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The evolving role of the European Commission in research on Africa

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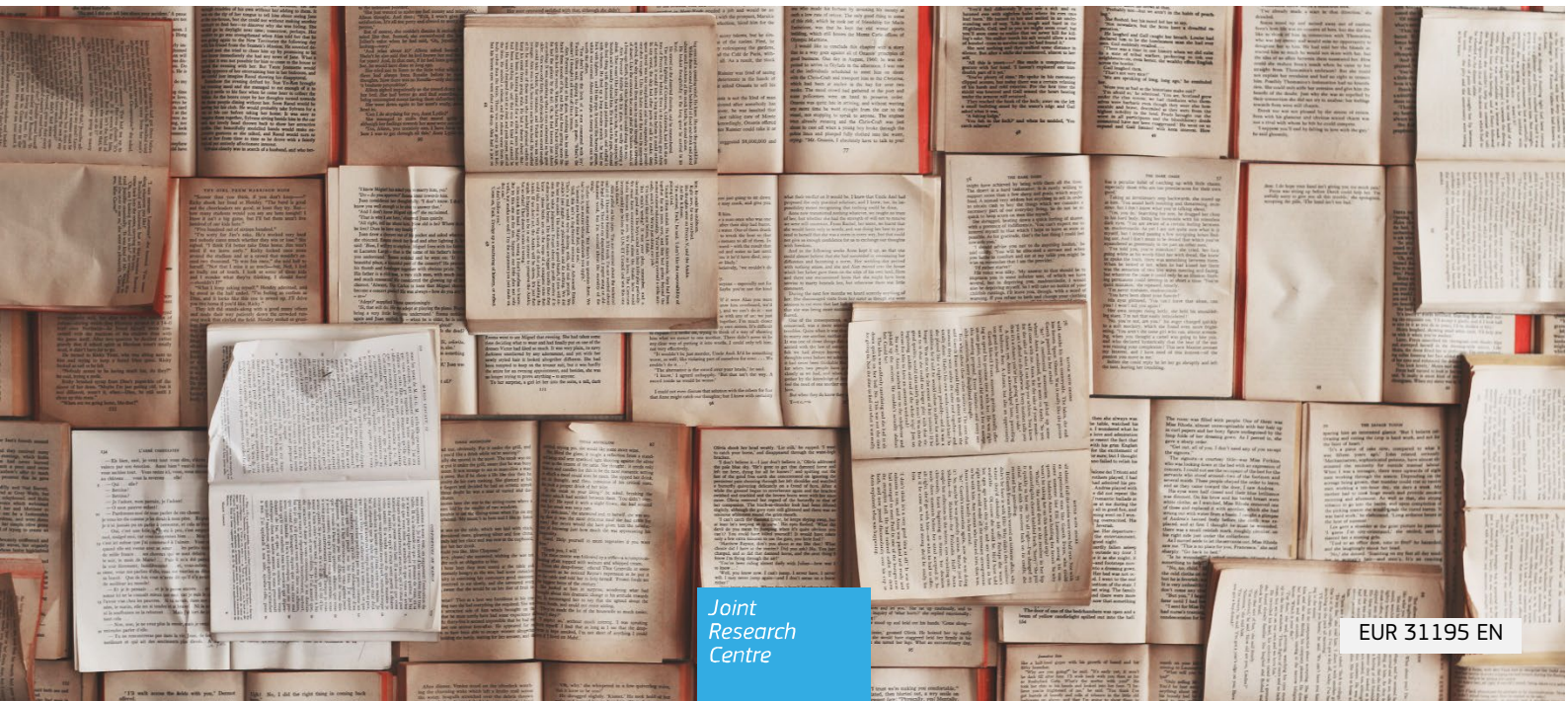

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Contents

Abstract

The European Union's (EU) scientific influence extends beyond its geographical borders. This report presents a retrospective analysis of peer-reviewed scientific articles by the EU with a specific focus on Africa. Its purpose is to identify trends based automated bibliometric tools and feed into the debate to shape the future pathway of EU funded research on Africa. This analysis showed an ever-evolving European response to overarching scientific challenges in Africa, which involved expanding scientific production and partnerships, and the growth of research across disciplinary boundaries. Our bibliometric analysis of 6,849 research items was conducted automatically from metadata available from the *Scopus* database of (only) peer-reviewed literature. It showed that the EU plays two distinct roles in African research: first, as a funder of research through its research and innovation Framework Programmes and, second, as a funder and producer of knowledge through the European Commission Joint Research Centre (JRC). Due to incomplete bibliometric metadata and the contributions by JRC scientists to externally funded projects, there was only 17% overlap between research items that acknowledge EU funding and items with at least one author from the JRC. Based on this – and a specific aim to discriminate trends in research originating from within the JRC - we analysed research acknowledging funding from the EU and research with at least one authors from the JRC as two separate datasets to inform three messages about science diplomacy between the EU and Africa.

1. General trends showed a growing focus on Africa and expanding collaboration with African scientists. When seen in the context of the prioritisation of African research in the Horizon Europe Framework Programme, these trends show that the EU views science as an important lever in its diplomatic relationship with Africa (i.e., a paradigm of '**science for diplomacy'**).

2. Thematic research focus has become more interdisciplinary in an apparent effort to solve applied global problems. This is consistent with using scientific research to inform and advance common diplomatic priorities shared between continents (i.e., a paradigm of '**science in diplomacy'**).

3. Although Africa-focused research produced by the JRC has doubled in the last two decades, the relative production of Africa-focused research was consistent across the 6th, 7th, and Horizon 2020 Framework Programmes. This suggests that Africa-focused research has remained relatively consistent over consecutive cycles of funding calls. Efforts to grow African-led research in Horizon Europe must be accompanied with efforts to develop scientific capacity, research infrastructure, and multilateral partnerships (i.e., this requires a paradigm of '**diplomacy for science**'). Historical trends suggest that the JRC can play an important role in this by acting as a scientific matchmaker to establish new ties between its research partners; and as a research enabler by using its open research infrastructure as a springboard for solving pressing global problems (as typified by its track-record in earth observation).

If historical trends continue, the EU should expect that its scientific relationship with Africa will become increasingly complex. The production of research items will grow in real terms, partnerships will expand as new collaborators enter the scientific arena, and research focus will increasingly transcend narrow disciplinary boundaries. This will have consequences for multifaceted science diplomacy. Building capacity on the use of automated machine learning tools and improving knowledge taxonomies to capture interdisciplinarity will help synthesise scientific content. Dedicated knowledge brokers can help navigate this complex research landscape to translate science into policy. In this regard, the Africa Knowledge Platform (https://africa-knowledge-platform.ec.europa.eu) supports the coordination, enhancement, and communication of JRC scientific knowledge to further the European Commission's policies on Africa.

Acknowledgements

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Executive summary

Policy context

The European Commission (EC) joint communication towards a **comprehensive Strategy with Africa**[1] acknowledges that Africa is facing novel opportunities and challenges emerging from economic, political, social, technological, demographic, climate, and environmental changes. It proposes five partnerships to strengthen the alliance between the European Union (EU) and Africa, including a focus on scientific research capacity (***Proposed Action 5***):

> *"It is proposed that the EU scales up EU-Africa academic and scientific cooperation…with a view to creating a knowledge society and economy. The EU should also support capacity building within Africa…the development of research and innovation capacities; harnessing the interaction between education, science, technology and innovation."*

To this end, the EU is prioritising Africa as part of the Horizon Europe Framework Programme launched in June 2021. This African focus aims to "*enhance cooperation with Africa to promote actions targeted to finding local adapted solutions to challenges of a global nature*", including €350 million earmarked for specific cooperation with Africa[2].

These initiatives build on a strong foundation of Africa-focused research by the EU, both as provider of external research funding through its Framework Programmes, and as a funder and producer of research though the Joint Research Centre (JRC). Future science diplomacy between the EU and Africa will, therefore, take place within the context of existing and past scientific capacity in the form of research outputs, collaborative networks, and thematic foci.

Purpose of this report

The EU plays a significant role in African research, both as a funder of research through its research and innovation Framework Programmes, and as a funder and producer of research carried out internally through the Joint Research Centre (JRC), either as research leaders or as research partners embedded in externally funded projects. This report presents a retrospective bibliometric analysis of the scientific research, restricted to peer-reviewed articles with an African focus; funded by the EU through funding calls or through the JRC. The purpose of this report is to identify trends based on the metadata from the *Scopus* database and analysed using automated machine learning tools. These trends feed into the debate for shaping future pathways of EU funded research on Africa. This analysis explored three main questions to inform science diplomacy between the EU and Africa:

- **Has the EU increased its research focus on Africa in recent decades?** Increased research output with an African focus, after controlling for a worldwide increasing trend in research output, would suggest that the EU has a growing interest in science diplomacy with Africa.
- **Have partnerships and collaboration structures for Africa-focused research changed through time?** Co-authorship networks shed light on the dynamics of the scientific process. The geographical spread of collaborative partnerships and how these partnerships have developed through time can help establish whether scientific research is a tool to grow new ties between the continents, or as a tool to entrench long-established relationships.
- **How has the thematic focus of Africa-focused research changed through time?** If scientific research is a tool to balance local interests in the face of global problems (science in diplomacy, as proposed by Horizon Europe), then one expects the thematic focus of research to have shifted towards international societal challenges. By contrast, a thematic focus on technical solutions for Africa-specific problems would be more consistent with technology-transfer and capacity building (science for diplomacy).

1 https://ec.europa.eu/international-partnerships/topics/africa-eu-partnership_en

2 https://op.europa.eu/en/publication-detail/-/publication/483efef5-cd83-11eb-ac72-01aa75ed71a1/language-en/format-PDF/source-214473085

Key conclusions

Based on peer-reviewed papers from the *Scopus* database, the EU's scientific relationship with Africa is dynamic and complex because scientific production, collaboration and thematic focus show the hallmarks of multifaceted science diplomacy:

- Growing research production, and the prioritisation of African research in the upcoming Horizon Europe Framework Programme, suggests that the EU views science as an important lever in its diplomatic relationship with Africa (i.e., a paradigm of **'science for diplomacy'**).
- Increased complexity of collaborative relationships, especially evidence that collaboration with the JRC also enhances collaborative links between non-JRC partners, shows that the EU plays the role of 'scientific matchmaker'. Bringing together stakeholders through scientific research supports the paradigm of **'science for diplomacy'**.
- Thematic research focus has shifted to solving applied global problems using interdisciplinary approaches. This is consistent with using scientific research to inform and advance common development priorities shared between countries, which increasingly spans multiple research disciplines (i.e., a paradigm of **'science in diplomacy'**).

These trends only materialised because African research was supported by developing scientific capacity, research infrastructure, and multilateral partnerships. These efforts underline the strong diplomatic ties between the EU and Africa (i.e., a paradigm of **'diplomacy for science'**).

The European-African scientific landscape includes all aspects of science diplomacy, which suggests considerable opportunity for using science to contribute to the political and policy ambitions of both continents. However, such opportunity is not without the challenges of managing the rapidly evolving scientific partnerships and the growing body of interdisciplinary information. The EU has a track-record of mobilising knowledge brokers at the science policy interface, but **future scientific opportunities could be unlocked by dedicating knowledge brokers to focus on Africa specifically**. This would require combinations of boundary-spanning experts with the express aim to integrate knowledge across scientific disciplines, **automated machine learning tools to integrate the growing body of scientific research**, and evidence products to synthesise and communicate this information for end-users.

Policy relevant messages

Science is an important tool to guide the implementation of the **European Commission's Strategic Plan 2020-2024 – International Cooperation and Development**[3]. Notably, the scientific community can support diplomacy with Africa by narrowing existing capacity gaps and strengthening ties with emerging countries and research institutions. Most scientific collaborations are between only a few countries and institutions, suggesting unfulfilled potential in meeting shared international goals between the EU and countries and institutions with existing, but largely underdeveloped, research links. This is relevant to **Theme 1 (Partnerships)** of the Strategic Plan, which "*aims to scale up cooperation with Africa into a comprehensive partnership of equals, capable of effectively tackling common challenges and achieving common goals, set under the wider umbrella of the SDGs*".

Science helps verify and strengthen the external dimension of EU policies in African countries, as well as its coherence with global aspirations (e.g., UN Sustainable Development Goals and similar multilateral agreements). **Theme 7 (Human Development)** of the Strategic Plan urges the EU to "*continue to shape global initiatives and international platforms to contribute to the achievement of the 2030 Agenda in these fields, in line with EU sector priorities*". Not only do international research collaborations allow the monitoring of global ambitions, they also ensure that EU policies, such as the European Green Deal, do not inadvertently externalise environmental damage to other parts of the world. Science is one pillar to support transformative and coherent change and associated governance towards EU-Africa strategic goals; for example, trade agreements should be aligned with the transition to equitable and sustainable food systems through the Farm to Fork Strategy (e.g., promoting organic farming in the EU and preventing unsustainable agricultural practices in Africa and associated exports to the EU).

3 https://ec.europa.eu/info/publications/strategic-plans-2020-2024-international-cooperation-and-development_en

Science diplomacy can be advanced by single entry points for knowledge in the form of dedicated platforms and knowledge brokers, using shared geographic lenses. **Section D (Knowledge Management)** of the Strategic Plan aims to support EU policy needs by "*[developing] a culture of collaboration and knowledge sharing; and [enhancing] uptake of internal and external knowledge and research".* The EC's Africa Knowledge Platform[4] developed by the JRC is one example of an evidence product to translate science into policy options by navigating the interface between science, policy, and communication. Engaging knowledge brokers in sectoral policy foresight exercises may prove helpful to elaborate strategic policy choices also promoting EU values.

Related and future JRC work

Research has become more complex and interdisciplinary. The JRC should build capacity on the use of machine learning tools and improve knowledge taxonomies to capture interdisciplinarity and synthesise scientific content. Knowledge synthesis of past and current EU-Africa scientific cooperation can help shape future paths within the JRC work programme 2023-24 and beyond.

Knowledge brokers have unique skills at the frontier between science, policy, and communication and should be institutionalised at the JRC. They are essential for making sense of outcomes from automated machine learning tools, integrating disconnected disciplines, and translating science into policy options.

The **Africa Knowledge Platform** (https://africa-knowledge-platform.ec.europa.eu) is a web-based entry-point to enhance and coordinate JRC knowledge on Africa. This highly visual platform is easy to use and conveys science-for-policy messages in a clear, concise, and integrated way. It brings together datasets, narratives, interactive tools, and partnerships across more than 30 disciplines and policy priorities. The Africa Knowledge Platform aims to support EU policymaking and science diplomacy, in line with the EU-Africa Strategy and international development agendas, like the UN Sustainable Development Goals. By bridging the gap between research and policy, the Africa Knowledge Platform empowers policymakers, stimulates knowledge-sharing, and enhances partnerships between European and African stakeholders. The JRC scientific work on Africa based on this report is summarised as a narrative within the Africa Knowledge Platform at https://africa-knowledge-platform.ec.europa.eu/jrcafricaresearch .

Summary of main results

The EU plays two distinct roles in scientific research on Africa: as a funder of research through its research and innovation Framework Programmes, and as a funder and producer of knowledge through the JRC. The JRC is fully funded through the Framework Programmes but only 17.6% of all JRC research items with an Africa-focus acknowledged funding from the Framework Programmes (Figure 1). Partial overlap could be due to (i) incomplete funding metadata that do not explicitly link JRC-authored research to the Framework Programmes, and (ii) JRC researchers participating in non-EU collaborations led and funded by other institutions We found 768 Africa-focused research items with at least one JRC author, which collectively acknowledged funding from 159 different sources. This illustrates that the JRC regularly plays a supporting role in collaborative projects led and funded by other institutions. Research solely funded by the EU and research funded and produced by the JRC were analysed separately due to incomplete overlap between these two sets of bibliometric data, and to also it allowed us to discriminate the particular roles of JRC researchers in Africa-focused research.

4 https://africa-knowledge-platform.jrc.ec.europa.eu

Figure 1. Venn diagram showing low overlap between research items funded by the European Union's Framework Programmes and items authored by members of the Joint Research Centre.

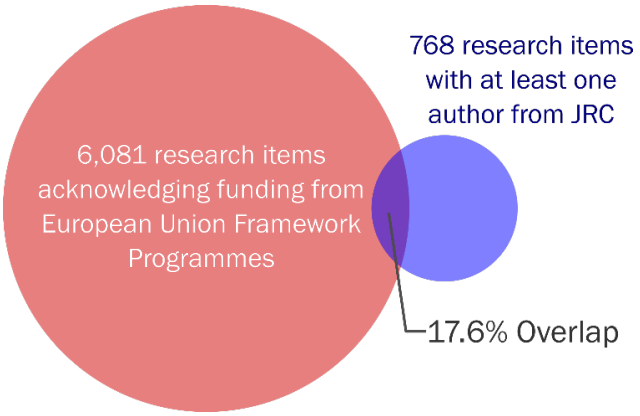


Table 1. Summary of the main findings from this report.

