Avenues for using Science for Smarter Development

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Abstract

In a study released as part of the UNESCO Science Report (2021), UNESCO analysed 56 research topics of strong relevance to eight Sustainable Development Goals (SDGs). These goals were: zero hunger (SDG2), good health and well-being (SDG3), clean water and sanitation (SDG6), affordable and clean energy (SDG7), industry, innovation and infrastructure (SDG9), climate action (SDG13), life below water (SDG14) and life on land (SDG15). The study analysed scientific publishing trends over 2011–2019 in 193 countries using Scopus (Elsevier) data; we found that half of the 56 topics analysed each accounted for less than 0.1% of global scientific output between 2011 and 2019, including climate-ready crops, transboundary water management and local strategies for climate-related disaster risk reduction. High-income countries are ceding ground to other income groups for most of the 56 topics under study, including those related to sustainable energy. For all of these topics, it is lower middle-income countries which have shown the strongest growth rate. We suggest avenues for providing more strategic support for research and innovation to scale-up sustainability science and industrial spin-offs.

Sustainability research not yet mainstream

In a study released on 11 June 2021 as part of the *UNESCO Science Report*, UNESCO analysed publishing trends in 193 countries over the period from 2011 to 2019 for 56 research topics of strong relevance to the Sustainable Development Goals (SDGs) [UNESCO, 2021].

The study focused on the extent to which these 56 research topics were contributing to eight SDGs (Figure 1). Between six and nine research topics were analysed for each of these eight goals (Straza and Schneegans, 2021).[1]

The study found that sustainability research was not yet mainstream in academic publishing at the global level. For instance, half of the 56 topics analysed each accounted for less than 0.1% of global scientific output between 2011 and 2019 (Figure 1).

To give an order of magnitude, between 2012 and 2019, scientists worldwide produced 4 769 scientific publications on climate-ready crops, 1 039 publications on local strategies to reduce the risk of climate-related disasters and 864 publications on transboundary water resource management, compared to more than 900,000 publications on artificial intelligence and robotics.[2]

Transboundary water resource management garnered little research interest, despite there being an indicator (SDG6.5.2) which tracks the percentage of transboundary basin area within a country that has an operational arrangement for water cooperation. For such an arrangement to qualify as operational, it must include the regular exchange of data and information (at least once a year).

There was almost no growth in research output on topics related to sustainable ocean management (SDG14) [Table 1]. At the other end of the scale, topics of relevance to industry, infrastructure and innovation (SDG9) showed the strongest growth rate. For instance, between 2011 and 2019, one-third (59) of the 193 countries analysed at least doubled their output on improving battery efficiency and almost as many (55) did the same for smart-grid technologies and sustainable transportation[3] (50).

