Funding flows for climate change research on Africa: where do they come from and where do they go?

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ABSTRACT
Africa has only contributed a small fraction of global greenhouse gas emissions yet faces disproportionate risks from climate change. This imbalance is one of many inequities associated with climate change and raises questions concerning the origin, distribution and thematic prioritization of funding for climate-change research on Africa. This article analyses a database comprising USD 1.51 trillion of research grants from 521 organizations around the world and covering all fields of research from 1990 to 2020. At most 3.8% of global funding for climate-change research is spent on African topics – a figure incommensurate with Africa’s share of the world population and vulnerability to climate change. Moreover, institutions based in Europe and North America received 78% of funding for climate research on Africa, while African institutions received only 14.5%. Research on climate mitigation received only 17% of the funding while climate impacts and adaptation each received around 40%. Except for Egypt and Nigeria, funding supported research on former British colonies more than other African countries. The findings highlight the need to prioritise research on a broader set of climate-change issues in Africa and to increase funding for Africa-based researchers in order to strengthen African ownership of research informing African responses to climate change.

1. Introduction

Africa comprises over a fourth of the world’s countries, almost a fifth of its population and is host to some of its most biodiverse ecosystems. African countries have contributed among the least to the causes of climate change yet Africa is warming faster than the global average and has many populations highly vulnerable to climate change impacts (Bond, 2019; Busby et al., 2014; IPCC, 2020). For example, total agricultural productivity growth in Africa has been reduced by 34% since 1961 due to climate change, more than any other world region (Ault et al., 2021). Between 2000–2019, floods and droughts affected 337 million people across the continent (CRED, 2019). Thus, in terms of scale and severity of observed climate change impacts and future climate risk, the continent merits a central place in global climate research.

Funding plays a key role in directing research priorities and thereby informing our responses to climate change. However, funding has often been overlooked by scholarship on climate change research (Overland & Sovacool, 2020). We know of no analysis published on the allocations of climate change research funding, its distribution across different themes or its relevance for climate policy pertaining to Africa.

This blind spot is mirrored in climate policy negotiations. For instance, the UNFCCC (2016) roadmap to transforming financial flows makes no mention of funding for climate change research. This contrasts with the more extensive scholarship on allocation of funding for direct adaptation and mitigation projects (Afful-Koomson, 2015; Boodoo et al., 2018; Kasdan et al., 2020). Discussions of climate finance disbursements concentrate on ‘support for climate action’ and the ratio of adaptation to mitigation funds, but do not explicitly cover climate change research funding (Fridahl & Linnér, 2016).

Under the Copenhagen Accord of the United Nations Framework Convention on Climate Change (UNFCCC), developed countries committed to allocating financial resources to support the climate change mitigation and adaptation efforts of developing countries (Boucher et al., 2016; Khan et al., 2019; Klöck et al., 2018). Developed countries were to take immediate action and mobilize USD 100 billion of ‘new and additional’ funding per year by 2020. Africa, least developed countries and small island developing states were to be prioritized (Fonta et al., 2018). Target 4 under Sustainable Development Goal (SDG) 13, ‘Climate Action’, reaffirms the financial commitment under the Copenhagen Accord (UN, 2017). As the deadline for this funding target passed in 2020 and given its implications for Africa’s response to climate change and the realization of SDG 13 in particular, it is timely to update...
our knowledge about actual climate financing flows (Mitchell et al., 2021), including for climate research.

Here, we seek to fill this gap by analysing financing for Africa-related climate research between 1990 and 2020. We use the Dimensions database, which provides access to data that are unprecedented in their scale and richness. This makes it possible to take research to an empirical level that has previously been unattainable. We identify which countries and organizations are funding Africa-related climate-change research, where the research is being carried out, and what topics and fields of research are prioritized.

The article is divided into five sections. In the next section we briefly review the relevant literature. In the third section we present our methodology for scraping data from the Dimensions database and analysing them. In the fourth section we present the results and discuss them, and in the final section we conclude and suggest some avenues for further research.

2. Background

The scientific literature on climate change has increased near-exponentially and even sub-categories such as climate change adaptation have become too large to assess manually (Sietsma et al., 2021). Callaghan et al. (2020) find that nearly 50,000 research papers on climate change were published in 2018 alone. Nevertheless, large knowledge gaps exist in research for many of the most vulnerable African countries and sectors at risk from climate change (Sietsma et al., 2021). These knowledge gaps are particularly large because Africa is such a large continent with such diverse climate and ecosystems, and, consequently, agricultural systems. Differentiated research is therefore needed to properly understand the variegated impacts of climate change across the continent.

Previous work by Niang et al. (2014) and Hendrix (2017) has focused on research publications rather than funding for research (that is, on summarizing research output rather than input). Looking at actual research funding enables us to say something about the priorities, intentions and resources available for different topics and, as we show, taking a funding perspective is especially relevant from a climate justice and development perspective. In addition, the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) will be published in 2022, and our empirical data and analysis can help set the stage for assessment of climate research funding in AR6 and beyond. To the extent that the existing research does touch on funding, there is a consensus that almost all funding for climate research on Africa originates outside the continent and flows to institutions based in Europe and the United States (Bakare et al., 2014; Bendana, 2019; Bliocharska et al., 2017; Siders, 2019).

This article is also relevant for several other branches of literature: on climate change as both a product and form of colonialism (Abimbola et al., 2021; Gram-Hanssen et al., 2021); on the role of developing country researchers in joint research, the power to set research agendas and the decolonization of science (Schipper et al., 2021; Trisos et al., 2021); on the importance of colonial legacies such as languages for current funding flows; on the allocations of climate change research funding on grounds of vulnerability, exposure or risk (Chen et al., 2015; Chen et al., 2018; Kling et al., 2021; Sarkodie & Strezov, 2018); and on biases such as the ‘streetlight effect’ in climate research involving developing countries (Hendrix, 2017). In the course of the article, we relate our analysis and findings to all these issue areas.

3. Methodology

This study uses data extracted from the world’s largest research-funding database, Dimensions (2020a). For the period 1990–2020, the database comprises 4.5 million research grants with a total value of USD 1.51 trillion granted by 521 funding organizations from 39 countries. Based on these data we have sought to identify which grants were provided for climate research and which of those focused on Africa. For the purpose of this article, we define ‘climate research’ to include research projects in the natural sciences, technical sciences, social sciences or humanities that state that they deal with climate change. To ensure transparency, we have posted the full dataset for this article online (Dimensions, 2020b).

