> CHAPTER 4

A global map of science

Mapping and characterizing SDG-related research across the world

AUTHORS

Tommaso Ciarli
Hugo Confraria
Ed Noyons
Ismael Ràfols
Alfredo Yegros

OVERVIEW

This chapter uses publication data to map and characterize SDG-related research across the globe.

Key challenges include:

- Higher income countries dominate the research agenda yet publish the lowest proportion of research related to the SDGs
- Few opportunities exist for knowledge transfer and capacity-building in low-income countries
- There is less focus on complex underlying societal issues than on immediate technological solutions

We also identified the following areas of opportunity:

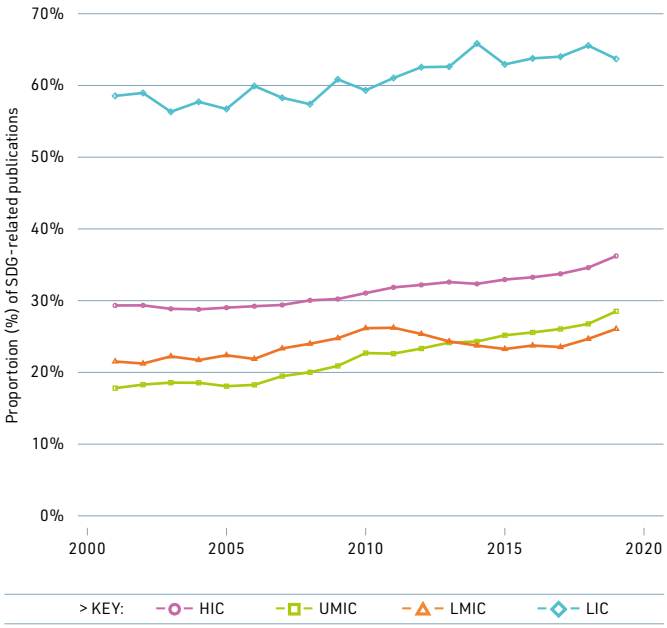
- Research in low-income countries is strongly related to SDGs
- Some synergies exist between research on different SDGs
- SDG-related research, especially on society-related SDGs, is more multidisciplinary and more likely to be used in policy and reported in the media than other types of research

Footnotes for this chapter are on page 61. A full list of references can be found on page 140.

Introduction

This chapter presents our findings about the countries, organizations and research disciplines that carry out research related to the Sustainable Development Goals (SDGs). We also identify the research areas that produce research related to more than one SDG and are thus in a good position to understand synergies and trade-offs between different SDGs. Finally, we describe a typology of SDG-related research and examine how it differs from other types of research. The next chapter (5) maps innovation activity in a similar way, using patent data.

Figure 4.1 / SDG-related publications in different country income groups (2001-2019)



The graph shows the proportion of publications that relate to any of the SDGs (1-16). It is based on the total number of publications in countries in each of the four World Bank income groups (2021 definition): high-income countries (HIC); upper-middle-income countries (UMIC); lower-middle-income countries (LMIC); low-income countries (LIC). Based on strict interpretation of SDG-related research (see page 52 for definition). See Appendix 2, Figure A.2.1 for a figure based on the loose interpretation. Figures based on Web of Science data. Centre for Science and Technology Studies (CWTS) version.

Our research builds on several earlier scientometric studies, which have analysed who conducts certain types of research and how research is used and funded. For example, studies have examined the alignment of research with health challenges,[1] different actors' priorities in shaping research directions,[2] the funding practices of interdisciplinary research,[3] and the use of interdisciplinary research in policy.[4]

Recent years have also seen several efforts to link academic publications to specific SDGs. These include studies by academics; research councils; publication data providers such as the Web of Science and Dimensions; publishers such as Elsevier; United Nations agencies; and consultancies to regional and national governments.[5] Despite important differences in which academic publications are linked to SDGs, these studies usually find that most SDG-related research is carried out in high-income countries (HICs), that it focuses on just a few SDGs (mainly relating to health, climate and energy), and is concentrated in a few disciplines, although this focus differs between countries. Some of these studies also report that much SDG-related research focuses on more than one of the SDGs.