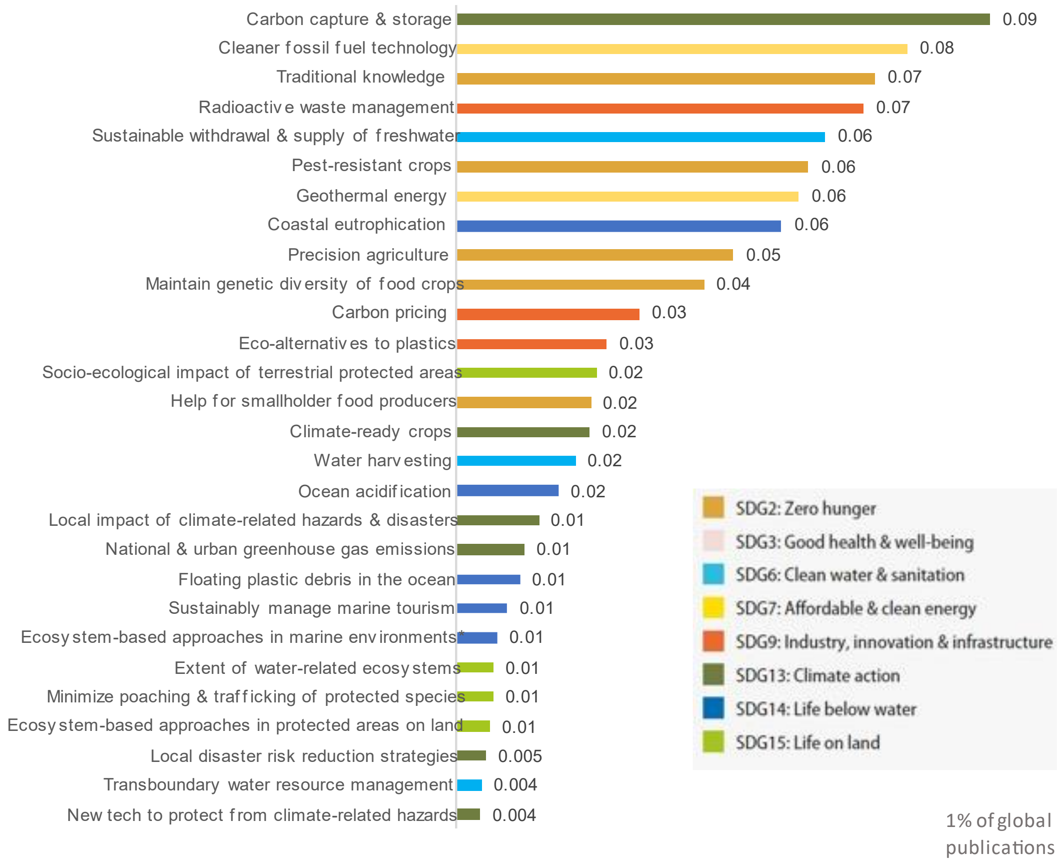
Despite the energy transition being at the heart of countries' digital and green transition, research into renewable sources of energy made up a relatively modest portion of scientific output over the period under study. For instance, global research on solar photovoltaics accounted for just 0.5% of scientific output between 2012 and 2019 and that on wind turbine technologies for just 0.3% (Figure 1).

[1] One of the virtues of such a narrow focus is that it shows just how few publications are being produced on topics that should be a priority, such as climate-ready crops and local strategies to reduce climate-related disaster risk. One drawback of this approach is the lack of comprehensive coverage of trends in sustainability science. In addition, it would be useful to complement the measure of academic output with patent data to get a more rounded picture for the selected industrial topics relating to energy, in particular.

[2] 900 456 publications to be exact, excluding publications in the Arts, Social Sciences and Humanities; data sourced from Scopus (Elsevier) and treated by Science-Metrix for UNESCO

[3] This topic includes vehicles powered by solar energy and hybrid or electric vehicles.

Figure 1. Research topics among the 56 analysed which accounted for less than 1% of scientific output worldwide, 2011–2019



Source: UNESCO Science Report 2021, using Scopus (Elsevier) data that include Social Sciences, Arts and Humanities; data treatment by Science Metrix.

Strongest growth in sustainability science observed in lower middle-income countries

Sustainability topics form far greater shares of national output in small and developing science systems where health and agricultural research tend to be a strong research focus. These regions are branching out from their traditional specialty areas. Latin America at least doubled its output on topics such as ecological construction materials and new technologies to protect from climate-related hazards. Caribbean scientists boosted their own output on topics related to energy and freshwater management. In sub-Saharan Africa, governments are investing in wind and solar energy systems to complement efforts to expand the traditional electrical grid. This investment is reflected in the doubling of research output in the subcontinent on smart-grid technologies, photovoltaics and wind turbine technologies, albeit from a low starting point.

Across the 56 broad research topics analysed, **lower middle-income countries** showed the strongest growth rate for all but SDG14 on life under water (Table 1). Their progress has been most spectacular when it comes to problem-solving for development. For instance, their global share of publications on the sustainable management of marine tourism has surged from 3% to 19% since 2011 (Figure 2). They quadrupled their research output on wastewater treatment, recycling and re-use, thereby raising their global share of output from 7.7% in 2011 to 14.6% in 2019. Lower middle-income countries now account for one-quarter of global publications on minimizing poaching and trafficking of protected species and one-fifth of global output on ecological approaches to industrial waste management, photovoltaics, biofuels and biomass (Figure 2).