The data were analysed on two levels. First, funding amounts for research on Africa and the rest of the world were estimated by carrying out keyword searches. For this purpose, a modified version of a Boolean search string developed by Overland and Sovacool (2020) was used in combination with a search string representing all African countries and major ecoregions. The resulting aggregate search string used for this article was as follows:

(“climate change” OR “climate crisis” OR “climate policy” OR “CO2 emissions” OR “Kyoto Protocol” OR “global warming” OR “GHG” OR “greenhouse effect” OR “greenhouse gas” OR “Paris Agreement”)

AND

(“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 “Congo” OR “Côte d’Ivoire” OR “Côte d’Ivoire” OR “Democratic Republic of the Congo” OR “Djibouti” OR “DRC” OR “Egypt” OR “Equatorial Guinea” OR “Eritrea” OR “Eswatini” OR “Swaziland” OR “Ethiopia” OR “Gabon” OR “Gambia” OR “Ghana” OR “Guinea” OR “Guinea-Bissau” OR “Kalahari” OR “Kenya” OR “Kilimanjaro” OR “Lesotho” OR “Liberia” OR “Libya” OR “Madagascar” OR “Maghreb” OR “Malawi” OR “Mali” OR “Mauritania” OR “Mauritius” OR “Morocco” OR “Mozambique” OR “Namibia” OR “Niger” OR “Nigeria” OR “Nile” OR “Okavango” OR “Rwanda” OR “Sahara” OR “Sahel” OR “Sahrawi” OR “São Tome and Príncipe” OR “São Tomé and Príncipe” OR “Senegal” OR “Seychelles” OR “Sierra Leone” OR “Somalia” OR “Somaliland” OR “South Africa” OR “South Sudan” OR “Sudan” OR “Tanzania” OR “Togo” OR “Tunisia” OR “Uganda” OR “Western Sahara” OR “Zambia” OR “Zimbabwe”)

By applying our search string to the titles and abstracts of research grants, we were able to generate quantitative estimates of the size of funding for climate research on Africa relative to climate research on the rest of the world. Although the Dimensions database includes data from 521 funding agencies from around the world, all titles and abstracts are in English, making
it possible to use only English keywords without biasing the results.

Using the search string, we identified a tentative 2,319 climate-change research projects on African topics, representing a total of USD 1.23 billion of funding. However, recognizing the risk of false hits, we also carried out a second, more in-depth qualitative level of analysis of research projects on climate change in Africa. This analysis was carried out by a team of five people over a period of three weeks, with twice-weekly plenary meetings to discuss ambivalent cases and to agree on common guidelines. The guidelines are included in the appendices at the end of the article and summarized here. We read the titles and abstracts of all identified projects in detail, reclassified projects where the Boolean keywords occurred accidentally and categorized projects according to the following criteria: source of funding; countries in which the research was carried out; African countries covered by the research; and whether the research was about climate change impacts, mitigation of greenhouse gases or adaptation to climate change. We also identified which climate-risk categories each project targeted, using seven categories from IPCC work on Africa: ecosystems, food systems, freshwater resources, urban areas, security and conflict, poverty and livelihoods and health (Niang et al., 2014, p. 1237).

There are several ways of categorizing climate-related activities. We chose the tripartite system of impacts, mitigation and adaptation drawing on the work of the IPCC, the International Institute for Applied Systems Analysis (IIASA), the World Conservation Monitoring Centre of the UN Environmental Programme and a considerable body of research (Caldeira et al., 2003; Nakicenovic et al., 1994; Overland & Sovacool, 2020; Parry, 2009; Richels et al., 2004; Rojas-Dowing et al., 2017; Wreford et al., 2010; Yohe et al., 2004; Zegeye, 2018). In the context of this article, the most important aspect of the typology is the distinction between adaptation and mitigation, as it connects with the concept of climate justice (Robinson and Shine, 2018). A disproportionate share of greenhouse gas emissions have been caused by wealthier, industrialized countries outside Africa (Ritchie, 2019). Also Africa contributes some emissions, mainly due to agricultural expansion and intensification through tropical deforestation and methane emissions from livestock cultivation (Foley et al., 2011; Tilman et al., 2011). Africa’s major oil and gas producers also have substantial emissions. However, whereas the world’s developed countries had emissions of 13.86 metric tons of CO equivalents (tCO2e) on average between 1990 and 2018, those of the African countries were less than a third of that, at 4.05 tCO2e (Climate Watch, 2021; World Bank, 2020).

However, the challenge of adapting to climate change falls most heavily on developing countries, including those in Africa, where there is also the need to lift people out of poverty and achieve development goals, without burning fossil fuels (Kartha & Baer, 2015). There is also much climate research that is neither about mitigation nor directly about adaptation, but simply about the impact on the natural world or human societies. In a climate justice perspective, it makes sense to make this a category that is distinct from actual adaptation, which is concerned with how societies and ecosystems adapt to those impacts.

When a research project covered multiple countries, we divided the funding for the project evenly between those countries. In defining regions of Africa, we first took into account the UN definition of Africa. This includes the Arabic-speaking countries of North Africa, which in some other contexts are defined as part of the Middle East and North Africa (MENA). Second, we used the African Union (AU) definition of five African regions (see Figure 1). In cases where a project stated that it was about a particular region, we split the funding evenly between the countries in that region. This means that the division of regional funding flows between countries within a region is an approximation, and this is a limitation of the analysis. Further detailed definitions of regions, ecoregions and other geographical names is provided in the appendices.

Drawing on Overland and Sovacool (2020), we took the 22 main fields of research and 155 sub-fields recognized by the Dimensions database and distinguished between natural and technical sciences on the one hand and social sciences and humanities on the other. Much climate research is inherently interdisciplinary or multidisciplinary, and we classified such projects as both natural and social sciences and counted them once for each category. The full list of main and subsidiary fields and our classification of them into natural and social sciences is presented in the appendices.

To assess whether research funding flows for research on a given country correlated with country-level expected vulnerability to climate change we used the ND-GAIN (2017) index. A broad range of indicators of climate change vulnerability are available (Muccione et al. 2017). We selected the ND-GAIN Country Index because it is best suited for our purposes. It measures a country’s exposure, sensitivity and capacity to adapt to the effects of climate change and is calibrated towards the potential impacts of climate change on key sectors of food, water, health, ecosystem service, human habitat, and infrastructure. It summarizes a country’s vulnerability to climate change and other global challenges (we do not include the ND-GAIN ‘readiness’ dimension, as it is less relevant for our research) (e.g. Chen et al., 2015). ND-GAIN has been applied widely in climate research on Africa (Chen et al., 2015; Chen et al., 2018; Kling et al., 2021; Sarkodie & Strezov, 2018).

The Dimensions database is the world’s largest with regard to research funding, and seeks to be as comprehensive as possible, incorporating all available data from research-funding organizations, private or public. However, it still has limitations. As no research funding organization is obliged to supply data to Dimensions, its coverage cannot be complete. A more specific weakness is that Dimensions does not distinguish between research funding from Belgian national sources and the European Union (EU) institutions based in Belgium. We got around this problem by manually checking each project that Dimensions categorized as Belgian-funded and determining whether the funding organization was indeed Belgian or in fact a body of the European Union based in Brussels.

