of ecosystem variability and the impact of land use on coastal waters.

Through the MESA project, the JRC also collaborates directly with the AU on building capacity in marine-resource management and monitoring the coastal environment.

Contacts at the JRC: Nicolas HOEPFFNER (nicolas.hoepffner@ec.europa.eu), Jean-Noel DRUON (jean-noel.druon@ec.europa.eu)

I.12 Agriculture and fisheries

Training courses are organised for African decision-makers on methods for carrying out economic policy analyses. Since 2016, knowledge-sharing activities have been set up with local partner institutions in the area of micro-economic modelling at farm level. In parallel, in five African countries, the ministries of agriculture, national statistical agencies and research institutions were trained in the analysis of policy scenarios. This activity started with generic training on micro-modelling, and will be followed up with workshops and training courses both on JRC premises and in local institutions in Africa.

Contact at the JRC: Felix REMBOLD (felix.rembold@ec.europa.eu)

I.13 Energy

http://iet.jrc.ec.europa.eu/remea/capacity-building

https://europa.eu/capacity4dev/afretep/

The JRC has been actively supporting knowledge- and capacity-building for renewable energy in Africa, exploiting in-house scientific expertise. As part of a project (2010-2013) financed by the European Commission's DG DEVCO, the JRC, with partners in university and research institutions across the African continent, supported the establishment of the African Renewable Energy Technology Platform (AFRETEP). As part of this project, the JRC organised training courses on rural electrification methods and decision-making support tools for researchers and policymakers in Africa. Regional workshops were organised in Kampala, Burkina Faso and Cape Town, involving 96 participants from 30 African countries.

Contact at the JRC: Sandor SZABO (sandor.szabo@ec.europa.eu)

I.15 Digital infrastructures

https://ec.europa.eu/jrc/en/event/workshop/gnss-international-summer-school-2017

https://www.enisa.europa.eu/topics/cyber-exercises

Training and knowledge sharing on the enabling technologies for digital services is key to rapid development, application and uptake of ICT by businesses and industry. The JRC organises a number of training events in this context:

(i) The radio-frequency spectrum is the basis for creating mobile and wireless services of all kinds. The JRC organises workshops on modern spectrum management involving experts from national spectrum regulators. The events focus on an experimental approach to learning about emerging techniques for managing the radio spectrum, such as spectrum sharing. Training activities on new instruments and tools for spectrum monitoring and signal analysis are also organised from time to time.

(ii) Satellite-based navigation systems are key enablers for digital infrastructures to provide precise positioning and timing services for day-to-day use. The JRC organises an annual summer school on global navigation satellite systems, in collaboration with the European Space Agency. The annual event focuses on global systems such as the United States' Global Positioning System (GPS) and the European Union's Galileo, and state-of-the-art technologies for satellite navigation. The lectures provide in-depth training to young researchers from academia and industry, to help prepare them for professional careers. Lectures are presented by experts from around the world.

(iii) The security of digital infrastructures ultimately depends on the cybersecurity of underlying ICT networks. The JRC organises training and cybersecurity simulation exercises for operators and decision-makers to promote preparedness against cyberattacks on networked infrastructures. The events are organised in collaboration with the European Network and Information Security Agency (ENISA), for which the JRC provides the tools and a platform for cybersecurity exercises.

Contact at the JRC: Georg PETER (georg.peter@ec.europa.eu)

I.17 Maritime security

The PMAR (Piracy, Maritime Awareness and Risks) projects run by the JRC between 2010 and 2015 aimed to build capacity for maritime security. African decision-makers and operational users were introduced to technologies and systems that map and track shipping activities off the coasts of Africa, from the ports out to the high seas. This was done in a series of meetings and workshops, and by providing web-based access to a real-time maritime picture of the Western Indian Ocean to two operational authorities in East Africa during one full year. Furthermore, authorities in some countries around the Gulf of Guinea were trained in the use of a system to collect, share and analyse piracy incident data.