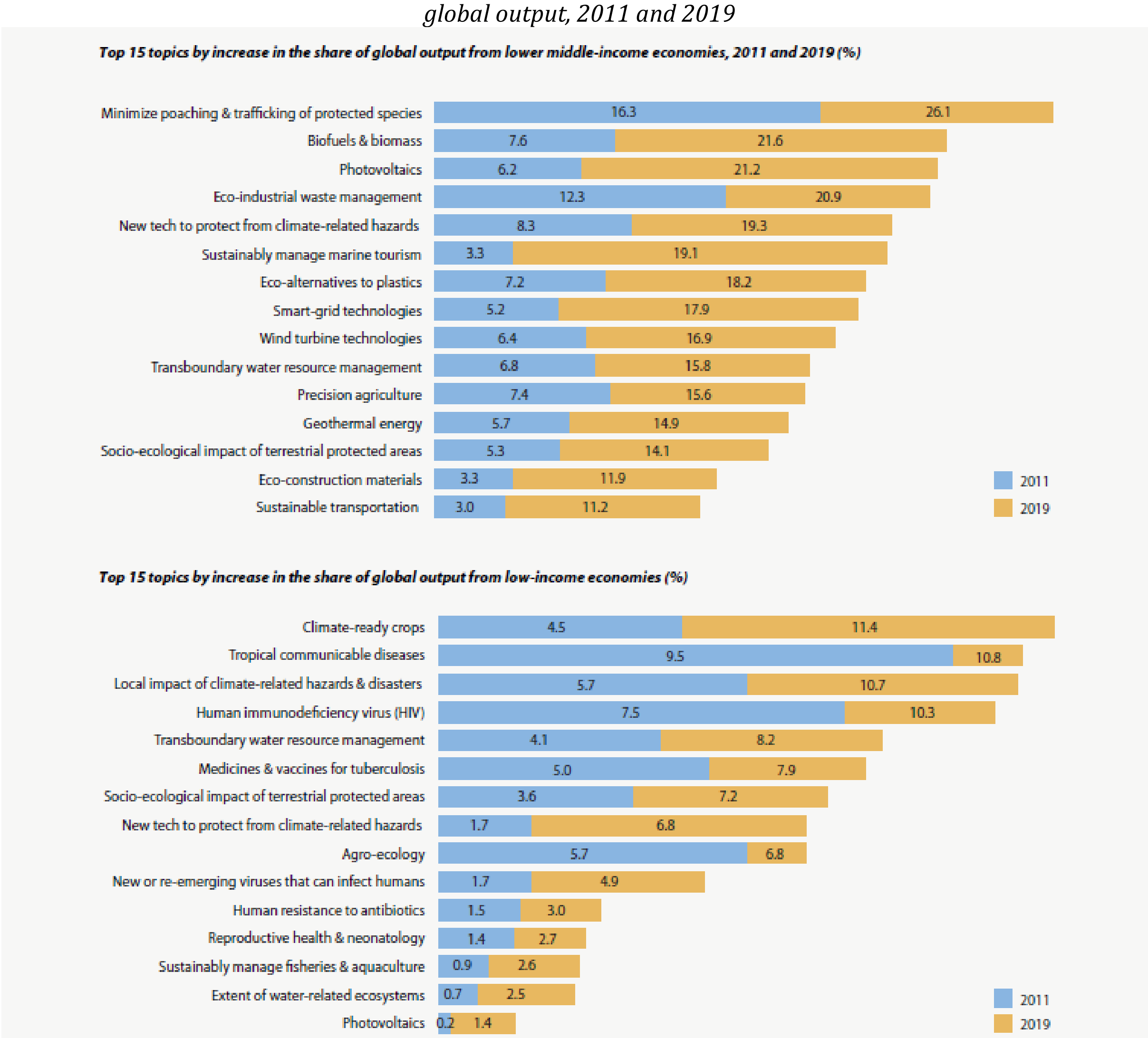
Low-income countries are least visible for topics related to SDGs 7 (energy), 9 (infrastructure, industrialization and innovation) and 14 (life below water). This income group is publishing more than previously on biofuels and biomass, solar and wind energy, in particular, but publications on each topic still amount to less than 1% of global output. On the other hand, they are contributing to 11% of global scientific output on climate-ready crops and studies of the local impact of climate-related hazards (Figure 2).