Research items that acknowledge funding from the European Union (EU) **(Figure 2)**	**Research authored by the Joint Research Centre (JRC)** **(Figure 3)**
Question 1: Has the overall production of scientific research related to Africa changed over time?	
Absolute research outputs, including Africa-focused research, increased across successive Framework Programmes in line with increased budgets. However, the **proportion of research items with a focus on Africa has remained constant**. At the start of each FP only about 1% of all research outputs have an African focus, but this grows to 3-4% as research output accumulates through time.	The JRC has produced more Africa-focused research through time, both in absolute numbers and as a proportion of all research. Although the JRC only authored about 0.1% of all papers globally with an African focus by 2020, this contribution had doubled since the 1990s. Currently, about 3% of all JRC research has a specific focus on Africa, up from 1% in 1990.
Question 2: Which international collaborative networks have generated Africa-focused research and how have these networks evolved through time?	
Partnerships between countries did not necessarily reflect the collaboration between institutions within these countries. **Collaborations between countries increased through time** (including about 150 countries), but a few dominant countries tend to be more central in international networks. **African countries were more commonly part of broader international networks than bilateral collaborations with European countries** (except for countries with entrenched collaborative relationships, like South Africa, Kenya, and Nigeria). **Institutional collaboration has also grown** across successive Framework Programmes (exceeding 8000 institutions for FP7). Partnerships tended to be less inclusive, comprising fewer links	**The JRC is highly collaborative**, with partnerships growing from fewer than 10 countries and institutions in the early 1990s to more than 80 countries and 600 institutions by 2020. Despite this, most country collaborations only produced few research outputs. The most prolific national partnerships with African countries were with South Africa, Kenya, Algeria, and Nigeria. **JRC plays the role of scientific partner as well as scientific matchmaker.** Collaborations have become more inclusive through time, with both countries and institutions more likely to collaborate with one another given a common link with the JRC. African collaboration has grown considerably since 2016, from direct collaborations with a limited set of

within sub-clusters of collaborators rather than wide-spanning collaborative networks.	African countries **evolving into more widespread international collaborative networks**.
Question 3: Has the thematic focus of research changed through the years to reflect broader international scientific trends?	
EU-funded research could be grouped in one of nine general thematic focus areas. There was a **growth in interdisciplinary research** with a policy focus, as well as research on climate science and technical environmental modelling. **Global themes,** like public health, environmental change, and interdisciplinary geographical research, **have remained relative constant over time**. Species biology and, to a lesser extent, infection diseases have received relatively less focus with time.	The JRC's work on Africa could be grouped into seven broad themes. A general trend was the **thematic evolution of technical earth observation research into new applied fields**, like climate change and natural resources and landcover. Atmospheric emissions, agricultural modelling, and development policy all followed a trend of increased thematic focus accompanied by subsequent decline. This is likely due to the growth in research outputs leading to relative decline in thematic focus, rather than an absolute declining interest in these topics.

Figure 2. Key messages from a bibliometric analysis of Africa-focused peer-reviewed research funded by the European Union's Framework Programmes 6, 7, and Horizon 2020 for Research and Innovation.

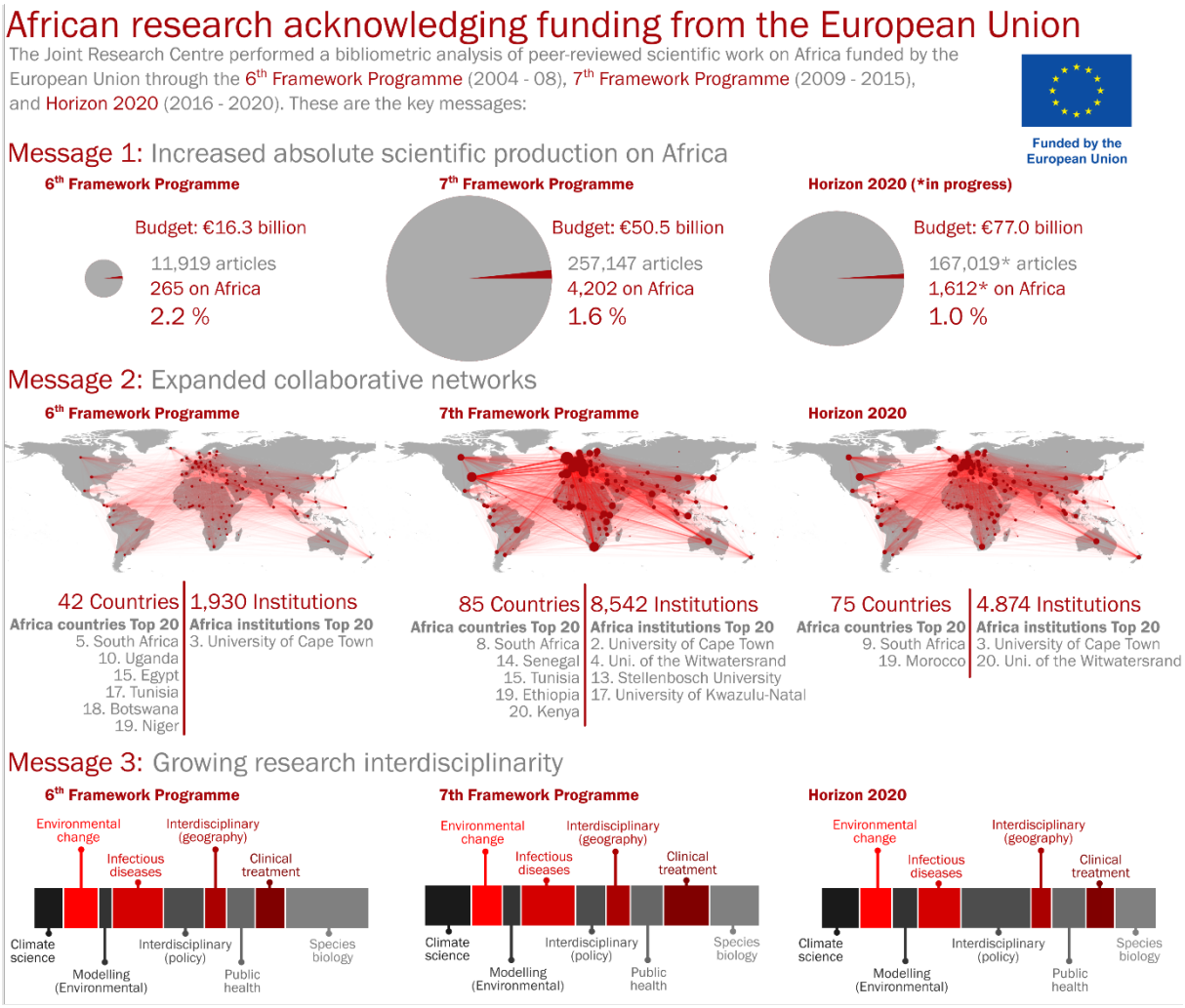
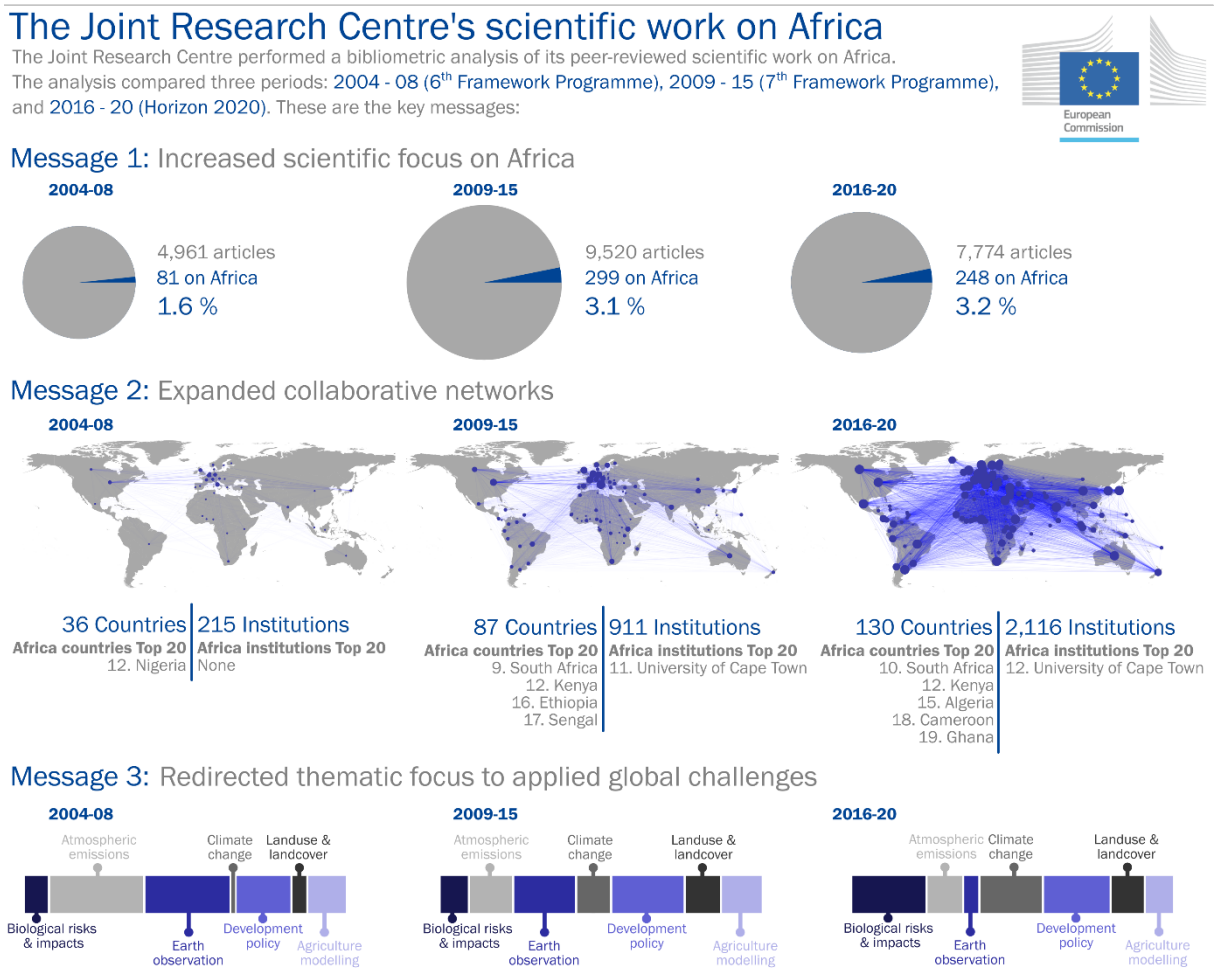


Figure 3. Key messages from a bibliometric analysis of Africa-focused peer-reviewed research by the Joint Research Centre for the periods 2004-08, 2009-15, and 2016-2020 (coinciding with the EU Framework Programmes 6, 7, and Horizon 2020 for Research and Innovation).



Quick guide

This report is split into four main sections.

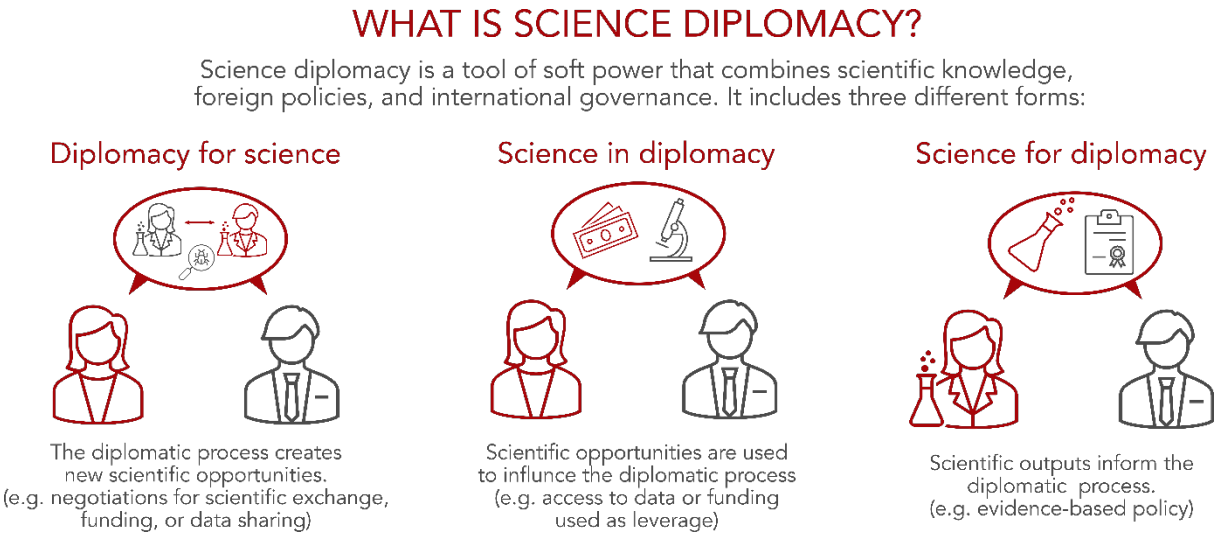
1. **Section 1 Introduction to science diplomacy** introduces science diplomacy between the EU and Africa. It presents the status quo of scientific capacity in Africa, the background of the EU Framework programmes, and the JRC's role as a knowledge broker at the science-policy interface.
2. **Section 2 Main findings** presents the results of the bibliometric analysis, separately for Africa-focused research that acknowledges funding from the EU through its Framework Programmes and research produced by the JRC.
3. **Section 3 Evaluating EU research on Africa** interprets the result of the bibliometric analyses in the context of the EU's changing focus on Africa, the perception of Africa's growing contributions to solving challenges of a global nature, and the potential and limitations of automated methods to manage knowledge at the science policy.
4. **Section 4 Take-home messages** concludes the study by evaluating how historical trends in scientific research relate to the science diplomacy relationship between the EU and Africa, proposing take-home messages for policy and future research priorities.

Technical details of the bibliometric analyses are presented as an Annex, which outline inclusion criteria of peer-reviewed publications, the theoretical background of collaborative network analysis and the process of using automated natural language processing to identify thematic research themes.

1 Introducing science diplomacy

The European Union (EU) relies on 'science diplomacy' to improve, maintain or develop international relations that, in turn, facilitate effective cooperation in research and innovation. Science diplomacy is an instrument of soft power that combines scientific knowledge, foreign policies, and international governance. Although science diplomacy is not a new concept, it defies simple definition. This is because it can manifest itself in one of three forms (Figure 4; Ruffini, 2017; van Langenhove, 2017). First, diplomatic methods can be used to facilitate international scientific cooperation (i.e., **diplomacy for science**). Second, scientific research can supply information and innovation to support international policies (i.e., **science in diplomacy**). Third, science itself can be leveraged as a tool to establish and consolidate diplomatic ties between countries (i.e., **science for diplomacy**). Science diplomacy is particularly relevant for the EU to enhance coordination with its international partners[5]. Understanding how the EU uses these approaches can be supported by an appreciation of international research collaborations as well as the geographical and thematic focus of scientific outputs.

Figure 4. The three components of science diplomacy.



Africa's scientific relationship with Europe is embedded within the broader political landscape between the two continents (Cherry & Du Toit, 2018). Although this relationship has matured into a more equal partnership since its post-colonial origin, there are still inequalities when it comes to African research. For instance, Africa has fewer than 100 researchers per million people, compared to a global average of 1100 researchers per million people (European Commission Joint Research Centre, 2017a). Moreover, less than 2.6% of all research output globally includes at least one African author, which is to be expected considering that on average Africa only spends 0.4% of its GDP on research compared to 2.4% in Europe (Atickem et al., 2019). Even when research is produced within Africa, it is concentrated in only a few countries (e.g., roughly half of all African research between 2000-2015 came from Egypt and South Africa: Sooryamoorthy, 2018) or is in collaboration with external partners (e.g., 77% of research from central Africa includes European co-authors: Boshoff 2009). This means that Europe plays an important role in the scientific relationship with Africa, both as a producer and as a funder of scientific research.

1.1 The EU as a funder of scientific research

The EU funds scientific research by external institutions, including research on Africa, through its research and innovation Framework Programmes (FP). The earliest FPs started in the 1980s and were small and localised compared to their current incarnations. The Maastricht Treaty of 1992 allowed for the pursuit for European-level research activities that also furthered non-research interests (through the communitization of research policy to further European integration: Prange-Gstöhl, 2017). This embedded science diplomacy into research funding since the Fourth FP (1994 – 1998). However, it was from the Seventh FP in 2007 that international collaboration became a major focus of European research funding. The budget for the Seventh FP was a

5 Science diplomacy in EU international cooperation: https://eeas.europa.eu/topics/science-diplomacy_en. Science diplomacy in Horizon 2020 EU research & innovation programme, e.g., the InsSciDE project (Inventing a shared Science Diplomacy for Europe at https://www.insscide.eu/, including Ruffini P.B (2017) pitch at https://www.insscide.eu/IMG/pdf/pitch_3.4.pdf)

threefold increase from its predecessor (increasing from approximately €16 billion to €50 billion: Prange-Gstöhl 2017) and specifically encouraged participation by researchers across the world (McCarthy et al., 2010). This trend has continued with a budget of €95 billion for Horizon Europe (2021-2027), where Pillar II aims specifically to tackle global challenges (climate change, health, clean energy, and digital technology) and encourage international participation, notably EU-Africa cooperation[6].

Expanding the international focus of the FPs can be viewed as a way of positioning European interests in the context of growing global challenges (Krull, 2005; Berkman 2019; Rungius & Flink, 2020). For example, European-funded international research consortia have included African researchers to address global problems on poverty-related diseases (e.g., Elliot et al., 2015) and plant- and animal health (e.g., Giovani et al. 2020). While the purpose of these consortia is to further the implementation of international policies (i.e., science in diplomacy), they also build research and diagnostic capacities in Africa and strengthen diplomatic relationships (i.e., science for diplomacy). In this context, Horizon Europe includes a specific focus on global challenges through its Africa Initiative around (1) public health, (2) the green transition, (3) innovation and technology, and (4) building capacities for science (EC 2021).

However, addressing global challenges through European research funding may entrench asymmetries and consolidate dominance of European scientists (Schmidt & Neuburger, 2017; Ovalle-Perandones et al., 2013). For example, Africa's high dependency on international funding can make the continent beholden to donors' priorities (Nordling 2010), so participation in funding programmes could be used as diplomatic leverage (Bradely, 2008; Leese, 2018). Therefore, the diplomatic context of EU-funded research needs to consider the structure of international collaboration networks to identify potential imbalances in collaboration patterns. Moreover, evaluating the thematic focus of collaborative research would indicate who stands to gain from new research, especially when it comes to global challenges.

1.2 The EU as a producer of scientific research

The EU is also a producer of scientific research through the European Commission's (EC) Joint Research Centre (JRC). The JRC is the EC's science and knowledge service and supports EU policies with independent scientific evidence throughout the whole policy cycle (EU Science Hub[7], Triollet & Alvarez Martinez 2021). The JRC was originally established in 1957 as a nuclear research organisation but has since diversified its research ambit to support a wide range of European policies (EC Joint Research Centre, 2007; Anonymous, 2017). JRC-produced research is also funded through FPs through infrastructure and staff salaries, so such financial contributions may be reflected in bibliometric metadata through author affiliations, rather than funding sources. Moreover, JRC researchers also participate in research collaborations led and funded by non-European partners. To accommodate these dynamics, analyses of EU-funded research should consider explicitly research authored by JRC scientists.