Our method, and how it differs from earlier studies, is explained on page 52.

A map of SDG-related research: SDGs, countries and disciplines

The proportion of publications that relate to any of the SDGs grew between 2001 and 2019, particularly after the launch of the Millennium Development Goals in 2005 and the introduction of the 2030 agenda in 2015. Yet the proportion remains low, particularly in higher income countries. As shown in Figure 4.1, 64% of publications from low income countries (LICs) relate to the SDGs, compared with just 34% in high-income countries (HICs), 26% in upper middle-income countries (UMICs), and 24% in low middle-income countries (LMICs). However, research by LICs has a limited contribution to global SDG-related research as it accounted for just 0.2% of all publications in the WoS between 2015-2019.[6]

Which SDGs attract most research?

Figure 4.2 shows, for each country group, the proportion of SDG-related research that focuses on each individual SDG. Of all the SDGs, SDG 3 (Good health and well-being) attracted the most research. Overall, 22% of WoS research was related to SDG 3, with just 30% related to the other 15 SDGs covered in this study combined. Environment-related SDGs – SDG 13 (Climate action), SDG 14 (Life below water) and SDG 15 (Life on land) – also attract a large share of research in all countries. Most of the remaining SDG-related research in LICs relates to SDG 1 (No poverty), SDG 2 (Zero hunger) and SDG 5 (Gender equality), while the remaining research in LMICs and UMICs is mostly linked to SDG 7 (Affordable and clean energy) and

SDG 6 (Clean water and sanitation). The other SDGs attract relatively little research, especially those related to conflict and inequalities (5, 10, and 16), education, decent work and economic growth and innovation (4, 8, and 9) and sustainable behaviour (11 and 12).

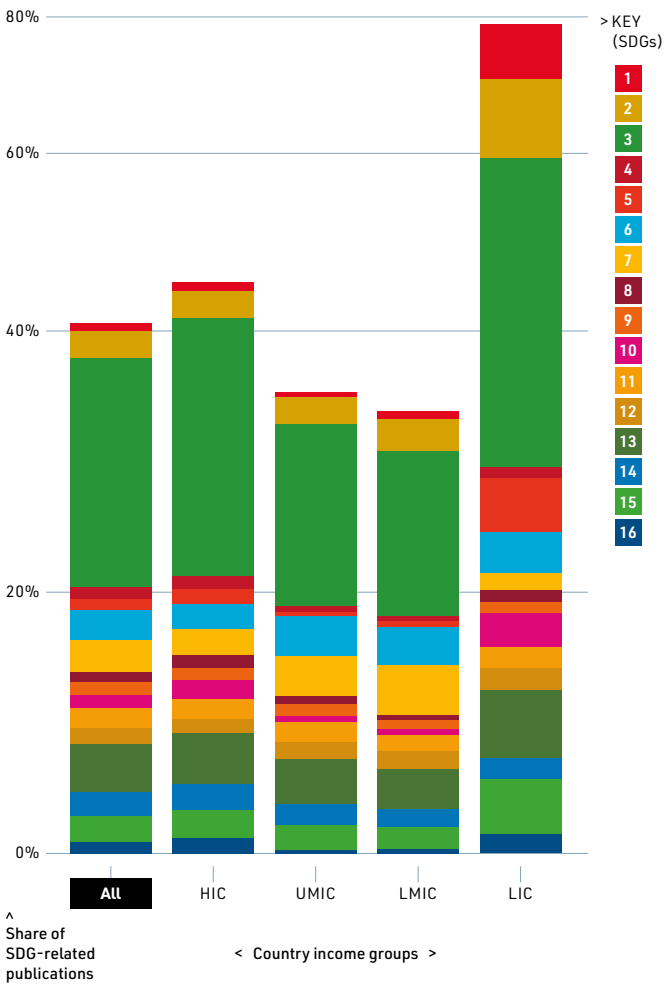
For some SDGs that attract a low share of research, publications have grown rapidly since 2001, as shown in Figure 4.3. For example, publications relating to SDG 11, 12, 9 and 8 have been among the fastest growing in most country groups. On the other hand, those related to pressing inequalities, conflict and education (SDGs 4, 5, 10 and 16) have grown less rapidly, with the exception of SDG 16 (Peace, justice and strong institutions) in LICs and SDG 4 (Quality education) in LMICs and UMICs. The greatest increase has been in publications relating to SDG 7 (Affordable and clean energy).