Another limitation is that some research in and on Africa may be financed directly by aid agencies, non-governmental
organisations or religious organisations. The Dimensions database only includes data from the world’s 521 major research-funding organisations and thus does not cover such other organisations and any research they might fund directly. However, many of the 521 research funding organisations listed in Dimensions (e.g. UK Research and Innovation) obtain significant financial resources from their government aid and development agencies, so some development aid funding for research is included in our data. Given these significant limitations and strengths of the Dimensions database, our findings provide the best estimate of funding patterns for Africa-related climate-change research that is possible to put together with current data availability.

4. Results and discussion

4.1. Proportion of research funding spent on climate change

Based on the analysis using the Boolean search string, we estimate changes in funding flows for Africa-related climate research and relate these to global research funding trends. Figure 2 panel A shows that funding for climate-related research on Africa has always been small – between USD 31000 and USD 97.83 million per year – compared to global climate research funding. The total amount spent on Africa-related climate research from 1990 to 2020 was (USD 1.262 billion). Panel B shows that the share of global funding for climate-change research that focused on Africa-related topics fluctuated upwards from around 0–5% between 1990 and 2020 with high variation year on year. Although this means that Africa has been receiving an increasing share of global climate research funding, the global funding for climate research has been on a decreasing trend since 2010 and the share for Africa is still very small and remains incommensurate with Africa’s share of the world population and vulnerability to climate change. This is problematic in a climate justice perspective, because – with the partial exception of South Africa, the emissions from the African agricultural sector and the African petroleum producing countries Algeria, Angola, Egypt, Libya and Nigeria (Anuga et al., 2020; Tongwane et al., 2016; Valentini et al., 2014) – climate change has been largely caused by the activities of non-African, industrialized countries.

In Panel C of Figure 2, we shift to a different perspective and compare the proportion of funding for research on Africa spent on climate-related topics to the share of global research funding that was spent on climate-related topics. This gives an indication of the prioritization of climate change within
research on Africa compared to the prioritization of climate change within research globally. From 1990 to 2010, there was negligible difference between African and global trends. However, from 2010 onwards, while funding allocated for climate research globally has never exceeded 4% of global research funding, the percentage of funding allocated to climate-related research on Africa has typically exceeded 4% of Africa-related research funding with up to 10% of funding allocated to climate-related topics in a given year. This could be interpreted as a response to the identified severity of climate change risks and impacts on the African continent from the 4th IPCC assessment report (2007) onwards (Fields, 2005; Masson-Delmotte et al., 2018), and the high variability potentially explained by irregular funding disbursement windows.

All numbers in this section are based on analysis using the Boolean search string, as this is best suited for large-scale
This unequal distribution of funding raises questions of unequal power dynamics in how climate change research agendas on Africa are shaped by research institutions in Europe and the USA. Controlling research funding is a key component of setting the research agenda (Vincent et al., 2020) and how funding is allocated within research collaborations can profoundly affect power relationships. Those empowered to shape research agendas can shape research answers, but this power dynamic is too rarely considered in climate change research. For example, faculty committees at lead institutions often value lead author or corresponding author positions more highly which drives Northern research partners to seek prominent authorship positions and leadership roles on collaborations rather than more readily make these positions available to developing country researchers (Hedt-Gauthier et al., 2018). Researchers at Northern institutions may also select research questions and shape outputs for a Northern
audience rather than providing actionable insights on climate change issues of concern to local partners (Nago & Krott, 2020), particularly if those local partners and institutions – unlike Northern institutions – are unable to commission subsequent research. Positioning African institutions as secondary to their Northern counterparts thus reinforces unequal relationships and obstructs co-production of the knowledge needed to address climate and environmental risks (Trisos et al., 2021; Vincent et al., 2020). In contrast, providing direct control of resources to all project partners confers a sense of equality that can better set the stage for an equitable research partnership (ESPA Directorate, 2018).

The six African countries with institutions that received the most funding for Africa-related climate-change research over the period 1990–2020 were Kenya (2.3% – USD 14.2 mill.), South Africa (2.2% – USD 13.7 mill.), Tanzania (0.92% – USD 5.68 mill.), Ghana (0.86% – USD 5.3 mill.), Ethiopia (0.86% – USD 5.26 mill.) and Zambia (0.88% – USD 5.2 mill.). Although these amounts are a small fraction of those received by institutions outside Africa, this pattern of funding within Africa conforms to the findings of Hendrix (2017) that British colonial heritage might be important in explaining the geographic distribution of research. The notable exception is Ethiopia, which was never colonized. As the continent’s second-most-populous state and host to the African Union headquarters as well as to large UN offices, Ethiopia’s prominence is not surprising and constitutes an exception. A less significant exception is Tanzania, which was a German colony for around 35 years before becoming a British colony. These findings suggest that funding gravitates towards African countries with a British colonial legacy; however, the causal mechanism is not clear. It could be the fact that these countries are Anglophone (as a consequence of colonial histories) and therefore more accessible to the many researchers around the world who use English as their professional language; it could also be due to other aspects of colonial legacies or some other unknown factors.

4.4. The geography of Africa-related climate research

In the preceding paragraphs and Figure 3B, we examined the locations of the institutions that received most funding for climate research on Africa. We now assess the prioritization of different African countries as the objects of funded research and compare this with their vulnerability to climate change (see Figure 4).

The five African countries on which the most climate-research funding was spent between 1990 and 2020 were South Africa, Kenya, Tanzania, Ethiopia and Ghana (see Figure 4; see Appendix E for funding amounts for each country). The uneven allocation of funding for climate research highlights how more equitable distribution of research funding is not just a question of relations between developing and developed countries but also allocation among developing countries themselves. This finding confirms the argument of Hendrix (2017, p. 137), according to whom there is a ‘streetlight effect’ in climate research on Africa: a ‘tendency for researchers to focus on particular questions, cases and variables for reasons of convenience or data availability rather than broader relevance, policy impact, or construct validity’.

It is notable that comparatively little funding was spent on the study of Nigeria, despite its being the continent’s most populous state and English being its official language. This contrasts with the findings of Hendrix (2017), wherein Nigeria and other former British colonies are the most-favoured countries for Africa-related climate research. In another contrast to Hendrix (2017), Egypt, the most populous country in North Africa as well as being historically linked to the British Empire, has received limited attention despite its dependence on the Nile and its consequent vulnerability to climate change.

The difference between our findings and those of Hendrix (2017) may be due to the fact that his analysis is based on bibliometric data – mainly Google Scholar searchers and selected journals – while ours is based on research funding data. Both are useful. Bibliometric analysis says more about research
output, while research funding analysis is particularly relevant for questions of intended prioritization and distribution of research opportunities.

Funding has also been allocated for research on some countries with arid and semi-arid territories that have seen successive droughts and high climatic variability such as Mali (2.44% – USD 14.5 mill), Namibia (2.96% – USD 17.6 mill.), Niger (2.21% – USD 13.15 mill.), and Senegal (2.08% – USD 12.4 mill). Yet other countries with similar challenges, like Algeria (0.82% – USD 4.8 mill), have received less attention and research on North African countries is generally most underfunded compared to the climate vulnerability of those countries. The lack of funding for research on North African countries is reflected in a dearth of climate knowledge for the region (Niang et al., 2014; Vincent & Cundill, 2021). Among the North African countries, the largest amount of research funding has been focused on Tunisia (1.76% – USD 10.5 mill) despite it being the smallest of these states both in terms of population and surface area.