Table 1. Growth rate by income group for 56 research topics of strong relevance to eight Sustainable Development Goals, 2016–2019

	SDG2	SDG3	SDG6	SDG7	SDG9	SDG13	SDG14	SDG15
World	1.24	1.09	1.23	1.15	1.39	1.12	1.01	1.18
High-income	1.21	1.06	1.14	1.03	1.27	1.03	1.00	1.12
Upper middle-income	1.27	1.17	1.35	1.30	1.54	1.32	1.03	1.27
Lower middle-income	1.34	1.22	1.55	1.51	1.88	1.47	1.13	1.50
Low income	1.28	1.16	1.43	1.30	1.64	1.29	1.14	1.24

Source: UNESCO Science Report 2021, using Scopus (Elsevier) data that include Social Sciences, Arts and Humanities; data treatment by Science Metrix.

Figure 2. Top 15 research topics out of 56 analysed for lower middle-income and low-income countries by increase in their share of global output, 2011 and 2019



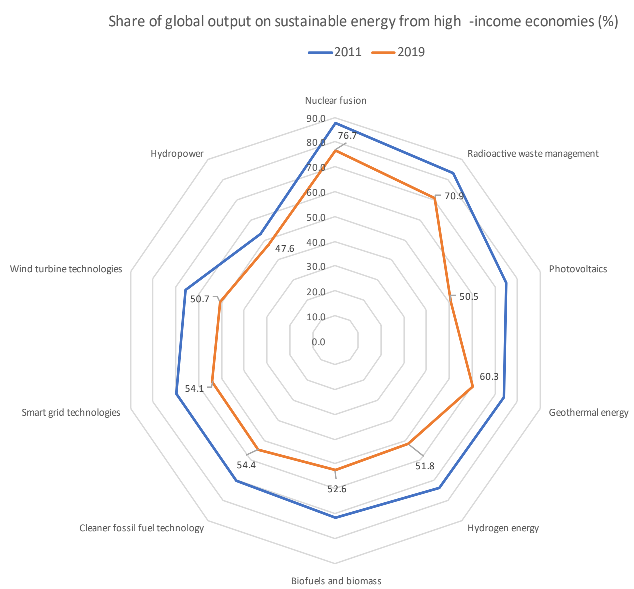
Source: UNESCO Science Report 2021, Figure 2.8, using Scopus (Elsevier), including Social Sciences, Arts and Humanities; data treatment by Science Metrix.

High-income economies are ceding ground to other income groups for most of the 56 topics under study, with the decline in global share of output being most noticeable with regard to improving battery efficiency and carbon capture and storage. These are both areas where China has increased its own output considerably.

They have also ceded ground in numerous areas of sustainable energy. Their share of global output declined by 5% or more for all of the energy topics analysed, as research interest grew among other income groups. For example, high-income economies produced 6 805 (74.8%) of the world's scientific publications on photovoltaics in 2011 and 7 928 (50.5%) in 2019 (Figure 3).

With the notable exception of China, progress among **upper middle-income countries** has been relatively modest. Countries in this income group made their greatest gains in national integrated water management and photovoltaics, where their share of global output grew by 8%. China boosted its own global share by more than 20% for the topics of battery efficiency (to 53%), the study of national and urban greenhouse gas emissions (to 47%), hydrogen energy (to 43%) and carbon pricing (to 41%). China also accounted for almost all growth within this income group on geothermal energy, radioactive waste management and the study of floating plastic debris in the ocean.

Figure 3. Share of high-income countries in scientific output on topics related to sustainable energy, 2011 and 2019



Source: UNESCO Science Report 2021, using Scopus (Elsevier) data that include Social Sciences, Arts and Humanities; data treatment by Science Metrix.