Due to its explicit mission to support EU policies, work by the JRC aligns with the paradigm of science in diplomacy. Furthermore, the role of the JRC, like the science-policy interface more broadly, has grown in recent decades from a result-focused research agenda to also encompassing a knowledge-brokering one (White, 2019). Knowledge brokering entails the 'institutionalisation' of scientific evidence in policy and practice by interacting with stakeholders directly, developing their research capacity, managing expert networks, and creating knowledge products (Topp et al., 2019; White, 2019). Like all knowledge brokers, the more than 2000 research staff members at the JRC must balance the public duty to engage with the policy process with their professional need to remain scientifically independent (Oliver & Cairney, 2019; Gluckman et al., 2021). As such, the thematic focus and research collaborations of JRC research are deeply embedded in EU science diplomacy.

A recent example of the JRC's role as a knowledge broker for Africa's policy context is the development of the Africa Knowledge Platform (AKP)[8], a web-based entry-point to enhance and coordinate JRC knowledge on Africa. The purpose of the AKP is not to generate new scientific research, but rather to present existing JRC data in a way that is easily accessible for EU policymakers working on Africa. The findings from this report are intended to feed into the AKP by introducing a data-driven narrative on the EU research landscape related to Africa.

6 International cooperation https://ec.europa.eu/info/research-and-innovation/strategy/strategy-2020-2024/europe-world/international-cooperation_en#Horizon-Europe, and the EU-Africa cooperation in Horizon Europe with around €350 million under Calls for Proposals that are particularly relevant for cooperation with Africa. https://op.europa.eu/en/publication-detail/-/publication/483efef5-cd83-11eb-ac72-01aa75ed71a1/language-en/format-PDF/source-214473085

7 https://ec.europa.eu/jrc/en

8 https://africa-knowledge-platform.jrc.ec.europa.eu

1.3 Aims of this report

In this study, we analyse scientific output, restricted to peer-reviewed (refereed or scholarly) articles with a focus on Africa to better understand the EC's scientific diplomacy on the continent. It must be noted that such an analysis based on records from the *Scopus* database would not include relevant JRC publications, such as Scientific Technical reports, Science for Policy reports, and other non-peer-reviewed articles. We built on the approach of Borchard and Estreguil (2020), who used bibliometrics and text-analysis to scan the agricultural research landscape in Africa. Although research outputs do not reflect diplomatic priorities on their own, they do provide some insights into scientific priorities. Our study focuses on (a) research funded by the EU through its FPs and (b) research carried out by the JRC to answer the following questions:

1. **Has the EU increased its research focus on Africa in recent decades?** Increased research output with an African focus, after controlling for a worldwide increasing trend in research output, would suggest that the EU has a growing interest in science diplomacy with Africa.
2. **Have partnerships and collaboration structures for Africa-focused research changed through time?** Co-authorship networks shed light on the dynamics of the scientific process. For instance, network analysis can be used to indicate the geographical spread of collaborative partnerships and how these links have evolved through time. These patterns can establish whether collaboration is a tool to grow new ties between stakeholders or as a tool to entrench long-established scientific networks.
3. **How has the thematic focus of Africa-focused research changed through time?** If scientific diplomacy is indeed a tool to balance local interests in the face of global problems (science in diplomacy), then one would expect the thematic focus of research to shift towards international societal challenges. By contrast, a thematic focus on technical solutions for Africa-specific problems would be more consistent with technology-transfer and capacity building (science for diplomacy).

Answering these three questions would begin to unpack the various dimensions of scientific diplomacy between the EU and Africa. This analysis gives both historical perspectives and current insights, which will become relevant in the context of anticipatory governance in the coming years.

2 Main findings

We analysed research acknowledging EU-funding and JRC-produced research separately even though the JRC is also funded through FPs. The data indicated that only a small percentage of JRC-produced research items listed FPs as a funding source (10.4% of research items listed the 'European Commission' as a funding source, 4.7% listed the 'Seventh FP', 1.6% listed 'Horizon 2020', and 0.9% simply listed the 'Joint Research Centre'). This could be due to inadequate reporting of funding sources, but it more likely represents a situation where JRC authors are frequent contributors to projects led by other researchers and funded from other sources. The corpus of 768 research items authored by the JRC collectively acknowledged a total of 159 different funding sources. We treated JRC-authored and EU-funded research independently even though there may be some overlap.

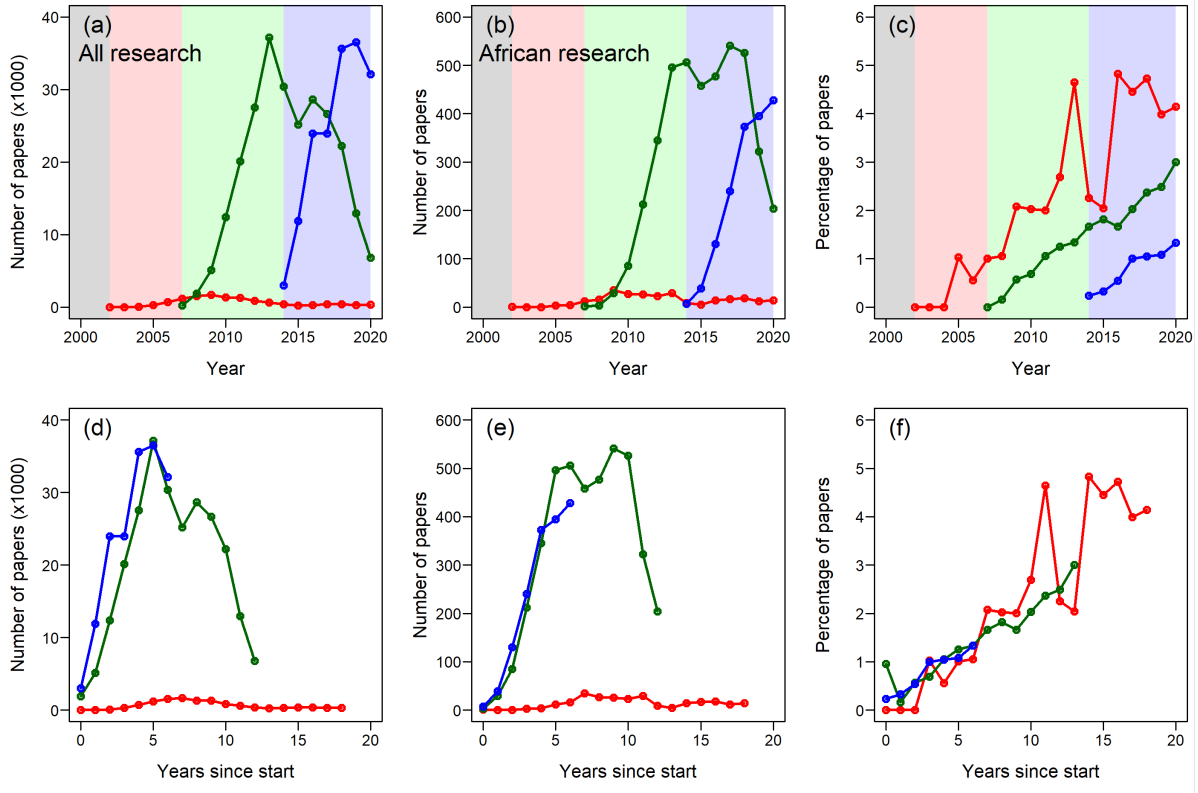
2.1 Research production increased through time

2.1.1 Research acknowledging funding from the EU

Research funded by the EU varied between the successive Framework Programmes. FP 6 funded 11,919 research items of which 265 (2.22%) focused on Africa. FP 7 funded 257,147 research items of which 4,202 (1.63%) had an African focus. Although still in progress, as of 2020 Horizon2020 funded 167,019 research items and 1,612 (0.97%) of these were related to Africa. However, absolute research outputs are time-dependent (Figure 5), so they should be interpreted carefully.

Figure 5. Research output funded by the EC's FPs 6 (red), 7 (green) and Horizon2020 (blue).

(**a**) Total research output regardless of focus, (**b**) research output with a specific focus on Africa, and (**c**) the percentage of total research with an African focus. The coloured backgrounds denote the durations of the respective FPs. (**d**) The total research output regardless of focus, (**e**) the output of Africa-focused research and (**f**) the percentage of Africa-focused research standardised to the start of the respective FPs.



All FPs showed the same trend where outputs increased during the first few years, reached a peak, and then declined after the end of the programme (Figure 5 a & b). This is to be expected because research is generally only published at the end of a research programme and the peer-review process adds further delays between a study's completion and its eventual publication. Overall research output tended to peak before Africa-focused

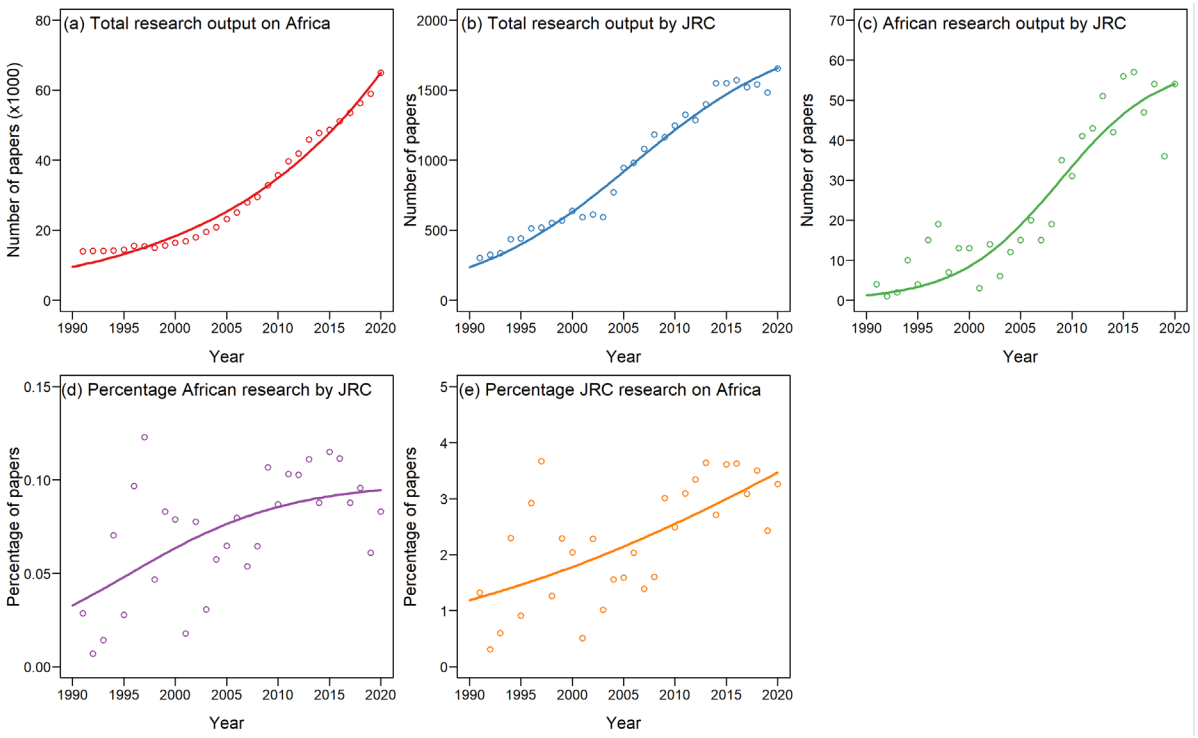
research, which meant that the percentage of papers with an African focus increased through time within the course of each FP (Figure 5c). Aligning the FPs according to the number of years since the start of the programme showed that outputs for FP6 were considerably lower than for FP7 and Horizon 2020 (which is consistent with the step-change in overall funding availability from €16 billion to €50 billion and €77 billion, respectively). FP7 and Horizon 2020 were remarkably similar for all and Africa-focused research (Figure 5 d & e). Once aligned, all FPs showed similar percentages of African focused research (Figure 5 f), indicating that the focus on Africa has been relatively consistent across multiple European funding programmes.

2.1.2 JRC research

We analysed the whole period 1990-2020, for a total of 910,891 records, and found that the total number of research items on Africa increased unabated for three decades (Figure 6a). When restricting to the JRC research regardless of research focus, the search yielded 28,211 research items during the same period (Figure 6b) of which 768 focused on Africa specifically (Figure 6c). These items have increased steadily over the last three decades but seem to have stabilised in recent years. There are indications that the JRC has increased its focus on Africa because African research by the JRC as a percentage of total Africa-focused research has roughly doubled since the 1990s (Figure 6d), although the JRC still produces less than 0.1% of all research with a focus on Africa. Within the JRC, Africa has also received more focus since the 1990s as the percentage of research items with a focus on Africa has increased threefold to the point where approximately 3% of JRC research output focuses on Africa specifically.

Figure 6. Increased output of research items with an African focus by the European Commission Joint Research Centre (JRC).

(**a**) The increase in all research items on Africa, regardless of authors, (**b**) the total research output by authors from the JRC irrespective of topic, and (**c**) JRC outputs with a specific focus on Africa. (**d**) The percentage of all Africa-focused research authored by the JRC, and (**e**) the percentage of JRC research with an African focus. Sigmoidal curves are fitted to the data in all panels.



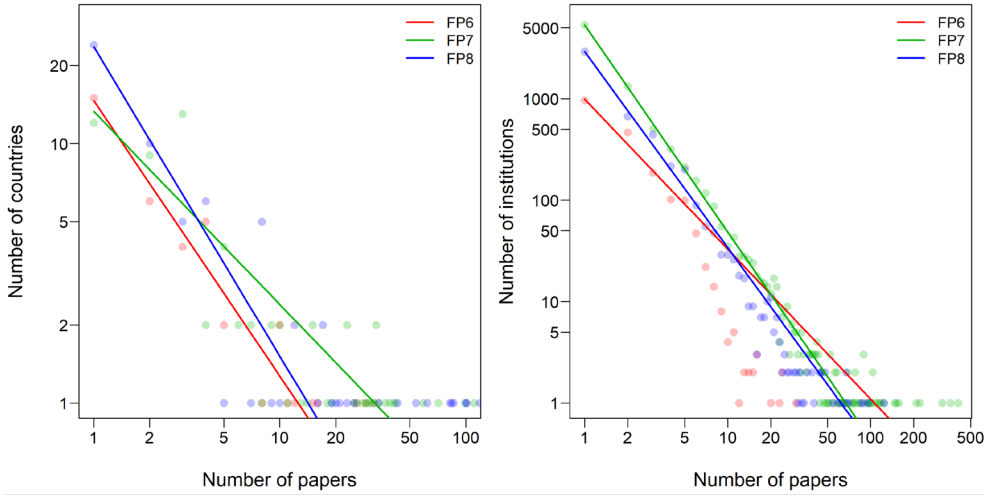
2.2 Collaborative networks have become larger and more diverse

2.2.1 Research acknowledging funding from the EU

For research acknowledging EU funding, as expected from the Power Law, most countries and research institutions produced only a few research outputs, with a minority being especially prolific (Figure 7). For FP6, FP7 and Horizon 2020, the most productive countries were European, with the United Kingdom, France and Germany consistently ranked in the Top 3 countries. South Africa was the only African country within the top 20 productive countries across all FPs (FP6 = 5th, FP7 = 8th, Horizon 2020 = 9th). Similarly, the University of Cape Town was the only African institution that was in the top 20 institutions across all three FPs. There appears to be some turnover amongst the most productive African countries because the top 20 most productive varied across the FPs (**FP6:** 5th = South Africa, 10th = Uganda, 15th = Egypt, 17th = Tunisia, 18th = Botswana, 19th = Niger; **FP7:** 8th = South Africa, 14th = Senegal, 15th = Tunisia, 19th = Ethiopia, 20th = Kenya; **Horizon 2020:** 9th = South Africa, 19th Morocco). The only African institutions within the top 20 were all South African (**FP6:** University of Cape Town; **FP7:** University of Cape Town, University of Witwatersrand, Stellenbosch University, University of Kwazulu-Natal; **Horizon 2020:** University of Cape Town, University of Witwatersrand). It is important, however, to distinguish between research output and research collaboration, because countries with few total outputs can still have widespread collaboration if their few papers have many co-authors.

Figure 7. Distribution of the number of research papers produced by countries (left) and research institutions (right) across the Framework Programmes 6, 7 and 8 (Horizon 2020).

The lines represent the Power Law fitted to the data (note: both axes are log-scaled).

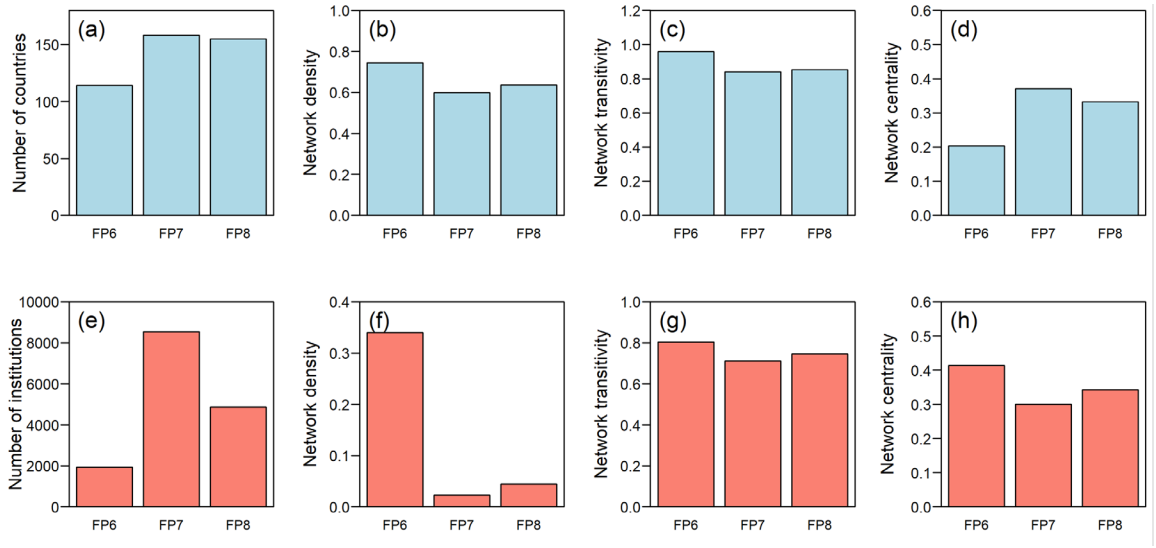


Overall, collaboration resulting from the research acknowledging funding from the EU has increased between countries over successive funding cycles (Figure 8a). International collaboration for research focussing on Africa extends well beyond the continent (Figure 9). Its pattern has changed in terms of the density of collaborations (i.e., the number of collaborative links, given the number of collaborators), particularly between FP6 and FP7. Even though more countries are working together, there are fewer links between these countries (Figure 8b) because sharing mutual collaborators was slightly less likely to include multilateral collaboration (i.e., lower transitivity: Figure 8c). As a result, collaborations between countries have become more centralised (Figure 8d).