Also underrepresented are the Central African states, including the Democratic Republic of the Congo (1.19% – USD 7 mill) with its large rainforest and peatland carbon sinks (Dargie et al., 2017). This is of note considering the limited capacity of stakeholders in the region to track rapidly evolving discourses on reduced emissions from avoided deforestation (Tiani et al., 2015).

One factor that may partly explain the uneven allocation of funding for research on African countries is the influence of development aid agendas in shaping the priorities of aid-donor

Figure 4. Climate-research funding and climate risk according to ND-GAIN by African country, 1990–2020. (For distribution of funding among institutions in all African countries, see the complete table in the appendices).

Figure 5. Comparison of climate change research funding on African countries before and after (UNFCCC) Copenhagen Accord (1 Jan. 2010), logarithmic scale, r=0.62. A smaller relative share of funding was spent studying countries below the red dotted line between 2010–2020, while those above the line received a greater relative share.
countries. Billions of dollars of development aid target Africa annually (Betzold & Weiler, 2017; Betzold & Weiler, 2018), and a small portion of this funding is spent on climate change research. It is therefore possible that development-aid priorities make it easier to obtain funding to study some African topics and countries more than others (Dieleman et al., 2016; Mason-D’Croz et al., 2019). Aid priorities may in turn change due to events such as natural disasters, armed conflicts and refugee crises. For example, disaster and development-related topics dominate adaptation research in many African countries (Sietsma et al., 2021). Other development aid priorities can include the strategic and business interests of donor countries, the status of aid-target countries as least-developed countries and, again, past colonial ties. Further research is needed to fully understand the relationship between development-aid policies and priorities in funding climate-change research on Africa.

Although Betzold and Weiler (2017) found countries that were assessed to be more exposed to climate change risks received more climate-related development finance for adaptation, other studies indicate climate change vulnerability is not a strong factor influencing the allocation of finance for climate change adaptation projects in developing countries (Donner et al., 2016; Doshi & Garshagen, 2020). Our analysis extends these results to research funding, finding no correlation between the ND-GAIN index of climate change vulnerability and climate change research funding (r=0.09). This lack of a relationship in funding of research on countries estimated to be more vulnerable to climate change is concerning although we also note that the national-level vulnerability index we used may mask substantial differences in vulnerability within countries, many of which are large and varied.

Figure 5 compares the research funding spent on studying African countries in the decade from 2010 to 2020 and the preceding 20 years (1990–2009). In absolute terms, more funding was spent between 2010 and 2020 than in the preceding two decades. Among the countries that saw the greatest increases for 2010–2020 compared to 1990–2009 were South Africa, Tanzania, Ethiopia, Malawi, Zambia and Ghana. Some of the countries with the largest declines were Botswana, Egypt, Morocco and Mauritius. At the regional level, North Africa saw the greatest decline whereas Southern Africa and the East African cluster of Kenya, Tanzania and Ethiopia experienced the greatest gains.

4.5. Funding allocated for research on climate mitigation versus impacts and adaptation

Climate-change-impact studies and adaptation studies each received almost 40% (USD 240 million) of the funding for research on climate-related issues in Africa while mitigation research received substantially less, at 17% (USD 105 million) (Figure 6). Although recent research points to important knowledge gaps on adaptation in specific sectors in Africa, such as cities (Vincent & Cundill, 2021), our results indicate that a high portion of research funds do go towards adaptation-focused research projects. One possible explanation for this pattern of greater funding for adaptation-related research in Africa is that many least developed countries express stronger demand for finance supporting adaptation rather than mitigation (Zhang & Pan, 2016). Research led by institutions based outside Africa may also lean towards impacts that can be investigated remotely, for example using climate models, rather than engaging in longer processes of co-production of research with local stakeholders (Tiani et al., 2015). This fits with previous work which found that the geographical distribution of author affiliations of climate change publications (in >15,000 articles) is skewed towards wealthy and institutionally well-developed countries (Pasgaard et al., 2015). Another explanation is that Africa has so far contributed less to greenhouse gas emissions compared to many other regions and thus has less of a mitigation responsibility in historical terms. However, there are some important exceptions. South Africa is a major coal producer and consumer; hence, it also requires a robust mitigation strategy (Chevallier, 2011; Favretto et al., 2018). Similarly, Algeria, Angola, Egypt, Libya and Nigeria have all produced significant amounts of oil and/or gas, and African countries face the challenge of ensuring access to energy for all (Sustainable Development Goal 7), lifting people out of poverty and achieving other development goals, without burning fossil fuels (Robinson and Shine, 2018). There is therefore a need for substantial increases in funding for mitigation research to accelerate African countries’ transition to renewable energy in order to prevent them from becoming major greenhouse gas polluters of the future (Asongu & Odhiambo, 2018; Vorster et al., 2011; Winkler & Marquand, 2009). There has also been limited research on co-benefits or trade-offs between adaptation and mitigation solutions in Africa (Héloïse & Cherubini, 2020; UNEP, 2021) a priority area for increased funding given the importance of food, energy, water and biodiversity sectors for both adaptation and mitigation, as well as the interlinkages among the Sustainable Development Goals across these sectors (Liu et al., 2018).

Since at least 2005, funding for climate change impact, adaptation and mitigation studies have been highly variable on an annual basis (Figure 6). This suggests an inconsistency in flows of climate change research funding on Africa which would likely affect research planning and outcomes. Figure 6 also indicates that funding for impact and adaptation research and funding for adaptation and mitigation research appear to move together, while funding for impact and mitigation research are less connected with each other over time. One explanation for this might be that understanding how to adapt to climate change depends on having knowledge about its observed and projected impacts (UNEP, 2021).