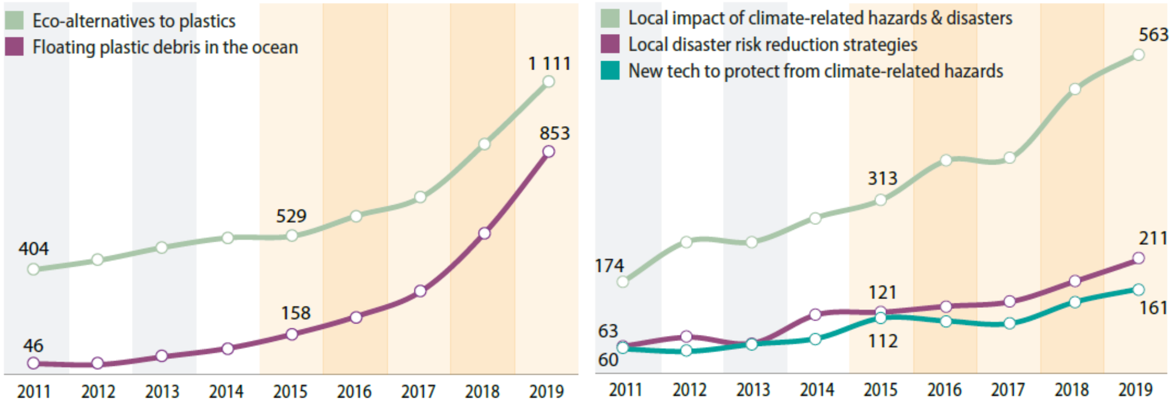
Much of sustainability science has been reactive

The UNESCO study suggests that much of sustainability science over the past decade has often been reactive, rather than pro-active. For example, the volume of output documenting the local impact of climate-related hazards and disasters is larger and growing faster than academic output on solutions such as disaster risk reduction strategies and new technologies to mitigate such hazards (Figure 4).

To take another example, scientific publications documenting floating plastic in the ocean are growing faster than research into ecological alternatives to plastics (Figure 4), even though less than 10% of plastic is currently recycled. With the long-term prospects for oil production being threatened by the growing affordability of renewables, oil companies are stepping up the production of synthetics like plastics, since plastics are also derived from oil. At current growth rates, plastic production could account for 20% of global oil by 2050 (UNEP, 2018). As long as the manufacturer is not held accountable for the full lifecycle of plastic goods and the cost of collecting and recycling waste products falls to public authorities, plastic goods will remain cheaper than ecological alternatives. This disguised subsidy is not only costly for the public purse. It is also holding back the development of more sustainable alternatives. Scientific knowledge can only be transformative if backed by policies which incentivize sustainable solutions.

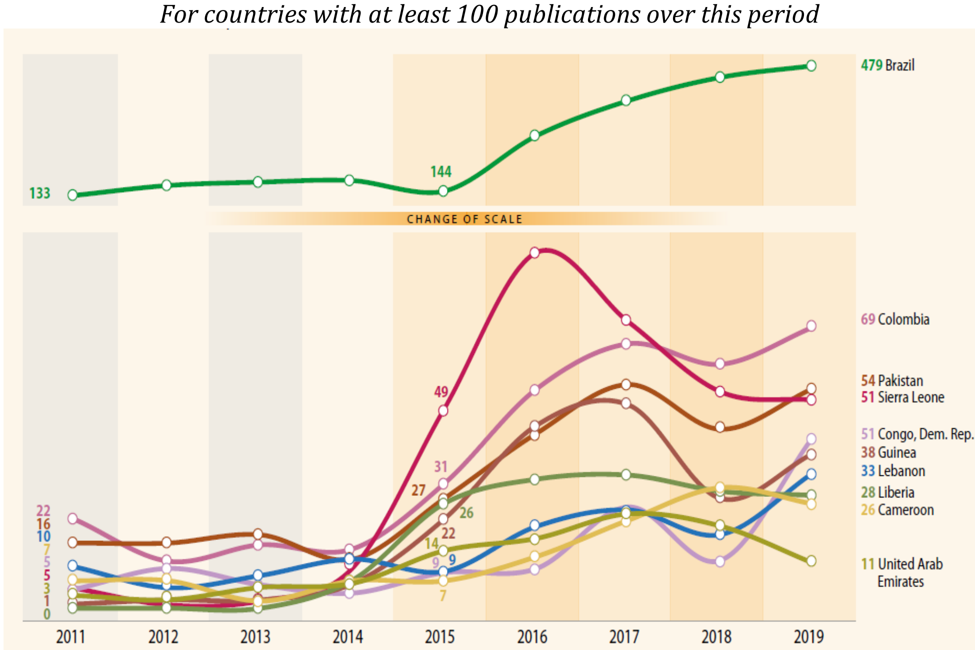
Less than two years before the onset of the Covid-19 pandemic, Fan *et al*. (2018) wrote these prophetic words. 'Few doubt that major epidemics and pandemics will strike again and few would argue that the world is adequately prepared'. The UNESCO study supports this affirmation. During the viral epidemics of the past decade, scientific research has tended to reactive, rather than pro-active. Between 2011 and 2019, there was a spike in research output in countries directly affected by a viral outbreak, such as the Zika epidemic in Brazil or the Ebola epidemics in the Democratic Republic of Congo and Guinea, Liberia and Sierra Leone (Figure 5).