Although considerably more institutions are involved in recent EU-funded research (Figure 8e), the links between these institutions became sparser (Figure 8f) and less centralised (Figure 8h). While centralisation between countries has increased this is not the same for institutions, which suggests that collaboration is mostly driven at country level and when collaboration is driven by a limited number of countries, it is likely due to multiple different institutions within those countries.

Figure 8. Collaborative network metrics for research acknowledging funding from the European Commission's sixth (FP6), seventh (FP7) and Horizon 2020 (FP8) Framework Programmes for countries (blue) and research institutions (red).

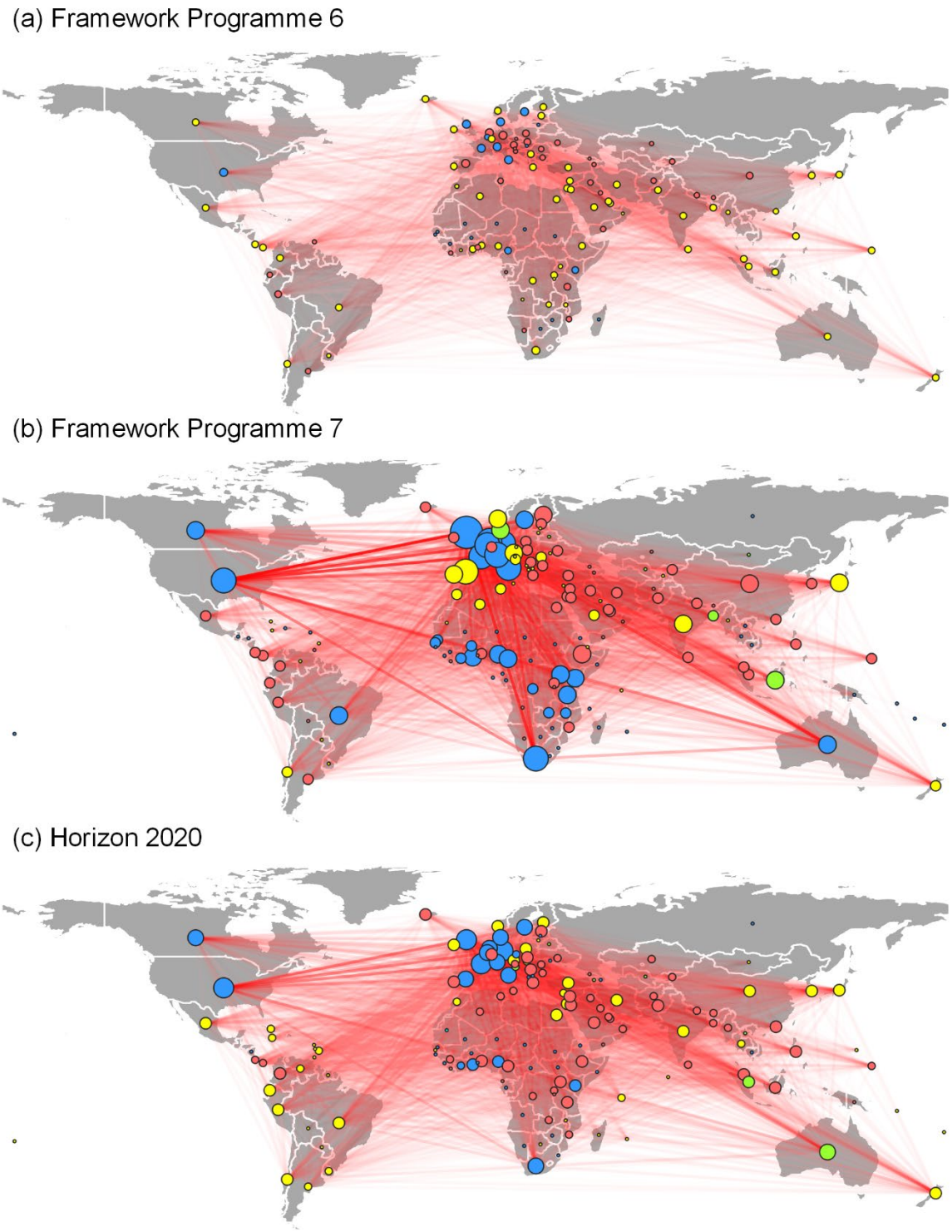
(**a**) The number of countries in the collaborative network, (**b**) the density of connections between countries, (**c**) the transitivity of collaborative links based on mutual collaboration between countries (i.e., probability of collaboration given a shared co-author), and (**d**) the centrality of collaboration between countries. (**e**) The number of different institutions in the collaborative network, (**f**) the density of connections between institutions, (**g**) the transitivity of collaborative links based on mutual collaboration between institutions, and (**h**) the centrality of collaboration between institutions.



The geographical distribution of collaboration between countries across the FPs was consistently widespread (Figure 9). Many African countries were included in collaborations during FP6, but these appear to be as part of more general international collaborations rather than of specific scientific partnerships between Europe and Africa (yellow sub-cluster in Figure 9a). By FP7, collaborative links between Europe and Africa became more entrenched (blue sub-cluster in Figure 9b), although some African countries – like Egypt, Ethiopia, and Mozambique – were still part of the broader international sub-network (red sub-cluster in Figure 9b). Although Horizon 2020 research outputs are still in progress, a similar pattern emerged of direct collaboration between European countries and scientifically entrenched African countries like South Africa, Kenya, and Nigeria (blue sub-cluster in Figure 9c). Most other African countries have been involved with Horizon 2020 through broader international collaborations (red sub-cluster in Figure 9c).

Figure 9. Collaborative links between countries for Africa-focused research that acknowledge funding from the European Commission's Framework Programmes (a) 6, (b) 7 and (c) Horizon 2020.

Countries are denoted as points, where size is scaled according to the number of collaborations and colour denotes the identity of collaborative sub-networks. Links between countries are darker when collaborations occur more frequently.

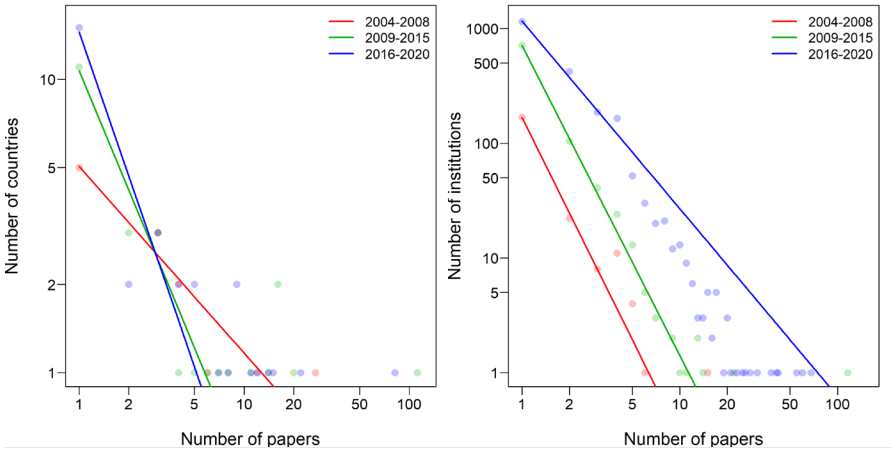


2.2.2 JRC research

As was the case with research acknowledging funding from the EU, most JRC research was produced with relatively few countries and institutions (Figure 10). European countries dominated the most prolific countries, with USA (6th) and China (9th) the most prolific non-European countries. In Africa, South Africa (10th), Kenya (11th), Algeria (18th), and Nigeria (20th) were the only countries in the top 20 most prolific countries associated with JRC research output. Understandably, the JRC was the most prolific institution, as was the Institute for Environmental Sustainability, which existed within the JRC until it was restructured in 2016. The most frequent research partnerships included some of the leading universities in the world (e.g., University of California, University of Oxford) and leading non-academic research institutes (e.g., NOAA, NASA, and the UK Meteorological Office). The University of Cape Town was the only African institution included in the top 20 most prolific for research with the JRC.

Figure 10. Distribution of the number of research papers produced by countries (left) and research institutions (right) that included a collaborator from the Joint Research Centre.

Lines represent the Power Law fitted to the data split into time-periods that coincide with the Framework programmes (note: both axes are log-scaled).



For research produced by the JRC, the last decade (2010-2020) has shown considerable growth in the number of collaborations with other countries and institutions (Figures 11a & 11e). These have not been simple bilateral partnerships either, because the density and transitivity of the collaborative network has also increased between countries (Figures 11b & 11c) and institutions (Figures 11f & 11g). This indicates that JRC research creates collaboration between its research partners, which is consistent with the perspective that the JRC has grown to become both a science service and a knowledge broker that manages diverse expert networks. While network centrality between countries has remained stable (Figure 11d), it has increased for institutions (Figure 11h). This pattern is notable because even though the JRC is central in this institutional collaborative network, it does not rely on only a few well-worn international partnerships with a limited set of countries.

The JRC's collaboration with partners from African countries on Africa-focused research was limited prior to 2008 (Figure 12a). During this early period, collaboration was restricted mainly to a few African countries (South Africa, Democratic Republic of Congo, Kenya, and Benin), which formed part of a more general international sub-network (yellow points in Figure 12a). In the years 2009 to 2015, collaboration with African countries grew stronger and a distinct sub-network emerged between predominantly equatorial African countries and European countries (blue points in Figure 12b). This pattern changed during the most recent period between 2016 and 2020 with direct JRC collaboration sub-networks mainly limited to countries like South Africa and Nigeria (blue sub-cluster in Figure 12c) (also connected internationally) and other African states becoming more embedded in a larger international collaborative sub-network (yellow sub-cluster in Figure 12c).

Figure 11. Collaborative network metrics for research by the European Commission's Joint Research Centre (JRC) for the period 1990-2020 for countries (blue) and research institutions (red).

(**a**) The exponential increase in the number of countries collaborating with the JRC is associated with increasing (**b**) network density and (**c**) transitivity, but static (**d**) network centrality. (**e**) The exponential increase in the number of institutions collaborating with the JRC is also associated with increasing (**f**) network density, (**g**) transitivity as well as (**h**) network centrality. The dashed line in panel d indicates a non-significant statistical relationship.

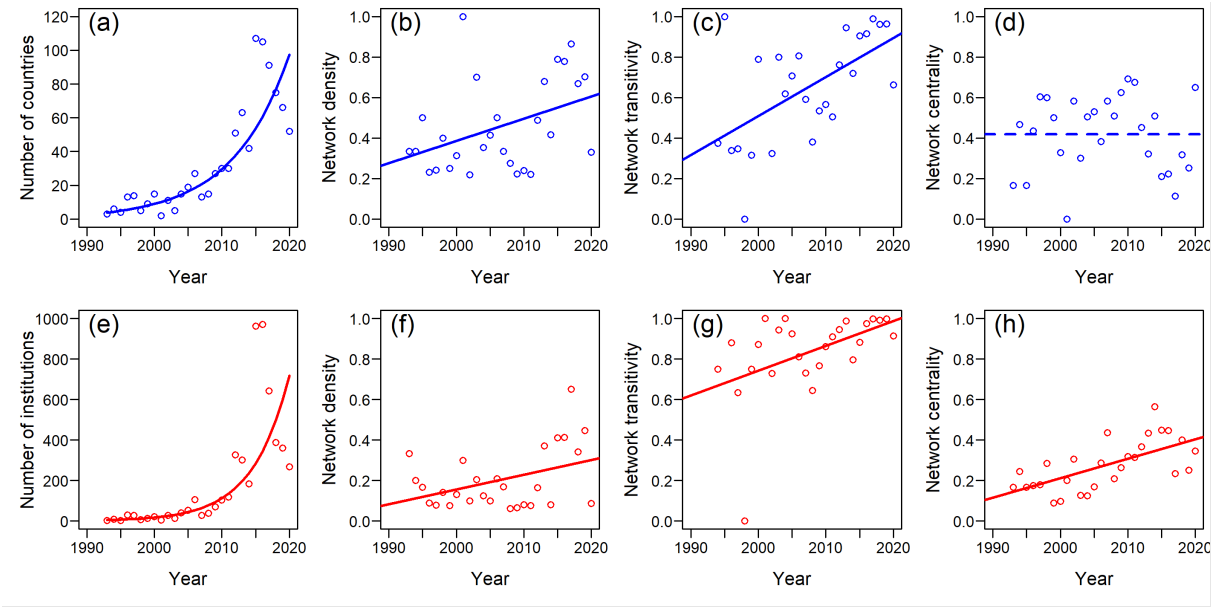
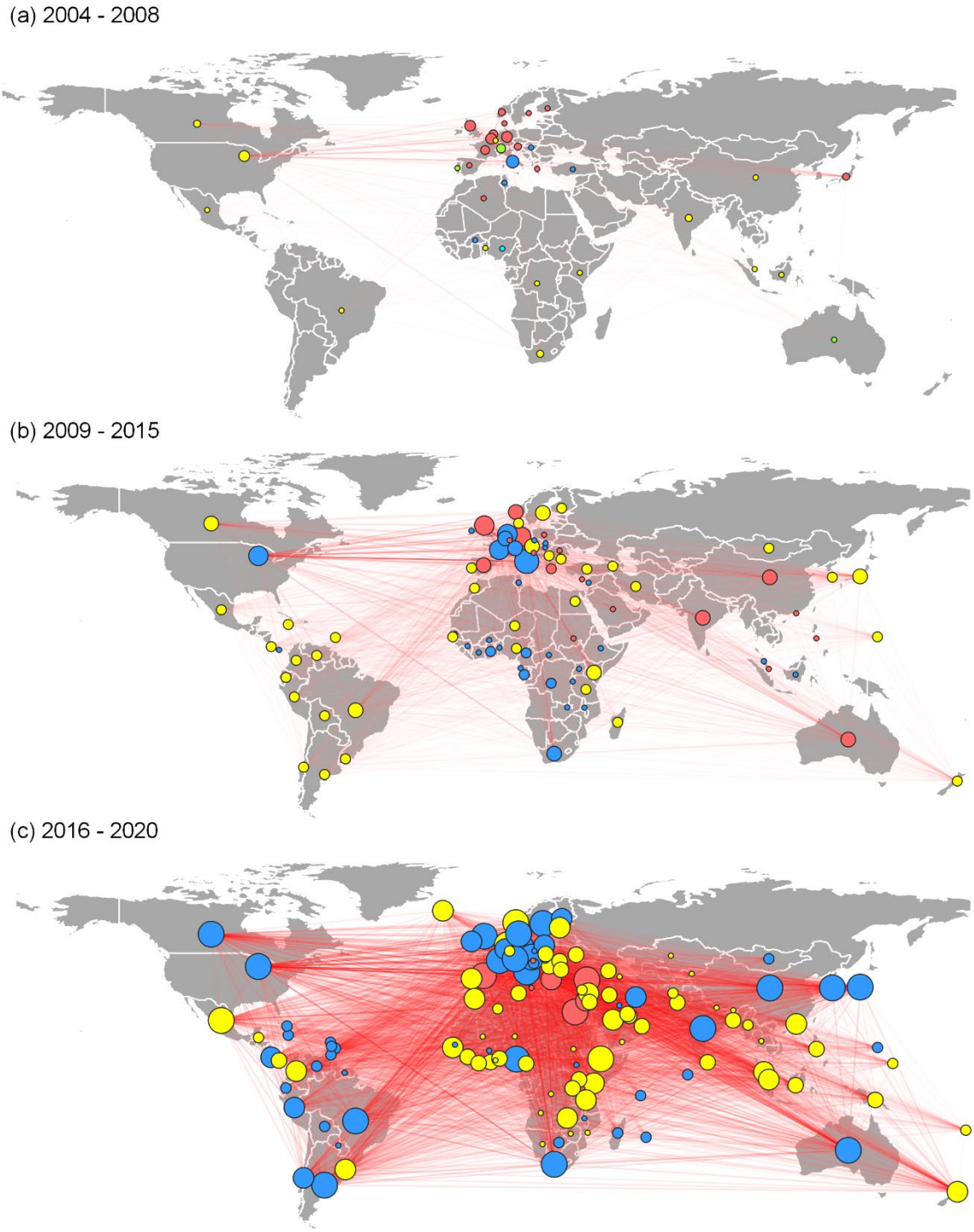


Figure 12. Collaborative links between countries for Africa-focused research produced by the European Commission's Joint Research Centre for the periods (a) 2004-2008, (b) 2009-2015 and (c) 2016-2020 (for comparison with the European Framework Programmes).

Countries are denoted as points, where size is scaled according to the number of collaborations and colour denotes the identity of collaborative sub-networks. Links between countries are darker when collaborations occur more frequently.