'The other SDGs attract relatively little research, especially those related to conflict and inequalities (5, 10, and 16), education, decent work and economic growth and innovation (4, 8, and 9) and sustainable behaviour (11 and 12).'

In HICs and UMICs, the growth of SDG-related publications has mostly plateaued since 2015, following 10 years of high growth. The exceptions are publications related to SDG 1 (No poverty) in HICs and to environment-related SDGs (13,14 and 15) and SDG 6 (Clean water and sanitation) in UMICs, which have continued to grow. In LMICs and LICs, publications have continued to grow for most SDGs, except for SDG 4 (Quality education) and SDG 7 (Affordable and clean energy) in LMICs.

Despite growing at different rates, the relative importance of the different SDGs in published research has remained remarkably stable across all country groups for 15 years, in line with the proportions shown in Figure 4.2.[7]

Figure 4.2 / Share of publications related to the SDGs by country group (2015-19)



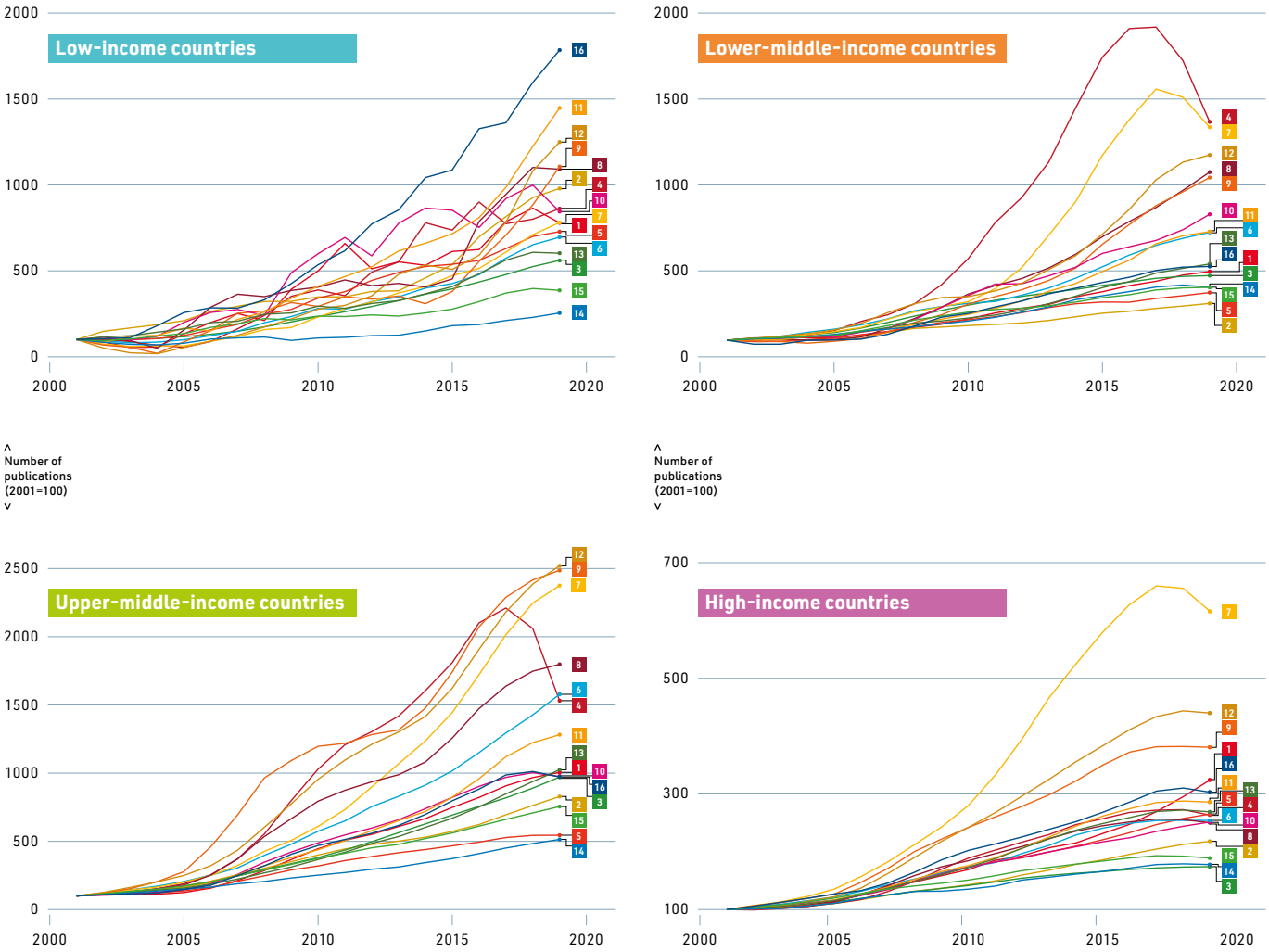
The chart shows the proportion of SDG-related research that relates to each SDG. Data is shown for each group of countries, defined according to World Bank classifications (2021 definition): high-income countries (HIC); upper-middle-income countries (UMIC); lower-middle-income countries (LMIC); and low-income countries (LIC). The proportions of SDG-related research shown here are higher than those in Figure 4.1, as Figure 4.2 uses the loose interpretation of SDG-related research (see page 52 for definition) in order to better show the differences in focus between country groups. See Appendix 2, Figure A.2.2 for a figure based on the strict interpretation.