Figure 4. Volume of global publications on topics related to plastics and climate hazards, 2011–2019



Source: UNESCO Science Report 2021, using Scopus (Elsevier) data that include Social Sciences, Arts and Humanities; data treatment by Science Metrix; adapted from Figures 2.7 and 2.9.

Figure 5. Top 10 countries for growth in scientific publishing on new or re-emerging viruses that can infect humans, 2011–2019
For countries with at least 100 publications over this period



Source: UNESCO Science Report 2021, using Scopus (Elsevier) data that include Social Sciences, Arts and Humanities; data treatment by Science Metrix; adapted from Figure 2.1.

Scientific collaboration and donor funding: a disconnect

International partnerships are considered fundamental to reaching the SDGs. At the global level, the share of scientific publications involving international co-authorship rose from 18.6% to 23.5% between 2011 and 2019, with strong variations from one country to another.

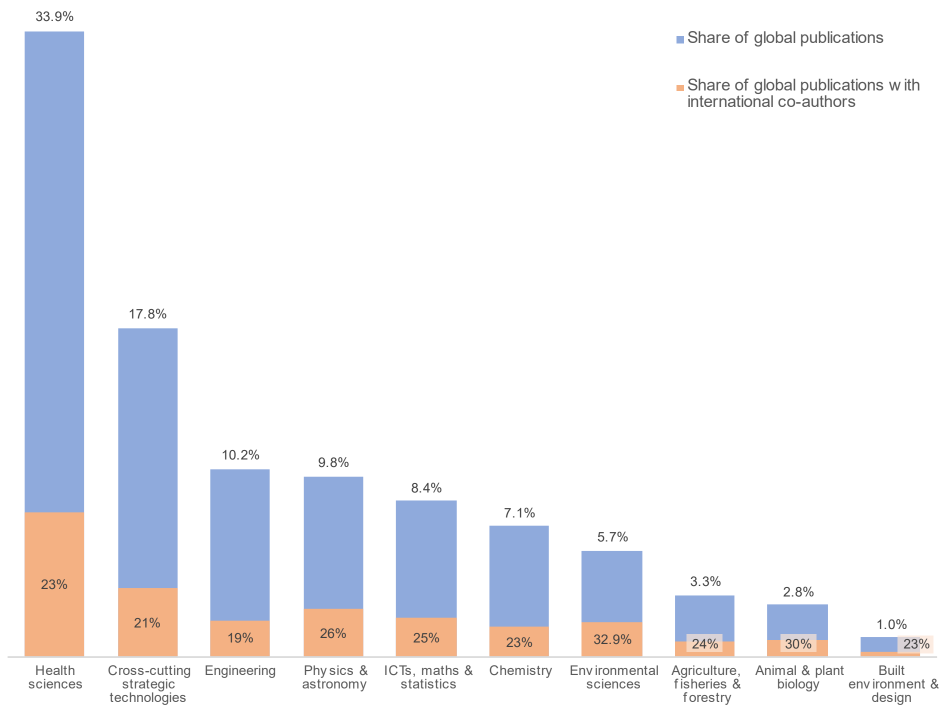
International scientific collaboration is highest for environmental sciences (33%) and lowest for engineering and cross-cutting strategic technologies such as artificial intelligence and robotics, materials science, energy and biotechnology. When it comes to the share of global scientific output, the situation is reversed, with environmental sciences (6%) trailing cross-cutting strategic technologies (18%) and engineering (10%) [Figure 6].