Figure 7 shows how funding for research on climate impacts, adaptation and mitigation has been distributed to research projects focused on different African regions, as well as particular ecoregions. More funding supported research on climate impacts and adaptation than on mitigation for all regions of Africa, as well as for research focussed on every individual country. Of the ecoregions we assessed, more funding was focussed on the Sahel than on any other ecoregion. As defined in the appendices, the Sahel includes Burkina Faso, Chad, Mali, Mauritania, Niger, Senegal and Sudan.
4.6. Alignment of research funding with sectoral climate risks

Out of seven climate-risk areas for Africa identified in the IPCC’s Fifth Assessment Report (AR5) (Niang et al., 2014), food systems is the most highly prioritised topic in funding for Africa-related climate research (Figure 8). Agriculture has always been a vital economic sector and source of employment across Africa (Webersik & Wilson, 2009), with food security remaining a concern in much of the continent and 57% of the population of Africa still living in rural areas (UNDESA, 2019). Yet over 90% of African food production is rainfed, rendering many regions and livelihoods vulnerable to food insecurity due to climate change (Bang et al., 2019; Evariste et al., 2018; Fuller et al., 2018). The agricultural sector has contributed the largest economic losses from climate change in Africa (Acevedo et al., 2017), with climate variables such as extreme heat negatively affecting outdoor labour productivity and agricultural supply chains (Fanzo et al., 2018; Graff Zivin & Neidell, 2014). Hence the emphasis on food systems is unsurprising and has been noted in Vincent and Cundill (2021). Within adaptation research specifically, there is a tendency for studies focused on Sub-Saharan Africa to concentrate on small-holder farmers (Abegunde et al., 2019; Shackleton et al., 2015), but there has also been some broader focus on crop yields (Muchuru & Nhamo, 2019). Similarly, freshwater systems have also been prioritised by funding and are intricately tied to food systems (Ogutu-Ohwayo & Balirwa, 2006).

Research on ecosystems received the second-highest funding amount. This emphasis reflects the richness of Africa’s biodiversity and ecosystem services and their recognition as strategic assets for sustainable development, including ecosystem-based adaptations to climate change such as forest management (Ofoegbu et al., 2017). Central African forests make up some of the largest natural carbon sinks on the planet with an average concentration of 425 Mg/h in their soil (Abernethy et al., 2016; Palm et al., 2004). Yet until recently, relatively little was known about the carbon storage services of these ecosystems such as the Congolese peatland carbon sink holding nearly 30 billion tonnes of carbon (Dargie et al., 2017; Lewis et al., 2009; Lewis et al., 2018). The significance of these ecosystems extends beyond their role as carbon sinks, as many people’s livelihoods also depend on the biodiversity they support.

We find that climate-related research on health, cities and urban areas, poverty and livelihoods, and security and conflict (including human migration, in accordance with IPCC AR5 risk classification) has received substantially less funding than food, ecosystems and freshwater (Figure 8). The higher allocations to research on food systems as compared to cities/urban areas matches observations of trends in academic
publications on climate-related risks which point to an emphasis on rural over urban issues, at least for security and conflict (Plä- nitz, 2019). However, Africa is the most rapidly urbanizing continent with a population expected to be more than 60% urban by 2050 (UN-Habitat, 2016). Understanding the direct and indirect relationship between urbanization, climate change risks and both adaptation and mitigation responses is an urgent priority with recent studies pointing to potential climate-change-mitigation and conservation co-benefits of well-planned urban areas (Colenbrander et al., 2018; Güneralp et al., 2017). There is also increasing recognition of the role of migration, including rural to urban migration, in adaptation (Wiederkehr et al., 2018), and of climate change as a risk factor for armed conflict (Busby et al., 2014; Mach et al., 2019). Growing evidence indicates that climate variability and change have already negatively impacted health, education attainment and economic growth across Africa and that future climate change poses severe risks to health, livelihoods, and poverty reduction efforts on the continent (Costello et al., 2009; Diffenbaugh & Burke, 2019; Hall- gatte & Rozenberg, 2017; Hyunen et al., 2013; Randell & Gray, 2019; Tibesigwa et al., 2017; Tosam & Mbih, 2015). Research financing has not kept pace with these emerging concerns nor considered other emerging themes such as projected risk from climate change to African heritage (Brooks et al., 2020); a broadening of research-funding priorities is needed to match projected future climate-related risks for Africa.

With a share of 28%, the social sciences and humanities play a greater role in Africa-related climate research than in global climate research, where these disciplines have a share of only 12% – according to our level 1 analysis using the Boolean search string (cf. Overland & Sovacool, 2020). In this regard, climate-change research on Africa has a strength over comparable research on other parts of the world in that it does not downplay the importance of the social and broader developmental aspects of climate change. For the detailed definition of what was counted as social sciences and humanities, see the appendices.

5. Conclusions

Funding for research on climate change in Africa between 1990 and 2020, seen through the lens of the Dimensions database, exhibits notable trends. Among these trends are the increase in the percentage of Africa-related research funding that is allocated to climate research, and a stronger social sciences element in Africa-related climate research than in climate research on the world as a whole. Climate-change impacts and adaptation have been the major foci of funding for research on Africa to date. This makes sense in terms of past emissions, but increased mitigation research is critical to a low-carbon and climate resilient future for Africa as populations, economies and energy consumption grow. There has also been little funding for research on major states like Egypt and Nigeria relative to their large population sizes. Overall, relatively little funding targets North and Central Africa compared to Southern and East Africa and most former British colonies and Anglophone countries. After 2015, despite pledges of support for increased funding (such as the Accra Consensus on agricultural research) there was no substantial increase in funding for climate-related research in Africa from developed countries.

Our study also highlights important issues of justice and equity in funding for climate research. Most funding for climate-change research on Africa goes to researchers based outside the continent. Africans have contributed among the least to causing climate change yet face some of its most severe impacts. The industrialized countries that carry most of the responsibility for greenhouse gas emissions thus have a responsibility not only to share climate-change research conducted at institutions in developed countries but also to substantially increase funding for research on climate change in Africa by researchers based at African institutions.

Climate change is increasingly framed as both a form and a product of colonization. Schipper et al. (2021) have noted the persistence of inequitable partnerships and colonial models of scientific practice, where researchers from the Global North often claim senior authorship rights, and researchers from the Global South are relegated to the status of local research assistants and data collectors. Our findings extend this notion to climate change research funding in Africa which also follows geographies of colonial legacy and locates power unequally, privileging researchers at institutions in Europe and the USA.
Recognizing Euro-American centrality and ongoing power imbalances both in causing climate change, and in how climate research is produced and used is an important first step. The next step is committing to decoloniality, meaning actively undoing those systems and ways of thinking – as opposed to post-coloniality, which is our historical reality and does not require taking responsibility for ongoing inequitable systems. Our analysis highlights that this work must include the transformation of allocations of climate change research funding. Without a more equitable allocation of climate change research funding to institutions based in Africa, the ability of African researchers to set research agendas will remain diminished. We propose an approach where for every dollar spent on Africa-related climate change research at institutions based in wealthy nations, an equal amount is spent on research at institutions in an African country.

In addition, the direct beneficiaries of climate change research funding (mainly non-African research institutions) can commit to opening up their power to others by practicing climate change research in inclusive teams. A major step in this direction is enabling marginalized groups to lead and set research agendas, as well as faculty committees at Northern universities valuing highly articles where a Northern-based researcher is not a lead or corresponding author but has made a substantial contribution, enabling those in privileged research institutions to more readily give up prominent authorship positions.

It also makes sense for African countries to invest their own resources towards understanding and responding to climate-change risks. Increased funding for climate research in Africa by Africans will be of limited value if African research institutions do not have the capacity to turn funding into good research. This is to some extent a chicken-and-egg problem: without sufficient funding it is difficult for research institutions to develop; with lack of development it is difficult to know where to channel the funding. One approach that could be particularly effective is for African governments to include climate-research funding in their Nationally Determined Contributions (NDCs) under the Paris Agreement.