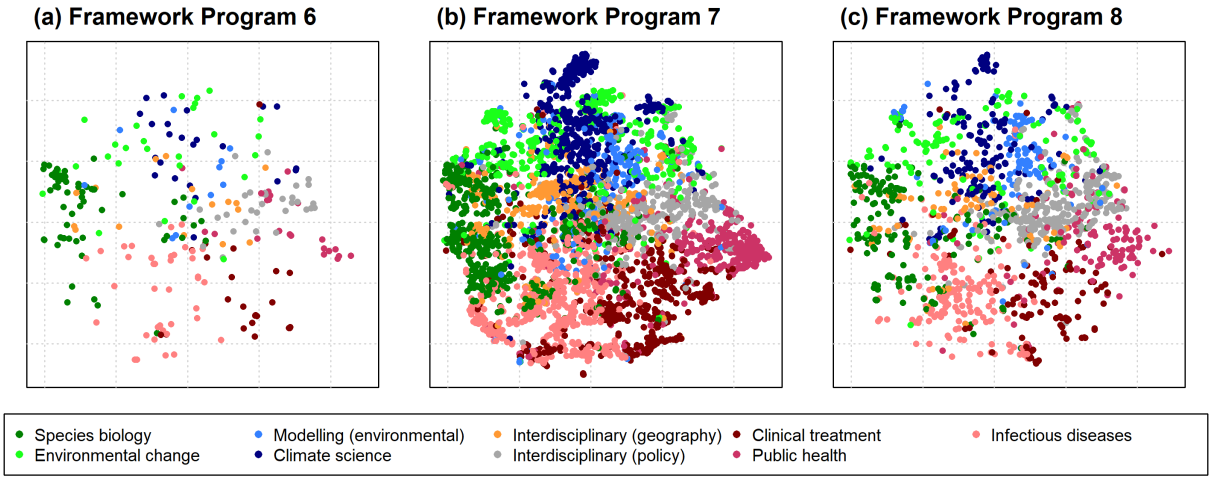
2.3 Evolving thematic research focus

2.3.1 Research acknowledging funding from the EU

Natural language processing identified nine themes for research acknowledging funding from the EU's Framework Programmes (Annex Figure 18) based on the statistical frequency of shared terms across research items (Figure 13, Figure 14, and Annex Table 2). While machine learning algorithms identified statistically distinguishable thematic clusters based on keyword frequencies, descriptive labels were chosen based on common keywords and the position of thematic clusters in the research landscape. It was relatively simple to label six of the themes using informative descriptors based on the top 15 key terms (Annex Table 2). The remaining three themes contained generic terms, which made them difficult to label. One of these included general terms related to geography (e.g., Africa, south, site, region), so we labelled this theme based on its central position in the research landscape (orange points in Figure 13) as *interdisciplinary theme with a common geographic focus*. Similarly, a second centrally positioned theme (grey points in Figure 13) shared common terms related to policy (e.g., development, local, international, projects, economic) and was positioned between the themes of public health and environmental change (mauve and light green points in Figure 13, respectively). Therefore, we labelled this as an *interdisciplinary theme with a common policy focus*. The third theme (light blue points in Figure 13) included general terms related to quantitative modelling (e.g., data, model, estimate, prediction, analysis, measurement). Since the research items within this theme were positioned in the research landscape between climate science (dark blue points) and environmental change (light green points), we labelled it as *Modelling (environmental)*. We identified three themes related to health: *Infectious diseases* (e.g., infectious, virus, disease, malaria), *Clinical treatment* (e.g., risk, age, treatment, children, patient), and *Public health* (e.g., health, care, service, access, strategic). The machine learning algorithm distinguished between these three themes, but their proximate position in the thematic landscape suggests that they are variations of a common theme (Healthcare) along a continuum of research, implementation, and strategic planning (Figure 13). We, therefore, represented these themes using a shared red colour palette.

Figure 13. The thematic research landscape for Africa-focused research funded by the European Commission's (a) Sixth, (b) Seventh, and (c) Eighth (Horizon 2020) Framework Programmes.

Each point is a research article presented in the two-dimensional t-distributed stochastic neighbour embedding (t-SNE) research landscape, where the proximity of points is based on the shared use of terms. Points are coloured based on thematic groups identified by unsupervised classification using Latent Dirichlet Allocation (LDA).

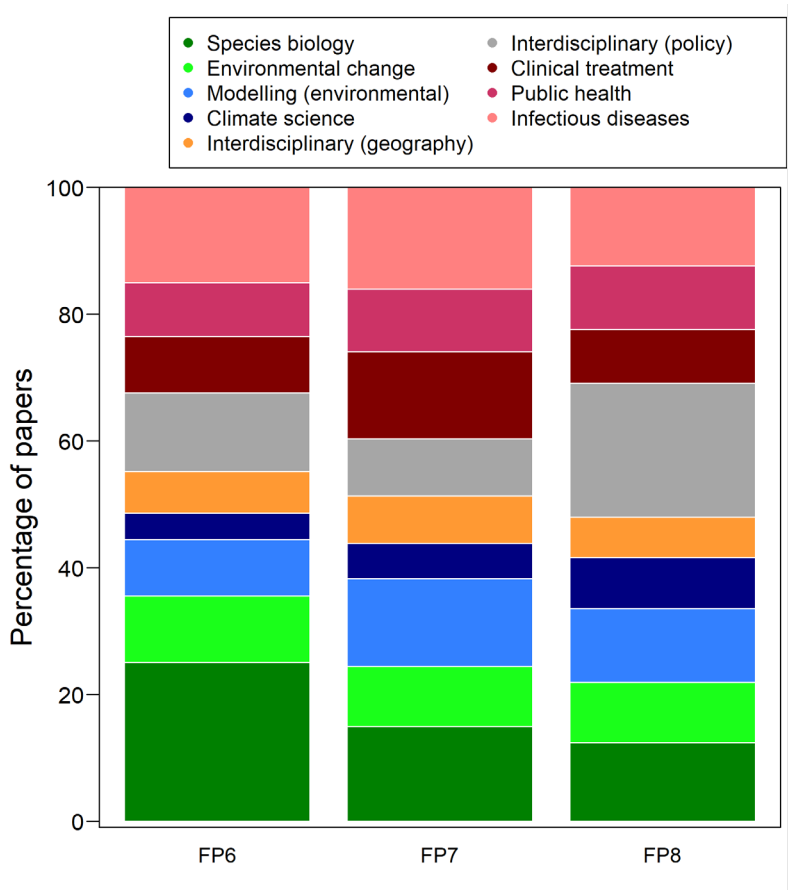


The density of points in Figure 13 reflects the changing production of research between the three FPs, recognising that the number of research items for Horizon 2020 will continue to accumulate after the end of this FP. Normalising output as a percentage of total research items indicated a changing thematic focus between the 6th, 7th and Horizon 2020 FPs (Figure 14). Notably, there has been a consistent decline in research on species biology as well as similar, albeit less pronounced, reduced focus on infectious diseases. The focus on other themes, like public health, environmental change and the geographical interdisciplinary theme remained relatively stable across the various FPs. The focus on climate science and environmental modelling

increased slightly. The interdisciplinary theme with a common policy focus increased substantially, to the extent that it became the most frequent theme in Horizon 2020 (FP8).

Figure 14. The changing thematic frequency for Africa-focused research items acknowledging funding from the European Commission's Sixth (FP6), Seventh (FP7), and Eighth (Horizon2020: FP8) Framework Programmes.

The thematic focus has changed significantly between the three framework programmes according to a X_2-test (X_2 = 238.44, df = 16, P-value < 0.001).



2.3.2 JRC Research

Seven research themes emerged from research published by the Joint Research Centre (Figure 15, Annex Figure 19, and Annex Table 3). These themes had a stronger disciplinary focus than research funded by the EU and tended to include more clearly definable scientific fields. These seven research themes have received more even focus from the Joint Research Centre through time (Figure 16).

There was a disproportionately large focus on earth observation research during the 1980s and 1990s, but this declined consistently in recent decades. These declines do not necessarily present a shift in research focus, but rather an evolution of research from satellite remote sensing technology to its various domains of application, such as for studying land use or climate change. This is illustrated by the proximity and overlap of dark green (earth observation), light green (Natural resources and landcover) and blue (Climate change) points in Figure 15, illustrating the conceptual overlap between these themes. There was a thematic evolution in fundamental research in remote sensing, which grew in prominence until it became embedded as a tool suitable for various applied contexts. Atmospheric emissions (light blue), agricultural modelling (orange) and development policy (purple) showed a sequence of increased research focus, followed by a subsequent decline (Figure 16). These trends should, however, be interpreted in a relative rather than absolute sense, as later declines could simply be caused by the increase in research output (Figure 6), which would result in a relative decline when specific themes grow at a slower rate than the total output. Three themes – biological risks and impacts (red), climate change (blue), and natural resources and landcover (light green) – increased steadily through time (Figure 16).

In the case of climate change and natural resources and landcover, increased thematic focus seems to be associated with the cross-disciplinary nature of these themes (as illustrated by the spread of blue and light green points in Figure 15).

Figure 15. The thematic research landscape for Africa-focused research by the European Commission's Joint research Centre for the periods (a) before 2003, (b) 2003-2007, (c) 2008-2014, and (d) 2014-2020.

Each point is a research article presented in the two-dimensional t-distributed stochastic neighbour embedding (t-SNE) research landscape, where the proximity of points is based on the shared use of terms. Points are coloured based on thematic groups identified by unsupervised classification using Latent Dirichlet Allocation (LDA).

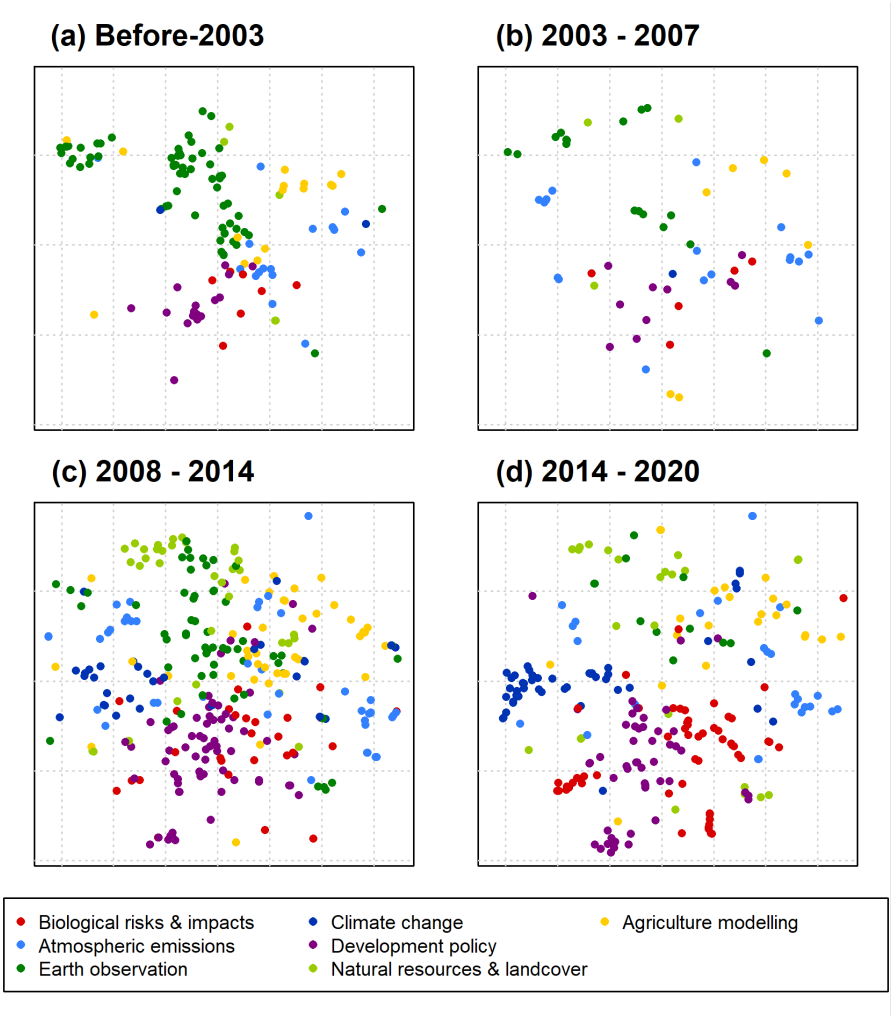
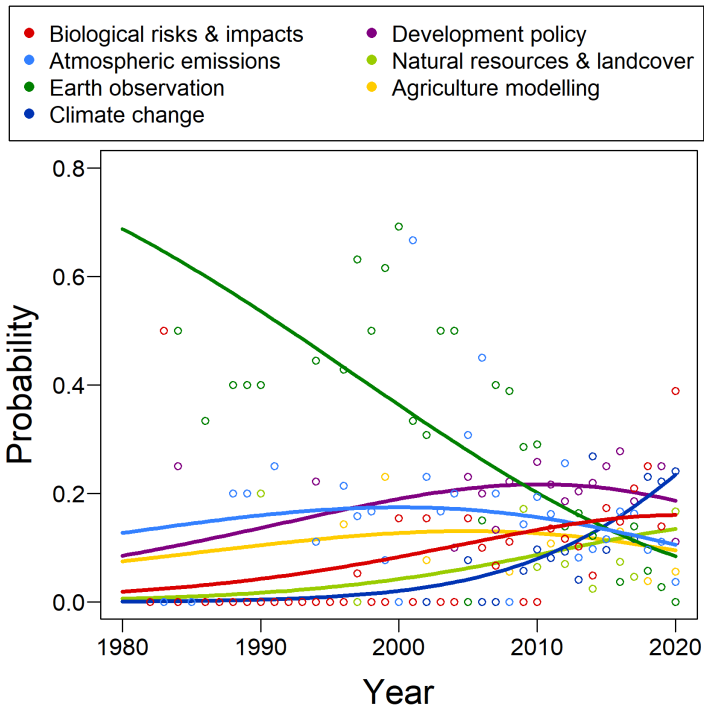


Figure 16. The changing thematic probability for Africa-focused research items produced by the European Commission's Joint Research Centre between 1980 and 2020.

The points are the proportion of research items in each theme through time, and the lines are the probabilities modelled using multinomial regression.



3 Evaluating EU research on Africa

Based on the *Scopus* database, the bibliometric analysis of peer-reviewed research reflects the complex and multifaceted scientific relationship between the EU and Africa. It would be a mistake to treat science diplomacy between these continents as a monolith. For instance, research funded through competitive grants from the EU differed from research produced by the JRC, in terms of scientific production, international collaboration and thematic focus. Science diplomacy likely differs depending on whether the EU is seen as a facilitator of or a participant in scientific research. Moreover, scientific ties between the EU and Africa are scale-dependent in that collaborative links between countries do not necessarily mirror collaborative links between research institutions within these countries. Thus, science diplomacy between countries would not necessarily reflect in institutional cooperation, or *vice versa*. Nevertheless, Africa-focused research show hallmarks of both *science in diplomacy* (as reflected in the thematic focus of research) as well as *science for diplomacy* (as reflected in collaborative networks) and, as we will explain, this is built on – and will most likely be developed further – a foundation of *diplomacy for science*.

3.1 A growing focus on Africa?

The relative numbers of research items focusing on Africa supports the view that the EU has an increasing scientific focus on Africa. Although the percentage of Africa-focused papers funded by the EU through its FPs has remained consistent across the 6th, 7th and Horizon 2020 FPs, the annual percentage of Africa-focused papers by the JRC has increased threefold since 1990. In both instances, the percentage of papers with a specific African focus was relatively small (typically <5 % of all outputs).

3.1.1 Pathways to international scientific partnership

European FPs are large competitive calls for funding, which could disadvantage applicants from countries without long research track-records or established research infrastructure. This general observation also holds true for funders besides the EU, as evidenced by funding for biomedical research from various sources, which also have a strong geographical bias in Africa concentrated in Southern and East Africa (Adam et al., 2020). While we did not track the recipients of funding from the FPs directly, our co-authorship network analysis indicated the clear preference of collaboration with Southern and East African researchers since the 7th and Horizon2020 FPs (Figure 9 b and c).

Global research collaboration – particularly with African countries – follows the path of least resistance, where collaboration is favoured with countries that share languages, cultures, or histories (Adams 2012; Adams et al. 2014). This was clear from our study, where European collaboration sub-networks favoured countries where English is commonly spoken (e.g., South Africa, Kenya, Nigeria). Similarly, North African collaborations were relatively scarce and when they did occur, they often included partners from the Middle East (e.g., the collaborative association between Egypt and Saudi Arabia). Network analyses in other contexts suggest that the topologies of co-author networks constrain collaborations, but in the case of Africa inter-continental collaboration is higher than expected from network topology alone (Guns & Wang 2017). This suggests that African countries still depend on non-African collaboration to maintain scientific productivity.

3.1.2 Country-level partnerships do not equate to institutional-level collaboration

Although country-level collaboration for European-funded research followed well-established collaboration pathways that increased the centrality of co-authorship links, the same did not apply to institutional collaboration, where network centrality has decreased over subsequent FPs (Figure 8d and h). So, while research collaboration tends to flow towards traditional partner countries, it does not always flow to the same research institutions within these countries. This supports Adams' (2013) view that research innovation relies on "coalitions of the willing" rather than international policy and coordination because multinational programmes alone will not create research excellence unless individual universities and research institutions are adequately resourced. Moreover, international collaboration in Africa increases when *individual* African researchers have spent time abroad during their research training or have received funding from international sources (Confraria et al. 2020), which suggests that Europe-African collaboration is partly driven by the individual scientists within institutions, rather than their institutions more generally. The misalignment between country- and institutional-level collaboration could also be interpreted by assuming that African research institutions are volatile and inconducive for establishing long-term collaborative relationships. However, this interpretation is unsupported

by our analyses because it remains to be proven that institutional volatility is large enough to affect co-authorship networks at the 5-7 year cycles of FPs.

3.1.3 Building equal science partnerships

Building scientific capacity at African scientific institutions will be challenging but necessary. As much as 84.5% of African researchers have at some stage in their career taken part in research activities despite lack of payment (Makoni, 2018). Such inadequate resourcing for African researchers will prevent equal scientific partnership between Europe and Africa. However, European researchers should be cautious of promoting short-term capacity building over long-term equal partnership (Skupien & Rüffin, 2020). African scientists have voiced concerns about 'helicopter research', where foreign researchers drop into local countries only for the duration of the project, relegating local participants to the roles of fieldworkers or assistants (Nordling, 2017). Efforts to empower African partners through financial support have regularly fallen short by either administering research grants through foreign organisations without local financial autonomy (Erondu et al., 2021), or by burdening local partners with additional anti-corruption reporting requirements that are not expected in the funders' home countries (Matupi, 2019). There is, therefore, a delicate balance between supporting African researchers financially without making them beholden to foreign research funding.