This finding is corroborated by the UNESCO study of trends in sustainability science, which found a particularly high level of collaboration since 2011 for the selected topics on sustainable environmental management and climate-related research, fields which also accounted for a small volume of scientific output. For instance, in 2019, high-income countries contributed to 500 of the 972 articles worldwide on climate-ready crops, middle-income countries to 706 articles and low-income countries to 111. This suggests a high level of international scientific collaboration on a topic for which overall output was low.

Research topics related to climate action and sustainable environmental management have received less attention from donors than advanced technology, according to Atteridge and Savvidou (2020), who found that just 2% of total development finance was directed towards environmental protection between 2013 and 2017.

This picture tallies with trends in official development assistance (ODA), where it is those topics which focused on industry, innovation and infrastructure (SDG9), as well as on sustainable cities and communities (SDG11), that received the most ODA between 2000 and 2013 (Sethi *et al.,* 2017). However, research output on engineering and the built environment and design, which is contributing to SDG9 and SDG11, show much lower ratios of international collaboration than environmental sciences (Figure 6).

Figure 6. Scientific publishing by broad field, overall and involving international collaboration, 2019



Note: Cross-cutting strategic technologies encompass AI and robotics, bioinformatics, biotechnology, blockchain technology, energy, Internet of Things, materials, nanoscience and nanotechnology, opto-electronics and photonics and strategic, defence and security studies.

Source: UNESCO Science Report 2021, using Scopus (Elsevier) data that exclude Social Sciences, Arts and Humanities; data treatment by Science Metrix.

Looking to the future

From the present study, we can conclude that greater support is needed to move sustainability science into the mainstream scientific publishing record.

To be effective, policies and related resources all need to point in the same strategic direction towards sustainable development. In Africa, for instance, science, technology and innovation (STI) policies are predicated primarily on 'economic growth and competitiveness rationales', rather than on sustainable development (AAS, 2018). This disconnect between policy priorities and research priorities can also be found on other continents. This calls for a systems approach to development planning that incorporates STI policy with other policy areas, such as education, industry, agriculture and trade. Strategic development planning, such as with regard to investment in infrastructure or job creation, should be approached through the lens of sustainable development, rather than as a parallel agenda.

Much of sustainability science is documenting environmental decline. In order to augment our chances of reaching our Sustainable Development Goals by 2030, research agendas should place greater emphasis in the coming decade on identifying sustainable solutions.

In the longer term, prevention is more economical than damage limitation in a crisis like the Covid-19 pandemic. Governments must take concrete steps now to prevent the next zoonotic epidemic by tackling the root causes of such epidemics; these causes include unfettered agricultural expansion and urbanization, deforestation and the illegal wildlife trade (IPBES, 2020).

It is countries on the frontlines of climate change and those most reliant on natural resources that are investing most heavily, proportionately, in the 'orphan' research topics on sustainability (Figure 1). Most are developing countries which lack the means to translate academic research into local solutions and upscale these, as necessary. Even though they contribute a sizeable share of global research on vital topics for sustainable development (Figure 2), low-income countries accounted for just 0.10% of global research expenditure[4] and lower middle-income countries for another 4.3% in 2018 (UNESCO, 2021).

This suggests the need for a fresh approach to development funding, to ensure that research emerging from lower-income countries can make a greater impact. The first step should be to re-equilibrate ODA to ensure that a larger share is aligned with sustainable environmental management and climate action.

In parallel, scientific communities in high-income and upper middle-income countries should increase their rate of collaboration with other income groups on topics related to the development of sustainable industries. The growth in sustainability science observed in lower middle-income countries suggests a real potential for the development of such industries but, currently, only one in five publications in supportive fields such as engineering and cross-cutting strategic technologies involves international collaboration.

The adoption of the *UNESCO Recommendation on Open Science* in 2021 should foster the practice of open science, increase access to scientific data and information, expand scientific collaboration within and beyond the scientific community and strengthen the science–policy–society interface. As more scientists and engineers use open licenses to share their publications, data, software and even hardware, greater international scientific collaboration should follow.

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[4] Statistics on research expenditure in developing countries in the present paper are provided by the UNESCO Institute for Statistics. Here, research expenditure includes foreign funding sources.