As the Dimensions database does not have perfect global coverage, our findings should not be interpreted as final conclusions but as a starting point for further investigation. This could, for example, be done through acquisition and in-depth analysis of research-funding data from individual African countries to correct for any gaps and biases in the Dimensions database. There are also specific topics that would benefit from further research, such as the climate-justice aspect of the research-funding patterns we have identified as well as the influence of development aid flows and priorities on the availability of funding for climate change research on specific African and other developing countries. Another avenue for further research could be to look more closely at how changing development aid priorities affect what Africa-related research on climate change is carried out. Yet another promising avenue for future research would be to compare funding for climate change research on different continents in order to get a more complete picture of inequalities in research funding globally. This would require developing search strings similar to the one we developed for Africa and applying them to the Dimensions database. The development of such search strings is not straightforward, but should be easier for other continents since we have already worked out an approach to Africa. Finally, as the Dimensions database is expanded and improved on a monthly basis, simply repeating our analysis in a few years might also yield new insights, especially concerning funding emanating from within Africa.

Note
1. Tanzania was a German colony for around 35 years before becoming a British colony.

Acknowledgements
This work was carried out with financial support from the UK Government’s Foreign, Commonwealth & Development Office and the International Development Research Centre, Ottawa, Canada (grant number 109419–001). C.H.T supported by FLAIR Fellowship Programme: a partnership between the African Academy of Sciences and the Royal Society funded by the UK Government’s Global Challenges Research Fund.

Disclosure statement
No potential conflict of interest was reported by the author(s).

Funding
This work was supported by FLAIR Fellowship Programme: a partnership between the African Academy of Sciences and the Royal Society funded by the UK Government’s Global Challenges Research Fund; the UK Government’s Foreign, Commonwealth and Development Office and the International Development Research Centre, Ottawa, Canada: [grant number 109419 – 001].

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Appendices

Appendix A. Interpretation of geographical terms

When research funding in the Dimensions database was dedicated to a geographical unit that was not a country, we needed to define which country(ies) that geographical term covers in order to be able to generate statistics on funding for the study of different countries. This was done according to the definitions in this table. Funding flows were divided evenly between the countries covered by a geographical term. For example, if funding was dedicated to a region consisting of three countries, the funding would be divided equally between those three countries in our dataset.

| Term                     | Countries that this region includes | Countries     |
|--------------------------|-------------------------------------|---------------|
| AFRICA                   | Benin, Burkina Faso, Cabo Verde, Cote d'Ivoire, Gambia, Ghana, Guinea-Bissau, Guinea, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, Togo, Burundi, Cameroon, Central African Republic, Chad, Congo, Democratic Republic of Congo, Equatorial Guinea, Gabon, Sao Tome-and-Principe, Comoros, Djibouti, Ethiopia, Eritrea, Kenya, Madagascar, Mauritius, Rwanda, Seychelles, Somalia, South Sudan, Sudan, Tanzania, Uganda, Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe, Algeria, Egypt, Libya, Mauritania, Morocco, Sahrawi Arab Democratic Republic, Tunisia | 55 |
| ATLANTIC REGION OF AFRICA| Angola, Benin, Cameroon, Cabo Verde, Democratic Republic of the Congo, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea-Bissau, Cote d'Ivoire, Liberia, Mauritania, Morocco, Namibia, Nigeria, Republic of the Congo, Sao Tome-and-Principe, Senegal, Sierra Leone, South Africa, Togo, Western Sahara | 24 |
| CONGO BASIN              | Democratic Republic of the Congo, Cameroon, Central African Republic, Gabon, Equatorial Guinea, Congo | 6 |
| EAST CENTRAL AFRICA      | Comoros, Djibouti, Ethiopia, Eritrea, Kenya, Madagascar, Mauritius, Rwanda, Seychelles, Somalia, South Sudan, Sudan, Tanzania, Uganda, Burundi, Cameroon, Central African Republic, Chad, Congo, Democratic Republic of Congo, Equatorial Guinea, Gabon, Sao Tome-and-Principe | 23 |
| EQUATORIAL AFRICA        | Angola, Cameroon, CAR, Chad, Congo, Democratic Republic of the Congo, Equatorial Guinea, Gabon, Sudan, Zambia, Burundi, Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Seychelles, Somalia, Tanzania, Uganda, Benin, Burkina Faso, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Sao Tome-and-Principe, Senegal, Sierra Leone, Togo, Botswana, Zimbabwe, Namibia, Cabo Verde | 45 |
| GREAT LAKES REGION HORN OF AFRICA | Burundi, Democratic Republic of the Congo, Kenya, Malawi, Rwanda, Tanzania, Uganda | 7 |
| KALAHARI DESERT          | Botswana, Namibia, South Africa | 9 |
| KILIMANJARO              | Tanzania | 3 |
| LAKE CHAD                | Chad, Niger, Nigeria, Cameroon | 1 |
| LAKE TANGANYIKA          | Tanzania, Democratic Republic of the Congo, Burundi, Zambia | 4 |
| LAKE VICTORIA MOUNT KENYA| Kenya, Tanzania, Uganda | 3 |
| NIGER RIVER              | Benin, Guinea, Mali, Niger, Nigeria | 1 |
| NILE                     | Burundi, Democratic Republic of the Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania, Uganda | 5 |
| NUBIA                    | Sudan | 1 |
| SAHARA                   | Chad, Mali, Algeria, Niger, Egypt, Tunisia, Libya, Mauritania, Sudan, Western Sahara | 10 |
| SAHEL                    | Libya | 7 |

(Continued)
Appendix B. Guidelines for qualitative classification of project titles and abstracts

The purpose of the qualitative classification was to check whether projects were correctly identified by Boolean search strings as being about Africa, to determine whether they were about mitigation, impact, or adaptation and which of seven types of climate risk they concerned.

- **Definitions:**
  
a) "Mitigation – actions that reduce net carbon emissions and limit long-term climate change."
  
b) "Adaptation – actions that help human and natural systems to adjust to climate change."
  
c) "Research on new technologies, on institutional designs and on climate and impacts science, which should reduce uncertainties and facilitate future decisions."

- Projects were allowed to have multiple/overlapping classifications; for example, they could be about both climate change mitigation and adaptation to climate change at the same time. When a project had such multiple categorisations, its funding was divided between those categories.

- The category “ambivalent” was applied to projects that were difficult to classify. This created more options for handling the ambivalence of projects and made it easier to double-check projects that were difficult to classify. For example, when counting funds for mitigation, we included both the projects that were clearly about mitigation and those that were probably about mitigation although not with certainty.