Web link: http://publications.jrc.ec.europa.eu/repository/handle/JRC97971

Contact at the JRC: Harm GREIDANUS (harm.greidanus@ec.europa.eu)

I.18 Chemical, biological, radiological and nuclear (CBRN) security and nuclear safety

ESARDA education course on nuclear safeguards and non-proliferation
https://esarda.jrc.ec.europa.eu/

The JRC has been organising an education and training course on nuclear safeguards and non-proliferation for 15 years under the auspices of the European Safeguards Research and Development Association (ESARDA) for both professionals and students. The lecturers include experts from organisations such as the International Atomic Energy Association (IAEA), the US Environmental Protection Agency, the Directorate-General for Energy (DG ENER) and the JRC. Funded by DG DEVCO through the Instrument for Safety Collaboration (INSC), regional courses are organised worldwide with the aim of building an educational and training network. The course will be organised during 2017-2018 in Algeria and South Africa.

Contact at the JRC: Kamel ABBAS (kamel.abbas@ec.europa.eu)

EUSECTRA – European Nuclear Security Training Centre
http://www.nusaset.org/

The JRC has several years' experience in the detection of and response to unregulated radioactive and nuclear material. Its European Nuclear Security Training Centre (EUSECTRA) provides training to border guards, customs officials, advanced nuclear operators and their trainers on radiation-detection techniques and response procedures. Many sessions have been organised for African countries. Three projects that include training sessions and the provision of detection instrumentation have currently reached the completion phase in Algeria, Morocco and the Democratic Republic of the Congo.

Contact at the JRC: Jean GALY (jean.galy@ec.europa.eu)

Nuclear safety
https://nuclear.jrc.ec.europa.eu/tipins/europeaid-safety-training/

The JRC supports DG DEVCO in a worldwide training and tutoring programme designed to strengthen the regulatory capacity of nuclear regulatory authorities and their technical support organisations. This programme is available for African countries.

Contact at the JRC: Ynte STOCKMANN (ynte.stockmann@ec.europa.eu)

Chemical, biological, radiological and nuclear (CBRN) security
http://www.cbrn-coe.eu/

To date, there are 32 ongoing or completed EU CBRN Centre of Excellence (CoE) projects in African countries, which address a wide variety of topics: border control and monitoring, illicit trafficking, import and export control, crisis management, first response, post-incident recovery, public health impact mitigation, waste management, safety and security, and the legal framework. Three of these projects were implemented by the JRC. With respect to training, the JRC manages the evaluation of project implementation and has been gathering as much training material as possible to ensure that a database exists and that the screened material would be available for long-term use by the partner countries (beyond the lifespan of the initiative). To this end, a learning management system is currently being populated with selected tagged and screened training material.

Examples include:

- a project with the aim of improving chemical safety and security in the East and Central African (ECA) region by training all first responders and personnel involved in managing chemicals, from storage to use to transport. Inter-country links between Burundi, the Democratic Republic of the Congo, Ghana, Kenya, Seychelles, Tanzania and Zambia are being strengthened by this ongoing project;

- a project geared towards improving the regional management of outbreaks with coordinated regional teams in the Atlantic African Facade (AAF) region, which provides training and builds capacity for being better prepared against outbreaks in the region, which includes Benin, Cameroon, Côte d'Ivoire, Gabon, Guinea, Liberia, Mauritania, Morocco, Senegal, Sierra Leone and Togo;

- a project on building regional border-control capacity to identify and detect chemical, radiological and nuclear (CRN) materials, implemented by the JRC in Benin, Gabon, Mauritania, Morocco and Senegal. This project also aims to foster inter-agency regional cooperation between national authorities.

Web link: http://www.cbrn-coe.eu/

Contact at the JRC: Margarida GOULART (margarida.goulart@ec.europa.eu)

II.1 Research and innovation

Building capacities for research and innovation strategies for smart specialisation (RIS3)
The JRC provides scientific support for the design and implementation of territorial innovation strategies through its Smart Specialisation Platform (S3P). The training mainly aims to provide conceptual and methodological frameworks to develop research and innovation strategies for smart specialisation (RIS3) in view of improving local innovation ecosystems. Examples of good practices are also exchanged to gain additional insights for the development of RIS3 worldwide.