3.1.4 The JRC as a scientific matchmaker

Based on the *Scopus* database, our results showed interesting trends in research collaborations with the JRC. The centrality of institutional JRC co-authorship networks has increased through time (Figure 11 h), which is expected because our search criteria always included the JRC as the common research partner. Nevertheless, the increasing network transitivity shows that collaboration links with the JRC have created links between partner countries and institutions. In layman's terms, increased transitivity means that if the JRC collaborates with, say, South Africa and Tanzania, the likelihood of collaborative links between South Africa and Tanzania will increase over time too. Such a pattern would not emerge if JRC researchers partook in bilateral 'helicopter research', where collaboration is seen only to further their own ends. Instead, JRC collaboration appears to create new research partnerships between third countries. This is illustrated in Figure 12c, which clearly shows how a country like South Africa, through its JRC collaboration, is also linked to Australia, North- and South America through its co-authorship relationships. This success seems to further the ambitions of the JRC Strategy 2030 that recognises 'sharing' as one of the core criteria of research excellence, given the emphasis on multidisciplinary research with multiple partners (EC Joint Research Centre, 2017b). This highlights the importance of evaluating research excellence using criteria beyond simply counting research outputs.

3.2 Africa-focused research in the context of global challenges

The new EU-Africa strategy emphasizes moving away from a Eurocentric vision and a donor-recipient relationship of the past to build shared responsibilities towards solving global challenges. To this end, the EC has prioritised Africa as part of the Horizon Europe FP, launched in June 2021, to specifically "*enhance cooperation with Africa to promote actions targeted to finding locally adapted solutions to challenges that are global in nature*" (EC, 2021). This research programme is the culmination of continuous engagement between EU and African funding institutions (i.e., *diplomacy for science*). While there are some concerns that European funding might entrench asymmetrical power over Africa (Schmidt & Neuburger, 2017), evidence from within Europe suggest that funding from FPs does not crowd out alternative sources of funding (Szücs, 2020). By contrast, EU funding can be used to mobilise additional funding from other sources (Szücs, 2020). Although it remains to be seen if this also applies to the African context, it suggests that Europe's growing contribution to funding African research is not intended to maintain current power structures (i.e., *science for diplomacy*), but rather an attempt to develop African science to address internal and global challenges (i.e., *science in diplomacy*). This view is supported further by the trends identified in our analysis of thematic research areas in recent years. Focus has shifted from traditional disciplinary research to focus more on global challenges. This further underlines Horizon Europe's decision to focus the Africa Initiative on global challenges around (1) public health, (2) the green transition, (3) innovation and technology, and (4) building capacities for science (EC, 2021).

3.2.1 Interdisciplinary science to tackle global problems

EU-funded research appears to have become more interdisciplinary over successive FPs (Figure 14). This is consistent with an increased focus on solving global challenges, which typically requires research across

disciplinary boundaries. These changing trends in thematic research focus are consistent with the perspective of '*science in diplomacy*', where scientific information is used to guide diplomatic processes between the EU and Africa, which tend to be complex and multifaceted. However, this interpretation comes with two caveats, one philosophical and the other practical.

First, the potential of science diplomacy for solving global challenges depends on an alignment between scientific evidence and the values held by those tasked with solving these problems (Rungius & Flink, 2020). If there is no alignment between evidence and values, even interdisciplinary research will be unable to turn into meaningful action. Participatory approaches between all actors at the science-policy interface may prove helpful here, as will be the acknowledgment of the role of values in modulating the decision-making context (e.g., the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services including a dedicated 'Values Assessment Report'[9])

A second, more practical, caveat of the growing interdisciplinarity of European-funded research is the novel challenge of managing, mobilising, and integrating these forms of information in the decision-making context. Our natural language processing algorithms tended to classify interdisciplinary research based on generic and generally uninformative terms, which required us to label these themes based on their central position in the research landscape (Figure 13). The consequence is that it would be difficult to query these interdisciplinary studies from databases because they cannot be classified using informative, yet simple, search strings. When research outputs can only be classified based on their thematic focus relative to other studies, it becomes challenging to mobilise this information to feed into the policy process because it is more difficult to assess the evidence base and knowledge gaps (Gluckman et al., 2021). Therefore, more effort is needed to develop informative taxonomies to classify interdisciplinary research in searchable databases.

3.2.2 Building applied solutions on the JRC's long-term foundational research

The changing thematic focus of research by the JRC reflects its evolving role in applied science. Early research by the JRC (1980-2000) was dominated by studies of remote sensing and earth observation (Figure 16). In the late 1980s, the JRC started the MARS project (Monitoring Agriculture with Remote Sensing) to evaluate agricultural policies using satellite technologies (EC, Joint Research Centre, 2007). The TREES project (TRopical Ecosystem Environment observation by Satellite) emerged in the early 1990s to create a global inventory of tropical forests to detect and quantify deforestation and assess its impact in the context of climate change (EC, Joint Research Centre, 2007). The declining prominence of earth observation in our thematic analysis (Figure 16) should not be interpreted as the demise of these pioneering efforts. Instead, it supports a view that the JRC has evolved from the strong technical foundation of earth observation to growing its focus on developing information products to guide policy in various thematic fields (e.g., Szantoi et al., 2016). Such evolution is a natural response from an organisation that aims to address more applied global challenges (Belward et al. 2022).

Recent efforts to study climate change, biological risks, biodiversity loss, and the consequences of landuse change were only possible because they built on the technical and methodological advances of earlier projects like MARS and TREES. The uptake of earth observation can be more efficient if focused on applied questions that can be addressed using remote sensing, rather than the pure remote sensing methods themselves (Palumbo et al., 2016). Such an approach is only possible when the methodological and technical foundation already exists, which is the case of the JRC's efforts to establish remote sensing expertise to make the best of Copernicus, the EU's earth observation programme. The evolving thematic focus of JRC research illustrates the long-term multiplier effects of investments in basic scientific expertise; thereby justifying the JRC's commitment to ensuring that 5% of its research remains exploratory (EC Joint Research Centre, 2017b, 2017c).

3.3 Automated knowledge management

Our bibliometric study revealed several important insights into the scientific relationship between Europe and Africa. Automated methods allowed us to evaluate the trends in scientific production, collaboration, and thematic focus in a collection of 6,849 scientific articles. To process this volume of information manually would have been a daunting task for a team of dedicated disciplinary experts, so in this sense, automated methods for systematic mapping are essential to keep abreast of ever-increasing scientific outputs. Natural language processing creates opportunities to evaluate the content of scientific outputs without necessarily having expertise in the specific scientific sub-domain. Therefore, automated bibliometric methods have considerable

9 https://ipbes.net/values-assessment

value at the science-policy interface, where large amounts of information must often be synthesised under strict time constraints.

Automated methods are not without their shortcomings. The first limitation is the quality of the input information from the bibliometric corpus. Content is limited by the completeness of research databases. In the case of our study that relied on *Scopus*, scientific output was limited to peer-reviewed items in English academic journals. This means that the grey literature (e.g., reports, policy briefs, conference contributions) and all non-English content were excluded from our study. Based on this, our study certainly underestimates much of the scientific content generated between Europe and Africa. A second limitation is the search criteria used for the study. We were purposely conservative in our study by restricting our search to research items that explicitly mentioned African countries in the title or abstract of the study. Thus, global studies that included Africa, or local studies that focused on Africa, but did not mention explicitly an African country in the title or abstract would be overlooked in our assessment.

3.3.1 Automation complements, but cannot replace, expert knowledge brokers

While automated methods simplify large parts of the research process, they suffer from the same trade-offs typical of other scientific methods when it comes to balancing broad research scopes and narrow scientific depth. This relates to the need for expert intervention to make sense of the automated processes. As we showed, natural language processing is efficient at grouping research items according to their thematic focus. However, these same methods are unable to make sense of the thematic grouping because they merely represent statistical relationships between word frequencies. Thus, expert intervention is necessary to label these groups to make sense of their thematic relationships.

The requirement for expert input in bibliometric analyses highlights the broader need for specialist knowledge-brokers at the science-policy interface (Buschke et al. 2022). This important role should not be tagged on to the day-to-day pressures of research scientists but should instead be tasked to dedicated specialists. Knowledge brokerage requires unique skills. Knowledge brokers *inform* policy options, they do not *determine* policy (Gluckman et al., 2021), which requires that they understand the policy context and the needs of policymakers (Topp et al., 2018; Oliver & Cairney, 2019). In the specific case of bibliometric analyses, knowledge brokers need to balance the technical ability to process and analyse large datasets with the judgment to know when to intervene with manual screening of datasets and outputs (Nakagawa et al., 2019). This ability to balance automation with expert intervention will become more important as machine learning tools become more common in synthesising scientific content (Nakagawa et al., 2019; Haddaway et al., 2020).

3.3.2 The Africa Knowledge Platform

As scientific service and knowledge brokering becomes more widely used, it will become institutionalised. It is unlikely that any one person will have all the skills needed for this role, so organisations at the science-policy interface should support dedicated teams to fill this role (Topp et al., 2018; White, 2019). In the case of the science relationship between Europe and Africa, the JRC is in the process of institutionalising knowledge brokering through its *Africa Knowledge Platform* (available at https://africa-knowledge-platform.ec.europa.eu/), which aims to synthesise and present policy-relevant scientific information on Africa. This report feeds into the AKP and is also repurposed as a simple narrative for a non-specialist readership (https://africa-knowledge-platform.ec.europa.eu/jrcafricaresearch).

4 Take-home messages

The EU's scientific relationship with Africa is as dynamic and complex as the diplomatic ties between the two continents. Patterns in scientific production, collaboration and thematic focus extracted from the analysis of peer-reviewed articles from the *Scopus* Database show the hallmarks of multifaceted science diplomacy. Various previously unrepresented African states are entering the global scientific arena and are joining EU-Africa scientific collaboration networks that have traditionally been limited to a few African countries, like South Africa or Nigeria. Thematic research focus has shifted to solving applied global problems using interdisciplinary approaches, which is what would be expected from a paradigm of '*science in diplomacy*'. The growing research collaboration with African scientists and the prioritisation of African research in the upcoming Horizon Europe FP shows that the EU sees science as an important lever in its relationships with Africa (i.e., '*Science for diplomacy*'). Supporting research in Africa by developing scientific capacity, research infrastructure, and multilateral partnerships would not be possible without strong diplomatic ties (i.e., '*Diplomacy for science*').

The fact that the EU-African scientific landscape includes all aspects of science diplomacy means that there is considerable opportunity to use science to contribute to the political and policy ambitions of both continents. But this opportunity should not be taken for granted because the intricate science-diplomacy landscape has many independent – and potentially unpredictable – facets. EU-African relationships are complex and there will not always share a common vision. Our study, for example, highlighted how the production, collaboration and focus of research funded by the EU is not necessarily the same as research produced by the JRC. Therefore, EU researchers and funders should ensure that their effort dedicated to producing scientific research on Africa is matched by equal effort to manage and mobilise this scientific information to serve policy priorities more effectively. Specific policy choices will advance science diplomacy between the EU and Africa.

4.1 Policy messages

Our bibliometric analyses support and reinforce the following five policy messages, most of which are already embodied in existing policies (both implicitly and explicitly).

- **Science is significant for strengthening the EU's position as a global leader.** A robust scientific foundation is needed to achieve the EU's priority for 2019-2024 of "*A stronger Europe in the World*". Our analyses showed how research trends have changed in response to pressing global challenges. Scientific networks with Africa will be particularly important for monitoring progress towards global aspirations, such as those linked to the Sustainable Development Goals, the Convention on Biological Diversity, and the Paris Climate Agreement. Equal partnerships with African researchers are also essential for tracking that European Policies – such as the Green Deal – do not inadvertently externalise environmental damage to other nations (Fuchs et al., 2020).
- **Science diplomacy with Africa will depend on supporting African researchers as equal scientific partners.** To date, scientific collaboration funded or carried out by the EC is formed by "coalitions of the willing", which are concentrated in just a few prominent countries and institutions. Moreover, these collaborative relationships are imperfectly aligned between countries and institutions, which suggests that country-level policy interventions do not necessarily lead to increased science capacity at the institution-level. The EC's *Comprehensive Strategy on Africa*[10] proposes that the EU scales up EU-Africa academic and scientific cooperation, including on technical and vocational education and training, and enhancing skills development. This is being implemented through Horizon Europe, which should endeavour to build capacity in underrepresented countries and institutions, while simultaneously recognising their capacity constraints.
- **Science has become more interdisciplinary to meet pressing global challenges.** Natural language processing showed that Africa-focused research is becoming more interdisciplinary and has grown from fundamental research on technical topics, to applied research to address global challenges like climate and landuse change. These trends are consistent with ambitions in the *Comprehensive Strategy on Africa* to develop along low-carbon, resource efficient and climate-resilient pathways. Research will continue to become more integrative, but there is still a scientific

10 https://ec.europa.eu/international-partnerships/system/files/communication-eu-africa-strategy-join-2020-4-final_en.pdf

gap for some of the elements in the European Green Deal, notably research into smart urbanisation, circular economy and fair value chains, human demography, and migration.

- **Evaluating scientific impact must consider multiple dimensions of the research process.** Africa-focused research has increased with time, but still comprises less than 5% of the science funded or produced by the EU. However, the impact of this research is greater than counting the number of scientific articles. Our analyses showed two important, but often overlooked, patterns of research impact. First, the JRC's collaborative networks demonstrated increased transitivity through time, which implies that the JRC serves as a 'scientific matchmaker' by bringing together collaborating countries and institutions. Second, thematic focus has shifted from fundamental work in earth observation to applied work on global problems. This was only possible because the earlier work laid the scientific foundation on which to build more problem-orientated solutions. Scientific impact evaluations should, therefore, look beyond research production by also considering how research contributes to new scientific partnerships as well as the long-term value of fundamental research without immediate applications.
- **Science diplomacy can be advanced by dedicated knowledge brokers, using shared geographic lenses.** Nearly all the trends in our bibliometric analysis point towards a research landscape with Africa that is becoming more complex. The short-term will likely see increased research outputs, more diverse collaborative networks, and blurred disciplinary boundaries. Complexity can be navigated by dedicated knowledge brokers. These brokers should be fluent in using automated knowledge management tools – such as bibliometrics and natural language processing – but should retain the expert judgement needed to make sense of these tools. Knowledge brokers can integrate disjointed scientific disciplines through common geographical lenses. The Africa Knowledge Platform was developed for this purpose to bring together the JRC's knowledge on Africa. If successful, it could serve as an example for similar evidence products for the EC's work in other parts of the world.

More specifically, science is an important tool to guide the implementation of the **European Commission's Strategic Plan 2020-2024 – International Cooperation and Development**[11]. Notably, scientific knowledge can support diplomacy with Africa by tackling existing gaps and reinforcing weak scientific ties with countries and institutions. This is relevant to **Theme 1 (Partnerships)** of the Strategic Plan, which "*aims to scale up cooperation with Africa into a comprehensive partnership of equals, capable of effectively tackling common challenges and achieving common goals, set under the wider umbrella of the SDGs*".

Science verifies and strengthens external dimension of EU policies in African countries, as well as its coherence with global aspirations (e.g., UN Sustainable Development Goals and similar multilateral agreements). **Theme 7 (Human Development)** of the Strategic Plan urges the EU to "*continue to shape global initiatives and international platforms to contribute to the achievement of the 2030 Agenda in these fields, in line with EU sector priorities*".

Section D (Knowledge Management) of the Strategic Plan aims to support EU policy needs by "[developing] a culture of collaboration and knowledge sharing; and [enhancing] uptake of internal and external knowledge and research". Including knowledge brokers in sectoral policy foresight exercises may prove helpful when elaborating strategic policy choices to promote EU values.

4.2 Research recommendations for the JRC

Research has become more complex and interdisciplinary. It is more integrative with blurred disciplinary boundaries. The JRC should build capacity in using machine learning tools and improved taxonomies to capture interdisciplinarity and synthesise scientific content. Knowledge synthesis of past and current EU-Africa scientific cooperation like the one conducted in this report can help shape future paths within the JRC work programme 2023-24 and beyond.

The content of this report was backwards-looking by design. Future research into the meta-science between the EU and Africa would benefit from a deeper understanding of the variation within the patterns we present here. A starting point would be more nuanced integration of bibliometric and thematic patterns to understand whether the thematic focus of a research project affects collaborative partnerships, and *vice versa*. This could

11 https://ec.europa.eu/info/publications/strategic-plans-2020-2024-international-cooperation-and-development_en

be achieved by either replicating the collaborative network analyses within individual research themes or by replicating the thematic natural language processing for narrower collaborative sub-clusters. Such sub-group analyses would determine whether there are any inadvertent trade-offs in Horizon Europe's dual objectives of growing partnership on Africa and researching specific global issues on public health, the green transition, innovation and technology, and building capacities for science. It may be that collaborative capacity already exists for some topics but not others, or that certain research activities are more conducive to establishing cross-continent partnerships. Dedicated knowledge brokers would be needed to interpret and navigate these types of intricacies.

Knowledge brokers have unique skills at the frontier between science, policy and communication and should be institutionalised at the JRC; they are essential for making sense of outcomes from machine learning tools, integrating disconnected disciplines, and translating science into policy options.

The **Africa Knowledge Platform**[12] is a web-based entry-point to enhance and coordinate JRC knowledge on Africa. This highly visual platform is easy to use and conveys science-for-policy messages in a clear, concise, and integrated way. It brings together datasets, narratives, interactive tools, and partnerships across more than 30 disciplines and policy priorities. The Africa Knowledge Platform aims to support EU policymaking and science diplomacy, in line with the EU-Africa Strategy and international development agendas like the UN Sustainable Development Goals. By bridging the gap between research and policy, the Africa Knowledge Platform empowers policymakers, stimulates knowledge-sharing, and enhances partnerships between European and African stakeholders.