- Projects on the following topics were classified as concerning climate mitigation:
  
  - Climate justice or a just energy transition
  
  - The consequences of mitigation resilience to climate change
  
  - The financial consequences of mitigation co-benefits of mitigation carbon trading
  
  - Studies of emissions (without necessarily doing anything to reduce them) > Maybe mitigation

- Projects on the following topics were classified as adaptation projects:
  
  - Risk management

- Rules about what was counted and what was not counted as a climate change project:
  
  - If a project seemed to be less than 0.33% about climate change according to our subjective assessment, we did not count it as a climate project.
  
  - If in doubt, and a project did not say much about climate change, did not focus on it and did not include it in the title, we did not count it as being about climate change.

- If a project was about a general topic, such as biodiversity or vector-borne diseases, and climate change was one of many factors mentioned as playing a contextual role for biodiversity or vector-borne diseases but not in focus and not highlighted, then we did not count the project as being about climate change.

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Appendix C. Countries financing Africa-related climate research before and after the Paris agreement 1990–2020, in 2010 USD

| Country | Funding 1990–2015 | Funding 2016–2020 | Sum of funding 1990–2020 |
|---------|-------------------|-------------------|--------------------------|
| United Kingdom | 77667534 | 110673319 | 188340853 |
| Europe | 144952400 | 41551705 | 186504104 |
| United States | 123802697 | 1449330 | 138296026 |
| Germany | 26953569 | 5684966 | 32638535 |
| Sweden | 9598347 | 11500847 | 21099194 |
| Norway | 9319752 | 3418124 | 12737877 |
| France | 4269654 | 3160988 | 7430642 |
| Canada | 9598347 | 2571212 | 5311502 |
| Finland | 5214792 | 0 | 5214792 |
| Switzerland | 3231838 | 1449798 | 4681636 |
| China | 1131816 | 211828 | 3243645 |
| Poland | 461868 | 864101 | 1325970 |
| Japan | 1051253 | 63573 | 1114825 |
| Australia | 732165 | 0 | 732165 |
| Italy | 591821 | 0 | 591821 |
| Denmark | 284120 | 0 | 284120 |
| New Zealand | 231973 | 0 | 231973 |
| Estonia | 100853 | 0 | 100853 |
| Portugal | 57956 | 0 | 57956 |

(Continued)
Appendix D. Locations of institutions receiving funding for climate change research on Africa, 1990–2020, in 2010 USD

| Country of research institution | Sum* | Country of research institution | Sum* |
|--------------------------------|------|---------------------------------|------|
| USA                            | 147710940 | C. African Rep.          | 807126 |
| UK                             | 122119599 | Morocco                     | 719813 |
| Germany                        | 51252661  | Latvia                        | 716014 |
| Sweden                         | 29237915  | Hungary                       | 685188 |
| France                         | 26950352  | Botswana                      | 665216 |
| Netherlands                    | 17591473  | Sri Lanka                     | 582192 |
| Norway                         | 17533682  | D.R. of the Congo             | 573337 |
| Italy                          | 16298589  | R. of the Congo               | 571262 |
| Kenya                          | 13152474  | Philippines                   | 565432 |
| South Africa                   | 12897557  | South Korea                   | 565432 |
| Finland                        | 12022798  | Jordan                        | 507118 |
| Switzerland                    | 10672297  | Portugal                      | 505780 |
| Austria                        | 7927310   | Greece                        | 488945 |
| Belgium                        | 7753940   | Bolivia                       | 465234 |
| Denmark                        | 7670210   | Togo                          | 423525 |
| Spain                          | 6940062   | Bulgaria                      | 375400 |
| Canada                         | 6066496   | Palestinian Territory         | 362675 |
| Ghana                          | 5885087   | Algeria                       | 345263 |
| Senegal                        | 5817337   | Kazakhstan                    | 338550 |
| Tanzania                       | 5246281   | Mozambique                    | 254619 |
| Niger                          | 5177209   | Cabo Verde                    | 254449 |
| Ethiopia                       | 4998693   | Iran                          | 245847 |
| China                          | 4967015   | Brunei                        | 236560 |
| Zambia                         | 4750765   | Rwanda                        | 212981 |
| Burkina Faso                   | 4439492   | Russia                        | 207362 |
| Cyprus                         | 3931350   | Sierra Leone                  | 183794 |
| Malawi                         | 3892839   | Estonia                       | 100853 |
| Seychelles                     | 3500508   | Mongolia                      | 54626 |
| Colombia                       | 3430305   | Thailand                      | 48329 |
| Tunisia                        | 3291363   | Nigeria                       | 47733 |
| Benin                          | 2833494   | Reunion                       | 42030 |
| Australia                      | 2793043   | Mauritius                     | 18274 |
| Uganda                         | 2522907   | Jamaica                       | 18274 |
| India                          | 2216528   | Malia                         | 18274 |
| Japan                          | 2073629   | Guinea-Bissau                 | 14489 |

*USD sums in this table are based on data generated after qualitative categorization of project abstracts.

Appendix E. Climate-related research on African countries, 1990–2020

| Country        | Funding in 2010 USD* | % of total |
|----------------|----------------------|------------|
| South Africa   | 46949797             | 7.906      |
| Kenya          | 42150430             | 7.098      |
| Tanzania       | 32048804             | 5.397      |
| Ethiopia       | 26765498             | 4.507      |
| Ghana          | 23772553             | 4.003      |
| Uganda         | 23152779             | 3.899      |
| Namibia        | 17605108             | 2.965      |
| Malawi         | 17387137             | 2.928      |
| Mali           | 14488656             | 2.440      |
| Niger          | 13145827             | 2.214      |
| Burkina Faso   | 12956467             | 2.182      |
| Madagascar     | 12735093             | 2.145      |
| Senegal        | 12356427             | 2.081      |
| Zambia         | 11940970             | 1.921      |
| Cameroon       | 10919109             | 1.839      |
| Tunisia        | 10446197             | 1.759      |
| Sudan          | 10394787             | 1.750      |
| Mozambique     | 96876088             | 1.631      |
| Nigeria        | 9643419              | 1.624      |
| Botswana       | 9136409              | 1.539      |
| Egypt          | 8774549              | 1.478      |
| Chad           | 8760925              | 1.477      |
| Mauritius      | 8691858              | 1.464      |
| Rwanda         | 8410488              | 1.416      |
| Benin          | 7779006              | 1.310      |
| Gambia         | 7653338              | 1.292      |
| Guinea         | 7657696              | 1.290      |
| Zimbabwe       | 7545109              | 1.271      |
| Libya          | 7472960              | 1.258      |
| Somalia        | 7450947              | 1.255      |
| Mauritania     | 7284658              | 1.227      |
| Seychelles     | 7228353              | 1.217      |
| Guinea-Bissau  | 7193789              | 1.211      |
| Cote d’Ivoire  | 7185980              | 1.210      |
| Cabo Verde     | 7135833              | 1.202      |
| Sierra Leone   | 7135833              | 1.202      |
| Togo           | 7135833              | 1.202      |
| Morocco        | 7066225              | 1.190      |
| Dem. Rep. of Congo | 7055155 | 1.188 |
| Congo          | 6330616              | 1.066      |
| Gabon          | 6090010              | 1.026      |
| Equatorial Guinea | 5843075 | 0.984 |
| Central African Republic | 5811742 | 0.979 |
| South Sudan    | 5592158              | 0.942      |
| Burundi        | 5563089              | 0.937      |
| Comoros        | 5458549              | 0.919      |
| Eritrea        | 5230981              | 0.881      |
| Sao Tome-and-Principe | 5044550 | 0.850 |
| Angola         | 4849604              | 0.817      |
| Algeria        | 4839929              | 0.815      |
| Djibouti       | 4681109              | 0.788      |
| Lesotho        | 4675843              | 0.787      |
| Swaziland      | 4512150              | 0.760      |
| Libya          | 3859925              | 0.650      |
| Sahrawi Arab Dem. Rep. | 3633064 | 0.612 |

*USD sums in this table are based on data generated after qualitative categorization of project abstracts.