Contact at the JRC: Alessandro RAINOLDI (alessandro.rainoldi@ec.europa.eu)

II.2 Knowledge-sharing

Science-policy interface

Addressing the science-policy interface requires a particular set of methodologies and skills, both of scientists and policymakers. Web platforms are developed to directly assist policymakers, by tailoring the information available and presenting it in appropriate 'languages' for different categories of users, and by developing ad-hoc decision-support systems. Specific capacity-building and science-policy networking events are also organised occasionally. For example, a summer school on skills for using evidence for policy, organised by the JRC and the International Institute for Applied Systems Analysis (IIASA) in August 2016 brought together about 100 policy practitioners and scientists from several African and European countries. The specific theme of the 2016 event was how to use evidence for robust policies that address the WEFE nexus. More information, including testimonials and training materials from the event, is available at https://ec.europa.eu/jrc/en/event/workshop/european-commission-au-iiasa-evidence-and-policy-event (EU-AU-IIASA Evidence and Policy Event).

Contact at the JRC: David MAIR (david.mair@ec.europa.eu)

II.3 Earth observation

To help reinforce African capacities in the use of Earth observation data, the JRC is working with the AUC, the Secretariat of the African, Caribbean and Pacific Group of States (ACP Secretariat), and several African Regional Economic Communities (listed in the left-hand column of the following table). The various services and applications have been developed and implemented through Regional Implementation Centres (right-hand column) linked to the Regional Economic Communities. The European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) provides key data and institutional support. JRC and EUMETSAT work with a range of companies to supply, install and maintain the infrastructure and for training:

Regional Economic Community (REC)	Regional Thematic Action	Regional Implementation Centre
CEMAC	Management of Water Resources (for fluvial transportation and environmental assessment)	**CICOS, Kinshasa**
ECOWAS	Water Management for Cropland and Rangeland Management	**AGRHYMET, Niamey**
IGAD	Land Degradation Mitigation, Natural Habitat Conservation and Forest Management	**ICPAC & RCMRD, Nairobi**
IOC	Coastal and Marine Resources Management	**MOI, Mauritius**
SADC	Agricultural and Environmental Resource Management	**BDMS, Gaborone**
ECOWAS	Coastal and Marine Resources Management	**UoG, Ghana**
Continental Support to Climate	Climate Change Monitoring	**ACMAD, Niamey**

Over the past 10 years, the JRC, together with key partners (such as EUMETSAT), has played an active role in developing Earth-observation information management capacities in Africa, promoting information technology competences and the use of geospatial information at national, regional and continental levels. Training has been widely promoted in the framework of all Earth observation and ICT development projects, in order to promote ownership and sustainability. Specific modules have been developed, both in Europe and in Africa, for basic trainees and for advanced users, such as academic, professional, thematic, ICT and GIS training courses, and 'hands-on' training on the use of specific toolkits. They rely on different learning modalities: on-site and distance learning, classroom training, on-the-job training, technological transfer, the sharing of experiences, and cross-fertilisation at continental, regional or national levels. An important example of an information platform associated with e-learning modules is the 'environmental station' (eStation), which provides information on vegetation, hydrology, fires and marine-resources management, using satellite data (see chapter II.3). The eStation was developed by the JRC in the framework of the MESA project, implemented with the AUC and the African Regional Economic Communities.

http://lms.training4mesa.org/

Contact at the JRC: Marco CLERICI (marco.clerici@ec.europa.eu)

Annex 2: List of acronyms

AAF	African Atlantic Façade
AARSE	African Association of Remote Sensing of the Environment
ACE-Water	African Centres of Excellence on Water
ACF	Action Contre la Faim
ACLED	Armed Conflict Location and Event Data
ACMAD	African Centre of Meteorological Applications for Development
ACP	African, Caribbean and Pacific
ACSAD	Arab Center for the Studies of Arid zones and Dry Lands
ADB	Asian Development Bank
ADO	African Drought Observatory
AEEP	Africa-EU Energy Partnership
AETR	Accord Européen sur les Transports Routiers (European Agreement on Road Transport)
AEWA	Agreement on the Conservation of African-Eurasian Migratory Waterbirds
AfDB	African Development Bank
AFRETEP	African Renewable Energy Technology Platform
AfSIS	African Soil Information System
AGC	Artisanal Gold Council
AGIR	Global Alliance for Resilience
AGRHYMET	Agrometeorology, Hydrology, Meteorology (regional centre)
AIS	Automatic Identification System
AMCOST	African Ministerial Council on Science and Technology
AMCOW	African Ministers' Council on Water
AMESD	African Monitoring of the Environment for Sustainable Development
AMIS	Agricultural Market Information System
AMM	Africa Media Monitor
AOSTI	African Observatory of Science, Technology and Innovation
APHLIS	African Post-harvest Losses Information System
APSA	African Peace and Security Architecture
ASAL	Agence Spatiale Algérienne (Algerian Space Agency)
ASAP	Anomaly hot Spots of Agricultural Production
ASI	Aluminium Stewardship Initiative
ASRIC	African Scientific Technical and Research Innovation Council
ASTII	African Science, Technology and Innovation Indicators
AU	African Union
AUC	African Union Commission
BC	Black carbon