12 https://africa-knowledge-platform.ec.europa.eu

5 References

Adam, T., Akuffo, H., Carter, J.G. Cheetham, M.J., Crisafulli, A., Danielson, C.M., Gunning, J., Haugen, B., Jaikowicz, D., Kay, S., Kilmarx, P.H., Mólto López, J., Olesen, O.F., Peñas-Jiménez, I., Tesfagiorgis, K., Wallica, S.K., Glass, R.I. (2020) WorldRePORT: a database for mapping biomedical research funding. *The Lancet*, 8, e27-e29.

Adams, J. (2012) The rise of research networks. *Nature*, 490, 335-336.

Adams, J. (2013) The fourth age of research. *Nature*, 497, 557-560.

Adams, J., Gurney, K., Hook, D., Leydesdorff, L. (2014) International collaboration clusters in Africa. *Scientometrics*, 98, 547-556.

Anonymous (2017) Hot Hub: Europe's Joint Research Centre is doing well, but must think bigger. *Nature,* 550. 8.

Aria, M. & Cuccurullo, C. (2017) bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, 1(4), 959-975.

Atickem, A., Stenseth, N.C., Fashing, P.J., Nguyen, N., Chapman, C., Bekele, A., Mekonnen, A., Omeja, P.A., & Kalbitzer, U. (2019). Build science in Africa. *Nature*, 570, 297-300.

Belward, A., Hartstra, J., Baruth, B., Beck, P., Carmona Moreno, C., Churchill, P., Craglia, M., Crandon, R., Ehrlich, D., Eva, H., Fortuny Guasch, J., Fullerton, K.T., Kemper, T., Kerdiles, H., Leo, O., Loudjani, P., Maenhout, G., Milenov, P., Pesaresi, M., Pinty, B., Zibordi, G. and Kreysa, J., A history of remote sensing at the JRC, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-49465-2, JRC127849.

Berkman, P.A. (2019) Evolution of science diplomacy and its local-global applications. *European Foreign Affairs Review*, 24, 63-80.

Blondel, V.D., Guillaume, J-L., Lamboitte, R. & Lefebre, E. (2008) Fast unfolding of communities in large networks. *Journal of Statistical Mechanics: theory and Experiment*, 2008, #P10008.

Borchardt, S. and Estreguil, C. (2020) Text Mining for Horizon Scanning, An Insight into Agricultural Research and Innovation in Africa, EUR 30349 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-21446-5, doi:10.2760/41501, JRC121445.

Boshoff, N. (2009) Neo-colonialism and research collaboration in Central Africa. *Scientometrics*, 81, 413-434.

Bradley, M. (2008) On the agenda: North-South research partnerships and agenda-setting processes. *Development in Practice*, 18, 673-685.

Buschke, F., Estreguil, C., Mancini, L., Mathieux, F., Evoa, H., Battistella, L. & Peedell, S. (2022) Digital storytelling through the European Commission's Africa Knowledge Platform to bridge the science-policy interface for raw materials. *Circular Economy and Sustainability*, doi: 10.1007/s43615-022-00198-2.

Cherry, A. & Du Toit, D. (2018) *The politics and drivers underpinning Africa-Europe research and innovation cooperation.* In: A. Cherry, J. Haselip, G. Ralphs, I.E., Wagner (eds.) Africa-Europe research and innovation cooperation. Palgrave Macmillan, Cham, Switzerland.

Confraria, H., Blankenberg, J. & Swart, C. (2020) *Which factors influence international research collaboration in Africa*. In: M, Ramutsindela, D. Mickler (eds.) Africa and the Sustainable Development Goals. Springer Nature, Switzerland.

Elliot, A., Nerima, B., Bagaya, B., Kambugu, A., Joloba, M., Cose, S., Pantaleo, G., Yazdanbakhsh, M., Mabey, D., Dunne, D., Moffett, A., Rwakishaya, E.K., Kaleebu, P., Mbidde, E.K. (2015) Capacity for science in sub-Saharan Africa. *The Lancet*, 385, 2435-2437.

Erondu, N.A., Aniebo, I., Kyobutungi, C., Midega, J., Okiro, E. & Okumu, F. (2021) Open letter to international funders of science and development in Africa. *Nature Medicine*, 27, 738-745.

EC (2021) Horizon Europe boosts EU-Africa cooperation in Research & Innovation. Publications of the European Union, Luxembourg. ISBN 978-92-76-38649-0, doi:10.2777/1333, KI-02-21-739-EN-N

EC, Joint Research Centre (2007) *Highlights of the JRC 50 years in science.* Publications Office of the European Union, Luxembourg.

EC, Joint Research Centre (2017a) *Science for the AU-EU Partnership: building knowledge for sustainable development*. Publications Office of the European Union, Luxembourg. ISBN 978-92-79-86961-7.

EC, Joint Research Centre (2017b) The European Commission's science and knowledge service: JRC Strategy 2030. Office of the European Union, Luxembourg.

EC, Joint Research Centre (2017c) JRC Implementation Review: In the context of the interim evaluation of the Horizon 2020 programme. EUR 28745 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-72267-7 (print),978-92-79-72268-4 (pdf), doi:10.2760/084617 (print),10.2760/459053 (online), JRC107957

Fuchs, R., Brown, C. & Rounsevell, M. (2020) Europe's Green Deal offshores environmental damage to other nations. *Nature*, 586, 671-673.

Gluckman, P.D., Bardsley, A. & Kaiser, M. (2021) Brokerage at the science-policy interface: from conceptual framework to practical guidance. *Humanities & Social Sciences Communication*, 8, e84.

Giovani, B., Blümel, S., Lopian, R., Teulon, D., Bloem, S. Galeano, C. et al. (2020) Science diplomacy for plant health. *Nature Plants,* ,6, 902-905.

Guns, R. & Wang, L. (2017) Detecting the emergence of new scientific collaboration links in Africa: a comparison of expected and realised collaboration intensities. *Journal of Informetrics*, 11, 892-903.

Haddaway, N.R., Callaghan, M.W., Collins, A.M., Lamb, W.F., Minx, J.C., Thomas, J. & John D. (2020) On the use of computer-assistance to facilitate systematic mapping. *Campbell Systematic Reviews*, e1129.

Hintzen, R., Papadopoulou, M., Mounce, R., Banks-Leite, C., Holt, R.D., Mills, M., Knight, A.T., Leroi, A.M. & Rosindell, J. (2019) Relationships between conservation biology and ecology shown through machine reading of 32,000 articles. *Conservation Biology,* 34, 721-732.

Krull, W. (2005) Helping to create symmetric partnerships: a new approach to supporting research in Sub-Saharan Africa. *Tropical Medicine and International Health*, 10, 119-120.

Leese, M. (2018) Between a carrot and a stick: science diplomacy and access to EU research funding. *Global Policy*, 9, 48-52.

Mutapi, F. (2019) Africa should set its own health-research agenda. *Nature*, 575, 567.

Makoni, M. (2018) Research is often Unpaid in sub-Saharan Africa. *Nature news* doi: 10.1038/d41586-018-07244-w

McCarthy, M., Maher, D., Ly, A. & Ndip, A. (2010) Developing the agenda for European Union collaboration on non-communicable diseases research in Sub-Saharan Africa. *Health Research Policy and Systems*, 8, #13.

Nakagawa, S., Samarasinghe, G., Haddaway, N.R., Westgate, M.J., O'Dea, R.E., Noble, D.W.A. & Lagisz, M. (2019) Research waving: visualizing the future of research synthesis. *Trends in Ecology and Evolution*, 34, 224-238.

Nordling, L. (2010) African nations vow to support science. *Nature*, 465, 994-995.

Nordling, L. (2015) Africa's fight for equality/ *Nature*, 521, 24-25.

Oliver, K. & Cairney, P. (2019) The dos and don't's of influencing policy: a systematic review and advice to academics. *Pelgrave Communications*, 5, e21.

Ovalle-Perandones, M-A., Gorraiz, J., Wieland, M., Gumpenberger, C. & Olmeda-Gómez, C. (2013) The influence of European Framework Programmes on scientific collaboration in nanotechnology. *Scientometrics*, 97, 59-74.

Palumbo, I., Rose, R.A., Headley, R.M.K., Nackoney, J., Vodacek, A. & Wegmann, M. (2016) Building capacity in remote sensing for conservation: present and future challenges. *Remote Sensing in Ecology and Conservation*, doi: 10,1002.rse2.31.

Prange-Gstöhl, H. (2017) *The external engagement of the European Union in science and Research*. In: R. Whitman, R. Youngs, C. Damro, S. Gstöhl, and S. Schunz (eds.) The European Union's Evolving External engagement. 1st Edition. Routledge

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Ruffini, P (2017) Science and Diplomacy: A New Dimension of International Relations. Springer, Cham, Switzerland.

Rungius, C. & Flink, T. (2020) Romancing science for global solutions: narratives and interpretive schemas for science diplomacy. *Humanities & Social Science Communications*, 7, e102.

Schmidt, L. & Neuburger, M. (2017) Trapped between privileges and precariousness: tracing transdisciplinary research in a postcolonial setting. *Futures*, 93, 54-67.

Skupien, S. & Rüffin, N. (2020) The geography pf research funding: semantics and beyond. *Journal of Studies in International Education*, 24, 24-38.

Sooryanmoorthy, R. (2018) The production of science in Africa: and analysis of publications in the science disciplines, 2000-2015. *Scientometrics*, 115, 317-349.

Szantoi, Z., Brink, A., Buchanan, G., Bastin, L., Lupi, A., Simonetti, D., Mayaux, P., Peedell, S. & Davy, J. (2016) A simple remote sensing based information systems for monitoring sites of conservation importance. *Remote Sensing in Ecology and conservation*, doi: 10.1002/rse2.14.

Szücs, F. (2020) Do research subsidies crowd out private R&D of large firms? Evidence from European Framework programmes. *Research Policy*, 49, 103923.

Topp, L., Mair, D., Smillie, L. & Cairney, P. (2019) Knowledge management for policy impact: the case of the European Commission's Joint Research Centre. *Pelgrave Communications*, 4, e87.

Triollet, R. and Alvarez Martinez, A.F., JRC Annual Report 2020, James, K. editor(s), Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-27025-6, doi:10.2760/110413, JRC123071.

Van Langenhove, L. (2017) *Tools for EU science diplomacy*. Publications Office of the European Union, Luxembourg.

White, H. (2019) The twenty-first century experimenting society: the four waves of the evidence revolution. *Pelgrave Communications*, 5, e47.

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8 List of abbreviations

AKP	Africa Knowledge Platform
EC	European Commission
EU	European Union
FP	Framework Programme
JRC	Joint Research Centre
LDA	Latent Dirichlet Allocation
MARS	Monitoring Agriculture with Remote Sensing
TREES	TRopical Ecosystem Environment observation by Satellite
t-SNE	*t*-distributed Stochastic Neighbour Embedding

9 Annex: Technical bibliometric methods

We examined trends in research acknowledging funding from the EU's Framework Programmes (FP) and research produced by the JRC in separate independent analyses. To do this, we first obtained a bibliometric corpus for each set of research outputs (hereafter referred to as EU-funded and JRC-produced research) and then quantified temporal trends in research output as well as trends in collaboration patterns between countries and institutions. Finally, we used natural language processing to identify broad research themes in the abstracts of the published papers and examined how these themes have changed through time.

9.1 Compiling a bibliometric corpus

All publication data was downloaded from *Scopus*, Elsevier's abstract and citation database (https://www.scopus.com/). We compiled two separate sets of publications: one for research that acknowledged funding from the EC through its FPs and a second one focussing specifically on research authored or co-authored by the JRC.

Because the *Scopus* database was launched in 2004, we limited our study of European-funded research to the 6th (2002-2006), 7th (2007-2013) and Horizon 2020 (2014-2020) FPs because earlier information on funding sources might be incomplete. This still allowed us to compare the effects of the specific prioritisation of international collaboration since the 7th FP.

For research funded by the EU through its FPs, we carried out three separate searches of the *Scopus* database. The first search was for all research items funded by the 6th FP, and this yielded 265 research items. We searched for all documents funded by this programme, and then narrowed the list to studies that included Africa-related terms in the title, abstract or keywords (search string is shown in Box 1). As African related terms, we used the term 'Africa' as well as the names of all African countries, including name changes (e.g., Swaziland & eSwatini) and synonyms (e.g., Ivory Coast & Côte d'Ivoire). Restricting our search to titles, abstracts and keywords was conservative, but ensured that the research items focussed specifically on Africa, rather than Africa being a smaller component of a larger international study.

The second search was for all research funded by the Seventh FP, narrowed down to papers on Africa using the same country terms described above (Box 2). For this second search, which yielded 4,204 research items, we also removed research items published after 2020 (to limit our analysis to completed years only) and before 2007 (because we assumed that there may be some inaccuracy in the reporting of any earlier records).

The third search was similar, but in addition to searching for Horizon 2020, we also included all the synonymous funding sources under the broader Horizon 2020 umbrella (e.g., Horizon 2020 Framework Programme, H2020, or Marie Skłodowska-Curie Actions) and we removed research items published after 2020 and before 2014 (Box 3). This third search yield 1,612 research items.

The second set of publications were those authored by at least one member of the JRC. To identify these items, we searched for the JRC affiliation ID code on *Scopus*, as well as for the affiliations linked to the JRC and its sub-units (Box 4). For this set of publications, we also narrowed down the number of items to those that included Africa and/or African countries as terms in the title, abstract or keywords and finally excluded items published after 2020. This search yielded 768 research items.

We analysed EU-funded research and JRC-produced research separately even though the JRC also receives funding through FPs. The data indicated that only a small percentage of JRC-produced research items listed FPs as a funding source (10.4% of research items listed the 'European Commission' as a funding source, 4.7% listed the 'Seventh FP', 1.6% listed 'Horizon 2020', and 0.9% simply listed the 'Joint Research Centre'). This could be due to inadequate reporting of funding sources, but it more likely represents a situation where JRC authors are frequent contributors to projects led by other researchers and funded from other sources. The corpus of 768 research items authored by the JRC acknowledged a total of 159 different funding sources, which suggests that only a small minority of Africa-focused research items by the JRC were funded through the FPs. As such, we treated JRC-authored and EU-funded research independently even though there was clear overlap.

Box 1: Document search string for Sixth Framework Programme

FUND-ALL("Sixth Framework Programme ") AND (TITLE-ABS-KEY("Africa" OR "Algeria" OR "Angola" OR "Benin" OR "Botswana" OR "Burkina Faso" OR "Burundi" OR "Cabo Verde" OR "Cameroon" OR "Central African Republic" OR "Chad" OR "Comoros" OR "Côte d'Ivoire" OR "Democratic Republic of the Congo" OR "Djibouti" OR "Egypt" OR "Equatorial Guinea" OR "Eritrea" OR "eSwatini" OR "Ethiopia" OR "Gabon" OR "Gambia" OR "Ghana" OR "Guinea" OR "Guinea-Bissau" OR "Ivory Coast" OR "Kenya" OR "Lesotho" OR "Liberia" OR "Libya" OR "Madagascar" OR "Malawi" OR "Mali" OR "Mauritania" OR "Morocco" OR "Mozambique" OR "Namibia" OR "Niger" OR "Nigeria" OR "Republic of the Congo" OR "Rwanda" OR "São Tomé and Principe" OR "Senegal" OR "Sierra Leone" OR "Somalia" OR "Somaliland" OR "South Africa" OR "South Sudan" OR "Sudan" OR "Swaziland" OR "Togo" OR "Tunisia" OR "Uganda" OR "Tanzania" OR "Western Sahara" OR "Zambia" OR "Zimbabwe")) AND (EXCLUDE (PUBYEAR,2021)) AND (LIMIT-TO (FUND-SPONSOR, “Sixth Framework Programme"))

Box 2: Document search string for Seventh Framework Programme

FUND-ALL("Seventh Framework Programme") AND (TITLE-ABS-KEY("Africa" OR "Algeria" OR "Angola" OR "Benin" OR "Botswana" OR "Burkina Faso" OR "Burundi" OR "Cabo Verde" OR "Cameroon" OR "Central African Republic" OR "Chad" OR "Comoros" OR "Côte d'Ivoire" OR "Democratic Republic of the Congo" OR "Djibouti" OR "Egypt" OR "Equatorial Guinea" OR "Eritrea" OR "eSwatini" OR "Ethiopia" OR "Gabon" OR "Gambia" OR "Ghana" OR "Guinea" OR "Guinea-Bissau" OR "Ivory Coast" OR "Kenya" OR "Lesotho" OR "Liberia" OR "Libya" OR "Madagascar" OR "Malawi" OR "Mali" OR "Mauritania" OR "Morocco" OR "Mozambique" OR "Namibia" OR "Niger" OR "Nigeria" OR "Republic of the Congo" OR "Rwanda" OR "São Tomé and Principe" OR "Senegal" OR "Sierra Leone" OR "Somalia" OR "Somaliland" OR "South Africa" OR "South Sudan" OR "Sudan" OR "Swaziland" OR "Togo" OR "Tunisia" OR "Uganda" OR "Tanzania" OR "Western Sahara" OR "Zambia" OR "Zimbabwe")) AND (EXCLUDE (PUBYEAR,2021)) AND (LIMIT-TO (FUND-SPONSOR, “Seventh Framework Programme")) AND (EXCLUDE (PUBYEAR,2004) OR EXCLUDE (PUBYEAR,2003) OR EXCLUDE (PUBYEAR,2000))