Figures based on Web of Science data; Centre for Science and Technology Studies (CWTS version).

> KEY: **Sustainable Development Goals**

- **SDG 1** No poverty
- **SDG 2** Zero hunger
- **SDG 3** Good health and well-being
- **SDG 4** Quality education
- **SDG 5** Gender equality
- **SDG 6** Clean water and sanitation
- **SDG 7** Affordable and clean energy
- **SDG 8** Decent work and economic growth
- **SDG 9** Industry, innovation and infrastructure
- **SDG 10** Reducing inequality
- **SDG 11** Sustainable cities and communities
- **SDG 12** Responsible consumption and production
- **SDG 13** Climate action
- **SDG 14** Life below water
- **SDG 15** Life on land
- **SDG 16** Peace, justice, and strong institutions
- **SDG 17** Partnerships for the Goals

Figure 4.3 / Growth of SDG-related publications (2001-19)



The graphs show the publications index for each SDG and for each World Bank income country group (2021 definition). The number of publications in 2001 is set to 100. Numbers for other years show the percentage growth in the index since 2001 (for example, 1000 would indicate ten times as many publications as in 2001). Based on the strict interpretation of SDG-related research (see page 52 for definition). See Appendix 2, Figure A.2.3 for figures based on the loose interpretation.

Figures based on Web of Science data (CWTS version).

> KEY: **Sustainable Development Goals**

- **SDG 1** No poverty
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- **SDG 8** Decent work and economic growth
- **SDG 9** Industry, innovation and infrastructure
- **SDG 10** Reducing inequality
- **SDG 11** Sustainable cities and communities
- **SDG 12** Responsible consumption and production
- **SDG 13** Climate action
- **SDG 14** Life below water
- **SDG 15** Life on land
- **SDG 16** Peace, justice, and strong institutions
- **SDG 17** Partnerships for the Goals

Mapping SDG-related research: our methods

To map and characterize what SDG-related academic publishing has taken place across the globe, we devised a method to assign research areas (groups of scientific publications related by citations) to specific SDGs. This approach reduces the uncertainty and ambiguity of assigning individual publications to an SDG,[8] and allows us to include publications that contribute to SDG-related research even if they do not use SDG-specific language in the title or abstract.

First, we **built a query** with a set of terms that are strongly associated with each SDG (from 1 to 16).[9] To capture a broad understanding of SDGs, we consulted policy reports, grey literature, scientific publications and web forums, alongside United Nations sources. We extracted relevant fragments from these texts, then selected keywords within them, first using text-mining techniques and then a manual selection.