BDMS	Botswana Department of Meteorological Service
B4Life	Biodiversity for Life
BIOPAMA	Biodiversity and Protected Areas Management Programme
CAAS	Conflict Alerting and Analysis System
CAP	Common agricultural policy
CARE	Cooperative for Assistance and Relief Everywhere
CBD	Convention on Biological Diversity
CBRN	Chemical, Biological, Radiological and Nuclear
CBRNE	Chemical, Biological, Radiological, Nuclear and Explosives
CEANWATCE	Central Eastern African Network of Water Centres of Excellence
CEMAC	Communauté Économique et Monétaire de l'Afrique Centrale (Economic and Monetary Community of Central Africa)
CEMR	Council of European Municipalities and Regions
CEPAM	Centre of Expertise on Population and Migration
CEPR	Centre for Economic Policy Research
CEPT	Conference of European Postal and Telecommunications Administrations
CEWS	Continental Early Warning System
CFS	Canadian Forest Service
CFSP	Common Foreign and Security Policy
CGIAR	Consultative Group on International Agricultural Research
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station Data
C-HSM	Copernicus Hot Spot Monitoring
CICOS	Commission Internationale du Bassin Congo-Oubangui-Sangha
CID	Community image data
CIESIN	Centre for International Earth Science Information Network
CIFOR	Centre for International Forestry Research
CILSS	Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (Permanent Inter-State Committee for Drought Control in the Sahel)
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement (Agricultural Research Centre for International Development)
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLRTAP	Convention on Long-range Transboundary Air Pollution
CMS	Convention on the Conservation of Migratory Species
CoE	Centre of excellence
CoM	Covenant of Mayors
COMIFAC	Commission des Forêts d'Afrique Centrale
COP	Conference of parties
CORDEX	Coordinated Regional Climate Downscaling Experiment
CREAF	Centre for Research on Ecology and Forestry Applications

CRN	Chemical, Radiological and Nuclear
CSIR	Council for Scientific and Industrial Research
CST	Crop statistical tool
CURAT	Centre Universitaire de Recherche et d'Application en Télédétection
CWIT	Countering WEEE Illegal Trade
DANIDA	Danish International Development Agency
DEWFORA	Improved Drought Early Warning and FORecasting to Strengthen Preparedness and Adaptation to Droughts in Africa
DfID	Department for International Development
DG AGRI	Directorate-General for Agriculture and Rural Development
DG CONNECT	Directorate-General for Communications Networks, Content and Technology
DG DEVCO	Directorate-General for International Cooperation and Development
DG ECHO	Directorate-General for European Civil Protection and Humanitarian Aid Operations
DG ENER	Directorate-General for Energy
DG ENV	Directorate-General for the Environment
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center)
DOPA	Digital Observatory for Protected Areas
DRC	Democratic Republic of the Congo
DRR	Disaster risk reduction
DST	Decision support tool
EAC	East African Community
EC	European Council
ECA	Eastern and Central Africa
ECCAS	Economic Community of Central Africa States
ECDPM	European Centre for Development Policy Management
ECHO	European Civil Protection and Humanitarian Aid Operations
ECMWF	European Centre for Medium-Range Weather Forecasts
ECOAGRIS	ECOWAS Agricultural Regional Information System
ECOWAS	Economic Community of West African States
EDF	European Development Fund
EDGAR	Emissions Database for Global Atmospheric Research
EDO	European Drought Observatory
EEAS	European External Action Service
EFAS	European Flood Awareness System
EFFIS	European Forest Fire Information System
eIDAS	Electronic Identification Authentication and Signature
EIP	European Innovation Partnership
ELD	Economics of Land Degradation