Box 3: Document search string for Horizon2020

FUND-ALL("Horizon 2020") AND (TITLE-ABS-KEY("Africa" OR "Algeria" OR "Angola" OR "Benin" OR "Botswana" OR "Burkina Faso" OR "Burundi" OR "Cabo Verde" OR "Cameroon" OR "Central African Republic" OR "Chad" OR "Comoros" OR "Côte d'Ivoire" OR "Democratic Republic of the Congo" OR "Djibouti" OR "Egypt" OR "Equatorial Guinea" OR "Eritrea" OR "eSwatini" OR "Ethiopia" OR "Gabon" OR "Gambia" OR "Ghana" OR "Guinea" OR "Guinea-Bissau" OR "Ivory Coast" OR "Kenya" OR "Lesotho" OR "Liberia" OR "Libya" OR "Madagascar" OR "Malawi" OR "Mali" OR "Mauritania" OR "Morocco" OR "Mozambique" OR "Namibia" OR "Niger" OR "Nigeria" OR "Republic of the Congo" OR "Rwanda" OR "São Tomé and Principe" OR "Senegal" OR "Sierra Leone" OR "Somalia" OR "Somaliland" OR "South Africa" OR "South Sudan" OR "Sudan" OR "Swaziland" OR "Togo" OR "Tunisia" OR "Uganda" OR "Tanzania" OR "Western Sahara" OR "Zambia" OR "Zimbabwe")) AND (EXCLUDE (PUBYEAR,2021)) AND (LIMIT-TO (FUND-SPONSOR, “Horizon 2020 Framework Programme") OR LIMIT-TO (FUND-SPONSOR, “Horizon 2020") OR LIMIT-TO (FUND-SPONSOR,"H2020 Excellent Science") OR LIMIT-TO (FUND-SPONSOR,"H2020 Marie Skłodowska-Curie Actions") OR LIMIT-TO (FUND-SPONSOR,"H2020 European Research Council")) AND (LIMIT-TO (PUBYEAR,2020) OR LIMIT-TO (PUBYEAR,2019) OR LIMIT-TO (PUBYEAR,2018) OR LIMIT-TO (PUBYEAR,2017) OR LIMIT-TO (PUBYEAR,2016) OR LIMIT-TO (PUBYEAR,2015) OR LIMIT-TO (PUBYEAR,2014))

Box 4: Document search string for research by the Joint Research Centre

(AF-ID ("60103695") OR AFFIL ("European Commission Joint Research Centre" OR "European Commission" OR "Joint Research Centre" OR "Commission of the European Communities" OR "Institute for environment and sustainability" OR "Institute for health and consumer protection" OR "Joint Research Centre of the European Commission" OR "Commission of the European" OR "European commission – Joint Research Centre" OR "EC JRC ISPRA SITE" OR "EC JRC INSTITUTE FOR TRANSURANIUM ELEMENTS ITU " OR "EC JRC INSTITUTE FOR ENERGY TRANSPORT IET" OR "EC JRC INSTITUTE FOR REFERENCE MATERIALS MEASUREMENTS IRMM" OR "EC JRC INSTITUTE FOR PROSPECTIVE TECHNOLOGICAL STUDIES IPTS")) (TITLE-ABS-KEY("Africa" OR "Algeria" OR "Angola" OR "Benin" OR "Botswana" OR "Burkina Faso" OR "Burundi" OR "Cabo Verde" OR "Cameroon" OR "Central African Republic" OR "Chad" OR "Comoros" OR "Côte d'Ivoire" OR "Democratic Republic of the Congo" OR "Djibouti" OR "Egypt" OR "Equatorial Guinea" OR "Eritrea" OR "eSwatini" OR "Ethiopia" OR "Gabon" OR "Gambia" OR "Ghana" OR "Guinea" OR "Guinea-Bissau" OR "Ivory Coast" OR "Kenya" OR "Lesotho" OR "Liberia" OR "Libya" OR "Madagascar" OR "Malawi" OR "Mali" OR "Mauritania" OR "Morocco" OR "Mozambique" OR "Namibia" OR "Niger" OR "Nigeria" OR "Republic of the Congo" OR "Rwanda" OR "São Tomé and Principe" OR "Senegal" OR "Sierra Leone" OR "Somalia" OR "Somaliland" OR "South Africa" OR "South Sudan" OR "Sudan" OR "Swaziland" OR "Togo" OR "Tunisia" OR "Uganda" OR "Tanzania" OR "Western Sahara" OR "Zambia" OR "Zimbabwe")) AND (EXCLUDE (PUBYEAR,2021))

9.2 Quantifying research output over time

For research acknowledging funding from EU FPs, we started by quantifying the total number of items published under each funding programme per year. We then narrowed these totals down to the subset of items with an African focus. Finally, we calculated the percentage of the total papers with an African focus. Because each FP had different starting dates, we also standardised the research output in time as the number of years since the start of each respective FP.

To summarise the output by the JRC, we used a slightly different approach because we presumed that output would be less restricted by the FP funding cycles. First, we quantified the total output of Africa-focused research per year between 1990 and 2020, regardless of the authors. We then quantified the total output by the JRC regardless of the research focus as well as the sub-set of research with an African focus. Finally, we quantified the percentage of all JRC research with an African focus. In all instances, we fitted a sigmoidal curve to each set of data assuming that the total publication output will eventually reach an upper ceiling: $P = \frac{T}{1-e^{-r(y-y_0)}}$ (where P is the number of publications in year y, T is the maximum number of publications per year, r is rate of growth and y_0 is the inflection year where the rate of growth is highest).

We assumed that research funded by the FPs is limited by the availability of funding, so the output would increase as grants become available and then decrease as the funding cycle winds down. By contrast, we assumed that JRC-authored research is limited by staffing, hence fitting saturating curves to reflect how research outputs would eventually plateau as the finite capacity of fixed staff numbers is reached.

For both EU-funded and JRC-authored research we quantified the frequency of research output according to the country and institutional affiliation of authors. We expected that most countries and institutions would only produce few research items, whereas a few countries and institutions would be highly prolific. This pattern is characterised by the Power Law, $C = \alpha P^{-\beta}$ where the number of countries, C, that have produced P research items is based on two constants α and β. The Power Law can be presented as a negative linear relationship in log-space.

9.3 Analysing collaborative networks

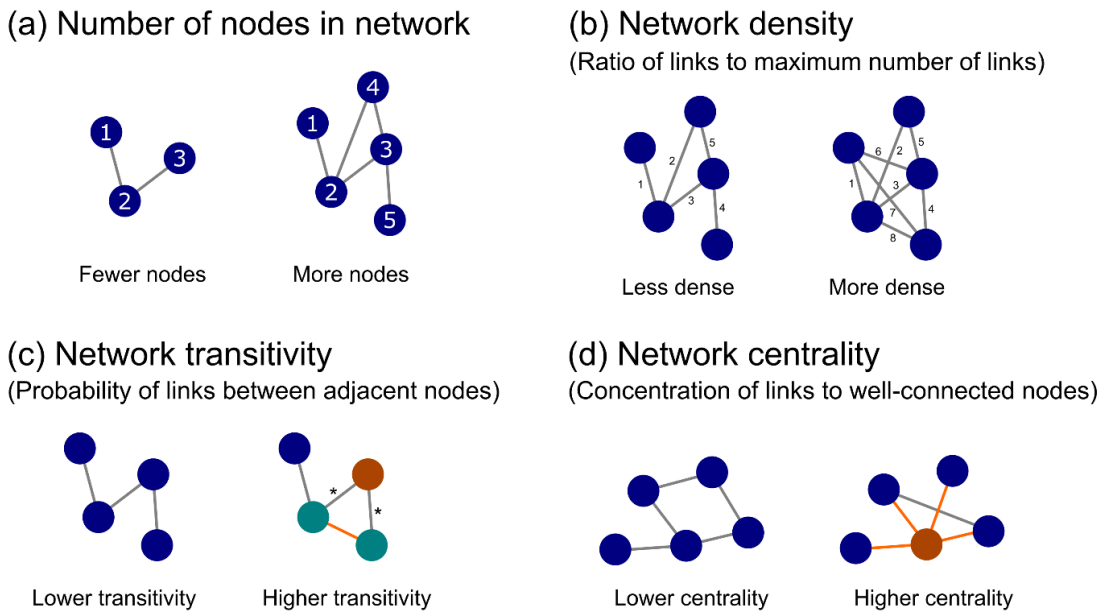
We used network metrics to compare the structure of collaborative networks for research funded by the EC or published by the JRC. To do this, we compiled two separate bipartite networks for (1) countries and (2) research institutions and linked these as nodes in a network if they shared co-authors on individual research items. Countries and institutions were derived from information on author affiliations on published research items. For research funded by the EU, we compiled separate collaborative networks for each of the FPs. For research by the JRC, we compiled separate networks for each year between 1990 and 2020. All analyses were carried out in R version 4.0.4 (R Core Team, 2021).

We calculated four network metrics (Figure 17) using the BIBLIONETWORK function in the BIBLIOMETRIX package (Arai & Cuccurullo, 2017). The first metric was the number of nodes in the network (i.e., count of countries or

institutions in separate analyses), which gave an indication of the size of the collaborative network (Figure 17a). Next, we quantified the network density, which is the number of links between nodes in the network as a proportion of the total possible links for a network of that size (Figure 17b). This indicated how well-connected the collaborative network was, with higher values indicating more dense collaborations and lower values indicating poorly connected collaborations. Third, we quantified network transitivity, which is the average probability that two nodes in a network will be connected given a shared connection to a third node (Figure 17c). Higher transitivity is an indicator of the inclusiveness of collaborations in terms of creating links between research partners (i.e., scientific matchmaking). Lastly, we calculated network centrality, which is the concentration of links to a few well-connected nodes (Figure 17d). High centrality indicates that collaborations are mostly driven by a few influential countries or institutions. We reported the network metrics for research funded by the EC across the three FPs. Annual network metrics for research produced by the JRC were compared by fitting separate regressions, which had the network metrics as a dependent variable and the calendar year as an independent variable.

Figure 17. Graphical representation of network metrics used to quantify collaborative networks.

Four network metrics were quantified: (a) the number of nodes in a network, as an indicator of the size of the collaborative network; (b) network density, as an indicator the connectedness of a collaborative network; (c) network transitivity, as an indicator of collaboration inclusiveness (probability of a link between a pair of nodes, orange line, given mutual association to a common node, denoted by *); and (d) network centrality, an indicator of the dominance of a few nodes in a collaboration network.



We mapped the collaboration networks between countries by geocoding the centroid coordinates of each country (MUTATE_GEOCODE function in the GGMAP package). In these maps, nodes were scaled according to the number of co-authorships and the transparency of links was scaled according to the frequency of collaborations. Sub-networks within a larger global collaboration network were identified using the Louvain method for community detection (Blondel et al., 2008) and were represented geographically using different colours.

9.4 Thematic analysis

To identify temporal trends in the thematic focus of research papers, we used natural language processing (following the same procedure as Hintzen et al., 2019). In a first analysis, we combined all 6,081 research items funded by the 6th, 7th and Horizon 2020 FPs. In a second analysis, we combined 768 research items produced by the JRC. This meant that thematic topics identified during the natural language processing could not necessarily be compared between these two datasets.

The abstracts of all research items were screened and all numeric characters and English 'stop words' (common words used in language without specific contextual meaning) were removed. Remaining words were stemmed to a common root using Porter's Stemming algorithm (screening and stemming were done with the TERMEXTRACTION function in the BIBLIOMETRIX package). The final list of terms was then used to compile a

document-term-matrix, which counted the number of times a term was mentioned in each research item (COCMATRIX function in the BIBLIOMETRIX package). We then removed all rare terms that occurred in fewer than 1% of all documents as well as common terms that occurred in more than 80% of documents, as these terms cannot be used to distinguish clear definable thematic topics (Hintzen et al., 2019).

These cleaned document-term matrices were analysed using Latent Dirichlet Allocation (LDA) models to identify general thematic topics (LDA function in TOPICMODELS package). LDA models are a form of unsupervised classification where research items are allocated to one of *k* thematic topics based on the natural co-occurrence of shared terms in their abstracts. Since we did not know how many thematic topics there were in the document sets, we first explored all values of *k* between 2 and 10 because we viewed this as the upper limit of reasonable qualitative interpretation. We then assessed the appropriateness of each number of topics using topic coherence, where the optimal value of *k* was identified as the LDA model with the highest coherence (using the CALCPROBCOHERENCE function in the TEXTMINER package). This process identified nine thematic topics for the research funded by the EU's FPs (Figure 18) and seven topics for research items produced by the JRC (Figure 19).

The LDA models only cluster research items based on commonly shared terms, but this process does not provide a qualitative description to these clusters. Therefore, we assigned informative descriptors to each cluster of research items funded by the EU (Table 2) and authored by the JRC (Table 3). These descriptors were based on (a) the 15 most common terms in the cluster, and (b) the relative position of research clusters in a two-dimensional research landscape.

We used *t*-distributed stochastic neighbour embedding (*t-SNE*) to present the relationships between topics in a two-dimensional research landscape, where individual research items are presented by points and their proximity in space relates to their thematic similarity (RTSNE function in RTSNE package). For research funded by 6th, 7th and Horizon 2020 FPs, we calculated the frequency of documents on each topic and tested whether these changed across the programmes using a X_2-test. For research produced by the JRC, we modelled the probability of each research topic through time using multinomial regression, where thematic topics were categorical dependent variables and calendar year was the continuous independent variable (MULTINOM function in NNET package).

Figure 18. The topic coherence for the number of themes in Africa-focused research funded by the European Commission's Framework Programmes.

Highest values indicate the LDA models with the highest coherence and suggest the optimal number of distinct research themes, in this case 9 themes.

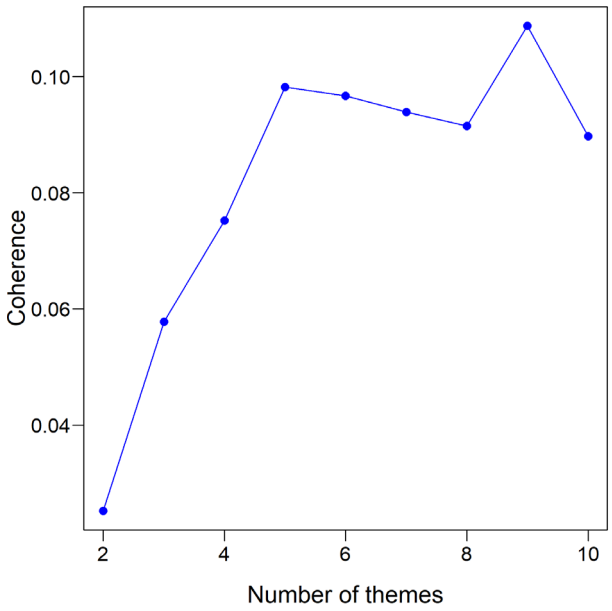


Figure 19. The topic coherence for the number of themes in Africa-focused research carried out by the European Commission's Joint Research Centre.

Highest values indicate the LDA models with the highest coherence and suggest the optimal number of distinct research themes, in this case 7 themes

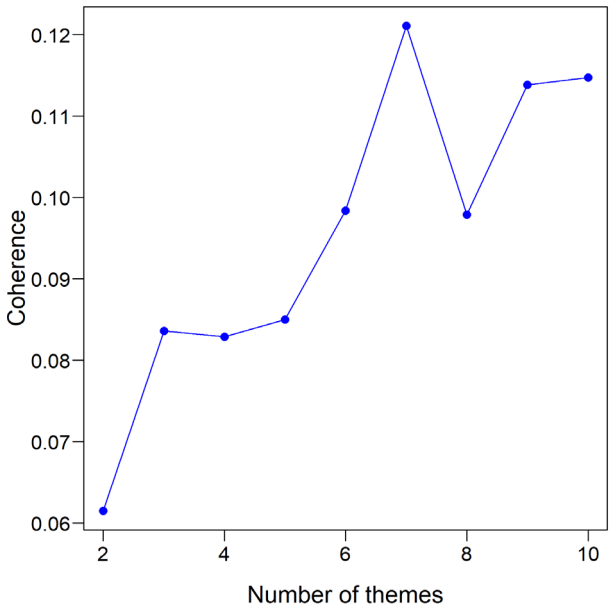


Table 2. The labels for the nine thematic topics identified from Africa-focused research funding by the European Commission's Framework Programmes.

Topic	Label	Top 15 terms[§]
1	Species biology	Species, population, genes, sequence, genetics, studies, isolation, sample, diversity, identification, reveal, type, three, strain, genomics
2	Clinical treatment	Association, risk, age, year, studies, treatment, children, group, patient, rate, women, HIV, Month, mortality, prevalence.
3	Public health	Health, countries, communities, care, studies, service, improvement, support, manage, access, implementation, include, strategic, system, intervention
4	Interdisciplinary (geography)	Africa, South, site, distribution, region, origin, European, evidence, central, remaining, east, earliest, provide, Asia, America
5	Interdisciplinary (policy)	Development, process, system, local, international, role, social, activities, projects, state, energies, technology, work, cultural, economic
6	Infectious diseases	Infectious, virus, disease, malaria, control, human, response, transmission, cell, resistance, detection, active, case, test, vector
7	Modelling (environmental)	Data, model, studies, estimate, baseline, method, comparison, performance, time, approach, prediction, field, combination, analysis, measurement
8	Environmental change	Change, increase, area, product, climate, impact, water, global, forest, land, food, conditions, environment, soil, effect
9	Climate science	Observation, season, region, model, temperature, concentration, surface, variable, dust, simulation, low, emissions, even, rainfall, aerosol

§ *Thematic topics were identified using all available terms, but only the Top 15 ranked terms in each topic are listed here. Rankings are based on the probability that a term was uniquely associated with the topic, so higher ranking terms are more informative indicators of a topic.*

Table 3. The labels for the nine thematic topics identified from Africa-focused research by the European Commission's Joint Research Centre.

Topic	Label	Top 15 terms[§]
1	Biological risks and impacts	Level, impact, species, risk, studies, assessment, population, food test, disease, identification, high, countries, health, case.
2	Atmospheric emissions	Emissions, global, region, surface, year, observation, record, south, average, measure, concentration, high, temperature, Asia, atmosphere
3	Earth observation	Data, map, vegetation, resolution, fires, spatial, Africa, monitor, scale, image, base, satellite, remote, methods, detection.
4	Climate change	Region, climate, Africa, change, model, global, projection, rainfall, precipitation, drought, simulation, increase, analysis, flood, large
5	Development policy	Development, system, countries, policies, European, energy, will, paper, economics, international, approach, agriculture, support, management, Africa
6	Natural resources and Landcover	Area, land, water, forest, cover, change, studies, assessment, potential, soil, global, ecosystem, site, nature, protection
7	Agricultural modelling	Model, product, estimate, time, data, season, performance, indicator, variable, crops, biomass, distribution, difference, yield, set

§ *Thematic topics were identified using all available terms, but only the Top 15 ranked terms in each topic are listed here. Rankings are based on the probability that a term was uniquely associated with the topic, so higher ranking terms are more informative indicators of a topic.*

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