Appendix F. Fields of research classified as natural and social sciences

Numbers are the codes used in the Dimensions database for the fields of research.

| Classified as natural and technical sciences | Classified as social sciences and humanities |
|---------------------------------------------|---------------------------------------------|
| 01 Mathematical Sciences                     | 01 Education                                |
| 0101 Pure Mathematics                        | 0101 Education Systems                       |
| 0102 Applied Mathematics                      | 0102 Curriculum and Pedagogy                 |
| 0103 Specialist Studies in Education          |                                             |

(Continued)
### Classified as natural and technical sciences

| Code | Field of Study                                                                 | Code | Field of Study                                                                 |
|------|-------------------------------------------------------------------------------|------|-------------------------------------------------------------------------------|
| 0701 | Agriculture, Land and Farm Sciences                                           | 0706 | Horticultural Production Studies                                                |
| 0702 | Animal Production Sciences                                                    | 0707 | Veterinary Sciences                                                            |
| 0703 | Crop and Pasture Production Sciences                                          | 0799 | Other Agricultural and Veterinary Sciences                                     |
| 0704 | Fisheries Sciences                                                              | 0799 | Other Food Science                                                             |
| 0705 | Forestry Sciences                                                              | 0800 | Other Agriculture Science                                                      |
| 0706 | Horticultural Production Sciences                                              | 0801 | Artificial Intelligence and Image Processing                                  |
| 0707 | Veterinary Sciences                                                            | 0802 | Computation Theory and Statistics                                             |
| 0708 | Veterinary Sciences                                                            | 0803 | Computer Software                                                              |
| 0709 | Veterinary Sciences                                                            | 0804 | Data Format                                                                    |
| 0701 | Agricultural and Veterinary Sciences                                          | 0805 | Distributed Computing                                                          |
| 0702 | Animal Production Sciences                                                    | 0806 | Information Systems                                                            |
| 0703 | Crop and Pasture Production Sciences                                          | 0807 | Library and Information Studies                                                |
| 0704 | Fisheries Sciences                                                              | 0808 | Other Information and Computing Sciences                                       |
| 0705 | Forestry Sciences                                                              | 0809 | Other Information and Computing Sciences                                       |
| 0706 | Horticultural Production Sciences                                              | 0810 | Other Information and Computing Sciences                                       |
| 0707 | Veterinary Sciences                                                            | 0811 | Other Information and Computing Sciences                                       |
| 0708 | Veterinary Sciences                                                            | 0812 | Other Information and Computing Sciences                                       |
| 0709 | Veterinary Sciences                                                            | 0813 | Other Information and Computing Sciences                                       |
| 0710 | Plant Production Sciences                                                      | 0814 | Other Information and Computing Sciences                                       |
| 0711 | Animal Production Sciences                                                    | 0815 | Other Information and Computing Sciences                                       |
| 0712 | Crop and Pasture Production Sciences                                          | 0816 | Other Information and Computing Sciences                                       |
| 0713 | Fisheries Sciences                                                              | 0817 | Other Information and Computing Sciences                                       |
| 0714 | Forestry Sciences                                                              | 0818 | Other Information and Computing Sciences                                       |
| 0715 | Horticultural Production Sciences                                              | 0819 | Other Information and Computing Sciences                                       |
| 0716 | Agricultural and Veterinary Sciences                                          | 0820 | Other Information and Computing Sciences                                       |
| 0717 | Plant Production Sciences                                                      | 0821 | Other Information and Computing Sciences                                       |
| 0718 | Animal Production Sciences                                                    | 0822 | Other Information and Computing Sciences                                       |
| 0719 | Crop and Pasture Production Sciences                                          | 0823 | Other Information and Computing Sciences                                       |
| 0720 | Fisheries Sciences                                                              | 0824 | Other Information and Computing Sciences                                       |
| 0721 | Forestry Sciences                                                              | 0825 | Other Information and Computing Sciences                                       |
| 0722 | Horticultural Production Sciences                                              | 0826 | Other Information and Computing Sciences                                       |
| 0723 | Agricultural and Veterinary Sciences                                          | 0827 | Other Information and Computing Sciences                                       |

(Continued)
Appendix G. ISO 3166–1 ALPHA-3 Country codes

| Code | Country             | Code | Country             | Code | Country              |
|------|---------------------|------|---------------------|------|----------------------|
| DZA  | Algeria             | MDG  | Madagascar          | NER  | Niger                |
| AGO  | Angola              | MWI  | Malawi              | NGA  | Nigeria              |
| BEN  | Benin               | MLI  | Mali                | RWA  | Rwanda               |
| BWA  | Botswana            | MRT  | Mauritania          | ESH  | Sahrawi Arab Dem. Rep.|
| BFA  | Burkina Faso        | MUS  | Mauritius           | STP  | São Tomé & Príncipe   |
| BDI  | Burundi             | MAR  | Morocco             | SEN  | Senegal              |
| CPV  | Cape Verde          | MOZ  | Mozambique          | SLE  | Sierra Leone         |
| CMR  | Cameroon            | NAM  | Namibia             | SYC  | Seychelles           |
|     |                     |      |                     | SLE  | Sierra Leone         |
|     |                     |      |                     | SOM  | Somalia              |
|     |                     |      |                     | ZAF  | South Africa         |
|     |                     |      |                     | SSD  | South Sudan          |
|     |                     |      |                     | SDN  | Sudan                |
|     |                     |      |                     | SWZ  | Swaziland            |
|     |                     |      |                     | TZA  | Tanzania             |
|     |                     |      |                     | TGA  | Togo                 |
|     |                     |      |                     | TUN  | Tunisia              |
|     |                     |      |                     | UGA  | Uganda               |
|     |                     |      |                     | UGA  | Uganda               |
|     |                     |      |                     | ZMB  | Zambia               |
|     |                     |      |                     | ZWE  | Zimbabwe             |

Continued.

Classified as natural and technical sciences
Classified as social sciences and humanities

1204 Engineering Design
1205 Urban and Regional Planning
1299 Other Built Environment and Design