ELI	Environmental Law Institute
EMEP	European Monitoring and Evaluation Programme
EMIS	Environmental Marine Information System
EMODIS	EROS Moderate Resolution Imaging Spectroradiometer
EMS	Emergency Management Service
ENI	European Neighbourhood Instrument
ENISA	European Network and Information Security Agency
ENPI	European Neighbourhood Partnership Instrument
EO	Earth observation
EPIC	Environmental Policy Integrated Climate (model)
EPSC	European Political Strategy Centre
ERCA	European Root Certification Authority
ESA	European Space Agency
ESARDA	European Safeguards Research and Development Association
ESRL	Earth System Research Laboratory
ETSI	European Telecommunications Standards Institute
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EUPL	European Union Public Licence
EUROMED	European-Mediterranean
EUSECTRA	European Nuclear Security Training Centre
EUWAM-Lab	EU West African Mobile Laboratory
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO Statistics Division
FDI	Foreign direct investments
FEWS NET	Famine Early Warning Systems Network
FLEGT	Forest Law Enforcement, Governance and Trade
FPI	Foreign Policy Instruments
GCCA+	Global Climate Change Alliance Plus
GCOS	Global Climate Observing System
GCRI	Global Conflict Risk Index
GDACS	Global Disaster Alert and Coordination System
GDO	Global Drought Observatory
GDP	Gross domestic product
GEO	Group on Earth Observations
GEO-GLAM	GEO Global Agricultural Monitoring
GEOSS	Global Earth Observation System of Systems
GERD	Gross Domestic Expenditure on R&D

GHG	Greenhouse gas
GHSL	Global Human Settlement Layer
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GloFAS	Global Flood Awareness System
GMES	Global Monitoring for Environment and Security
GOFC-GOLD	Global Observation for Forest Cover and Land Dynamics
GOOS	Global Ocean Observing System
GPCC	Global Precipitation Climatology Centre
GPS	Global Positioning System
GSP	Global Soil Partnership
GTOS	Global Terrestrial Observing System
GUF	Global Urban Footprint
GUO	Global Urban Observatory
GWIS	Global Wildfire Information System
GWP	Global Water Partnership
HDP	Human development progress
HERANA	Higher Education Research and Advocacy Network in Africa
HIPSSA	Harmonisation of ICT Policy in sub-Saharan Africa
HLPD	High Level policy dialogue
HLPE	High Level panel of experts
H2020	Horizon 2020
IAEA	International Atomic Energy Agency
IAEG-SDG	Inter-Agency and Expert Group on SDG Indicators
IASC	Inter-Agency Standing Committee
ICMM	International Council on Mining and Minerals
ICPAC	IGAD Climate Prediction and Applications Centre
IcSP	Instrument contributing to Stability and Peace
ICT	Information and communication technology
IDP	Internally displaced person
IEA	International Energy Agency
IFPRI	International Food Policy Research Institute
IfS	Instrument for Stability
IGAD	Intergovernmental Authority on Development
IGBP	International Geosphere-Biosphere Programme
IHA	International Hydropower Association
IHE	International Hydrology Education
IHP	International Hydrological Programme

IIASA	International Institute for Applied Systems Analysis
ILO	International Labour Organization
IMET	Integrated Management Effectiveness Toolkit
IMO	International Maritime Organization
IMPACT	Image processing and classification tool
(I)NDC	(Intended) nationally determined contributions
INFORM	Index for Risk Management
INGSA	International Network for Government Scientific Advice
INSC	Instrument for Safety Collaboration
INSPIRE	Infrastructure for Spatial Information in Europe
IOC	Indian Ocean Commission
IoT	Internet of Things
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPC	Integrated food security phase classification
IPCC	Intergovernmental Panel on Climate Change
IRD	Institute for Development Research
IRENA	International Renewable Energy Agency
IRP	International Resources Panel
IRSTEA	Institut National de Recherche en Sciences et Technologies pour L'environnement et L'agriculture (National Research Institute of Science and Technology for Environment and Agriculture)
ISPRS	International Society for Photogrammetry and Remote Sensing
IT	Information technology
ITPS	Intergovernmental Technical Panel on Soils
ITU	International Telecommunications Union
IUCN	International Union for Conservation of Nature
IUU	Illegal, Unreported and Unregulated
IWRM	Integrated Water Resources Management
JAES	Joint Africa-EU Strategy
JICA	Japan International Cooperation Agency
JRC	Joint Research Centre
KCMD	Knowledge Centre on Migration and Demography
KLC	Key landscapes for conservation
KMFRI	Kenya Marine and Fisheries Research Institute
LDC	Least-developed countries
LDN	Land degradation neutrality
LMI	Land Matrix Initiative
LOICZ	Land Ocean Interactions in the Coastal Zone
LRIT	Long-Range identification and tracking

LSLT	Large-scale land transfers
LUCAS	Land Use/Cover Area frame statistical Survey
LUISA	Land Use-based Integrated Sustainability Assessment
MARS	Monitoring Agricultural ResourceS
MARSE	Moroccan Association of Remote Sensing of the Environment
MASE	Programme to Promote Regional Maritime Security
MCI	Mining Contribution Index
MediPIET	Mediterranean Programme for Intervention Epidemiology Training
MESA	Monitoring of the Environment and Security in Africa
MOI	Mauritius Oceanography Institute
MPA	Marine protected areas
NAS	North Africa and Sahel
NASA	National Aeronautics and Space Administration
NASRDA	National Space Research and Development Agency
NATO	North Atlantic Treaty Organization
NBA	Niger (River) Basin Authority
NDVI	Normalised Difference Vegetation Index
NEPAD	New Partnership for Africa's Development
netCDF	Network Common Data Form
NGO	Non-governmental organisation
NMVOC	Non-methane volatile organic compounds
NOAA	National Oceanic and Atmospheric Administration
OAR	Oceanic and Atmospheric Research
OAU	Organisation of African Unity
ÖAW	Österreichische Akademie der Wissenschaften (Austrian Academy of Sciences)
OBP	Oceans Beyond Piracy
OC	Organic carbon
ODA	Official development assistance
OECD	Organisation for Economic Co-operation and Development
OFAC	Observatoire des Forêts d'Afrique Centrale (Observatory for Central African Forests)
OFESA	East African Forest Observatory
OPEC	Organization of the Petroleum Exporting Countries
OSS	Observatoire du Sahara et Sahel
OWL	Other wooded land
OXFAM	Oxford Committee for Famine Relief
PA	Protected area
PAGIRE	Action Plan for the Integrated Water Resources Management in Burkina Faso
PBL	Planbureau voor de Leefomgeving (Netherlands Environmental Assessment Agency)

PC	Personal computer
PDF	Portable document format
PEDL	Private Enterprise Development in Low-Income Countries
P4P	Purchase for progress
PHL	Post-harvest loss
PIDA	Programme for Infrastructure Development in Africa
PIRATES	Piracy Incident Reporting And informaTion Exchange System
PMAR	Piracy, Maritime Awareness and Risks
PRIO	Peace Research Institute Oslo
PSD	Physical Sciences Division
PUMA	Preparation for the Use of Meteosat Second Generation in Africa
PV	Photovoltaic
PVGIS	Photo-voltaic Geographical Information System
RAEL	Renewable and Appropriate Energy Laboratory
RAMPAO	Réseau Régional d'Aires Marines Protégées en Afrique de l'Ouest (Regional Network of Marine Protected Areas in West Africa)
RAN	Resilient Africa Network
R&D	Research and development
R&I	Research and innovation
RAPAC	Réseau des Aires Protégées d'Afrique Centrale (Network of Protected Areas of Central Africa)
RAPID-N	Rapid Natech Risk Assessment
RASFF	Rapid Alert System for Feed and Food
RCMRP	Regional Centre for Mapping of Resources for Development
RCP	Representative concentration pathway
ReCaREDD	Reinforcement of Capacities for REDD+
RECs	Regional Economic Communities
REDD+	Reducing Emissions from Deforestation and forest Degradation (REDD) and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries
RE2nAF	Renewable Energies for Rural Electrification of Africa
RIS3	Research and Innovation Strategies for Smart Specialisation
RM	Regional mechanisms
RMIS	Raw Materials Information System
RRIS	Regional Reference Information Systems
SADC	Southern African Development Community
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SANSA	South African National Space Agency
SANWATCE	Southern African Network of Water Centres of Excellence
SAR	Synthetic aperture radar

SDG	Sustainable Development Goal
SECAP	Sustainable Energy and Climate Action Plan
SE4ALL	Sustainable Energy for All
SHARE	Supporting Horn of Africa Resilience
SIDA	Swedish International Development Cooperation Agency
SME	Small and medium-sized enterprises
SPIRITS	Software for Processing and Interpreting Remote sensing Image Time Series
SPOT	Satellite Pour l'Observation de la Terre (Satellite for observation of Earth)
SSP	Shared socio-economic pathways
S3P	Smart Specialisation Platform
STECF	Scientific, Technical and Economic Committee for Fisheries
STI	Science, technology and innovation
STISA	Science, Technology and Innovation Strategy for Africa
STRADE	Strategic Dialogue on Sustainable Raw Materials for Europe
S2RAI	Support to Responsible Agricultural Investments in Ethiopia
SWAT	Soil and water assessment tool
SWD	Staff working document
SWERA	Solar and Wind Energy Resource Assessment
TAMSAT	Tropical Applications of Meteorology using Satellite
TSO	Technical support organisations
TV	Television
TVET	Technical vocational education and training
UCDP	Uppsala Conflict Data Program
UCLG	United cities and local governments
UCLGA	United Cities and Local Governments of Africa
UCT	University of Cape Town
UEMOA	Union Economique et Monétaire Ouest Africaine (West African Economic and Monetary Union)
UIS	UNESCO Institute for Statistics
UISP	Upgrading of Informal Settlements Programme
UK	United Kingdom
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNCTAD	United Nations Conference on Trade and Development
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNECE	United Nations Economic Commission for Europe
UN-ECOSOC	United Nations Economic and Social Council

UNEDRA	University Network for Disaster Risk Reduction in Africa
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations – Framework Convention on Climate Change
UNHABITAT	United Nations Human Settlements Programme
UNHCR	United Nations High Commissioner for Refugees (United Nations Refugee Agency)
UNICEF	United Nations Children's Fund
UNICRI	United Nations Interregional Crime and Justice Research Institute
UNIDO	United Nations Industrial Development Organization
UNISDR	United Nations International Strategy for Disaster Reduction (United Nations Office for Disaster Risk Reduction)
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
UNSDN	United Nations Social Development Network
UNU-EHS	United Nations University – Institute for Environment and Human Security
UNWTO	United Nations World Tourism Organization
UoG	University of Ghana
USA	United States of America
USAID	United States Agency for International Development
USGS	United States Geological Survey
VGGT	Voluntary Guidelines on the Responsible Governance of Tenure
VHR	Very high resolution
VID	Vienna Institute of Demography
VOC	Volatile Organic Compounds
WAD	World Atlas of Desertification
WANWATCE	Western African Network of Water Centres of Excellence
WASCAL	West African Science Service Centre on Climate Change and Adapted Land Use
WB	World Bank
WCMC	World Conservation Monitoring Centre
WCoE	Water Centre of Excellence
WEEE	Waste electrical and electronic equipment
WEFE	Water energy food ecosystems
WEI+	Water Exploitation Index
WFP	World Food Programme
WHO	World Health Organization
WIOMSA	Western Indian Ocean Marine Science Association
WGC	World Gold Council
WMO	World Meteorological Organization
WTO	World Trade Organization

Annex 3: Contributors

Report coordination

Aude NEUVILLE, Alan BELWARD

Editorial panel

Melis Sandrine ALGUADIS, Alan BELWARD, Bastian BERTZKY, Andreas BRINK, Daniela BUSCAGLIA, Tom DE GROEVE, Francois KAYITAKIRE, Gráinne MULHERN, Frank NEHER, Aude NEUVILLE, Stephen PEEDELL, Paolo ROGGERI, Zoltan SZANTOI , Jean-Luc WIDLOWSKI

Reviewers

Frank DENTENER, Pamela KENNEDY, David MAIR, Peeter PART

Authors and contributors by chapter or section

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Alan BELWARD, Aude NEUVILLE, Paolo ROGGERI

Policy context
Melis Sandrine ALGUADIS

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Chapter 14: Raw materials
Gian Andrea BLENGINI, Fulvio ARDENTE, Lucia MANCINI, Fabrice MATHIEUX, Slavko SOLAR, David PENNINGTON

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Alan BELWARD, Aude NEUVILLE, Paolo ROGGERI, François KAYITAKIRE, Tom DE GROEVE

Contact: JRC-Africa@ec.europa.eu

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