We then used those SDG-related queries to **search 4,013 clusters of publications in the Web of Science** published between 2015 and 2019. A cluster comprises a number of published documents which are related to each other because of their citation pattern.[10] Each cluster, then, represents a **research area** covering broadly similar topics.

Based on the results of the search, we connected each research area to one or more SDGs, depending on the proportion of publications that included our SDG query terms in their title and abstracts. For example, 22% of publications in the 'multidimensional poverty' research area[11] used terms relating to **SDG 1** (No poverty).

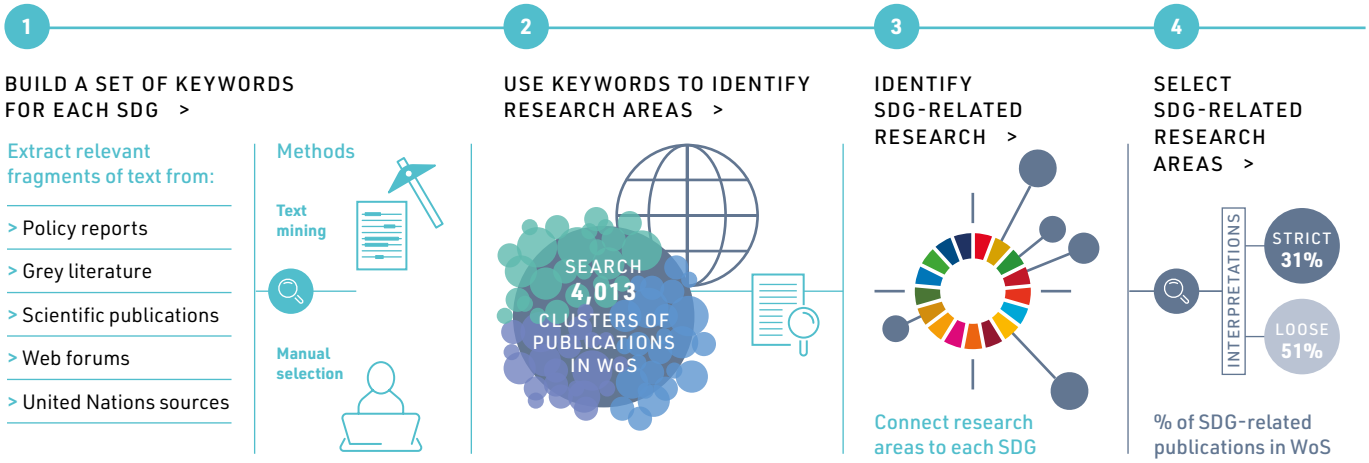
The results in this chapter are based on two different interpretations of SDG-related research, as follows:

- The *strict* interpretation includes only those research areas with publications directly related to the SDGs. Under this interpretation, 31% of all WoS research between 2015 and 2019 was SDG-related (1,120 research areas out of 4,013).
- The *loose* interpretation also includes research areas with publications that are less directly related but which may still be relevant. Under this interpretation, 51% of all WoS research between 2015 and 2019 was SDG-related (1,911 research areas).

As with all studies that map research published in academic journals, these methods are subject to certain limitations. In particular, the WoS does not cover most non-English language journals or those that focus mainly on topics of local relevance.[12] Moreover, much research, especially in low-income contexts, is not published in academic journals. However, our findings are still crucial in mapping and characterizing the contribution to the SDGs of academic research, which accounts for a large proportion of research funding and is widely used in policy and society. In Chapter 12, we suggest a tool and method that allows users to review the results in this chapter using different interpretations of SDG-related research.

> More detail about the methods, which are fully replicable, is provided in Appendix 2.

Figure 4.4 / An overview of our approach



Countries' capabilities for SDG-related research

In order to address local sustainability challenges, it is important for countries to build their own research and innovation capabilities. However, the vast majority (92%) of all publications in the WoS between 2015-19 were published by researchers in HICs and UMICs. This figure rises to 94% if we consider only SDG-related publications.[6]

Within income groups, the distribution of research is also extremely skewed, as shown in Figure 4.5. China accounts for 58% of all UMIC publications, India 57% of LMIC publications, and Ethiopia and Uganda 49% of LIC publications.[13]

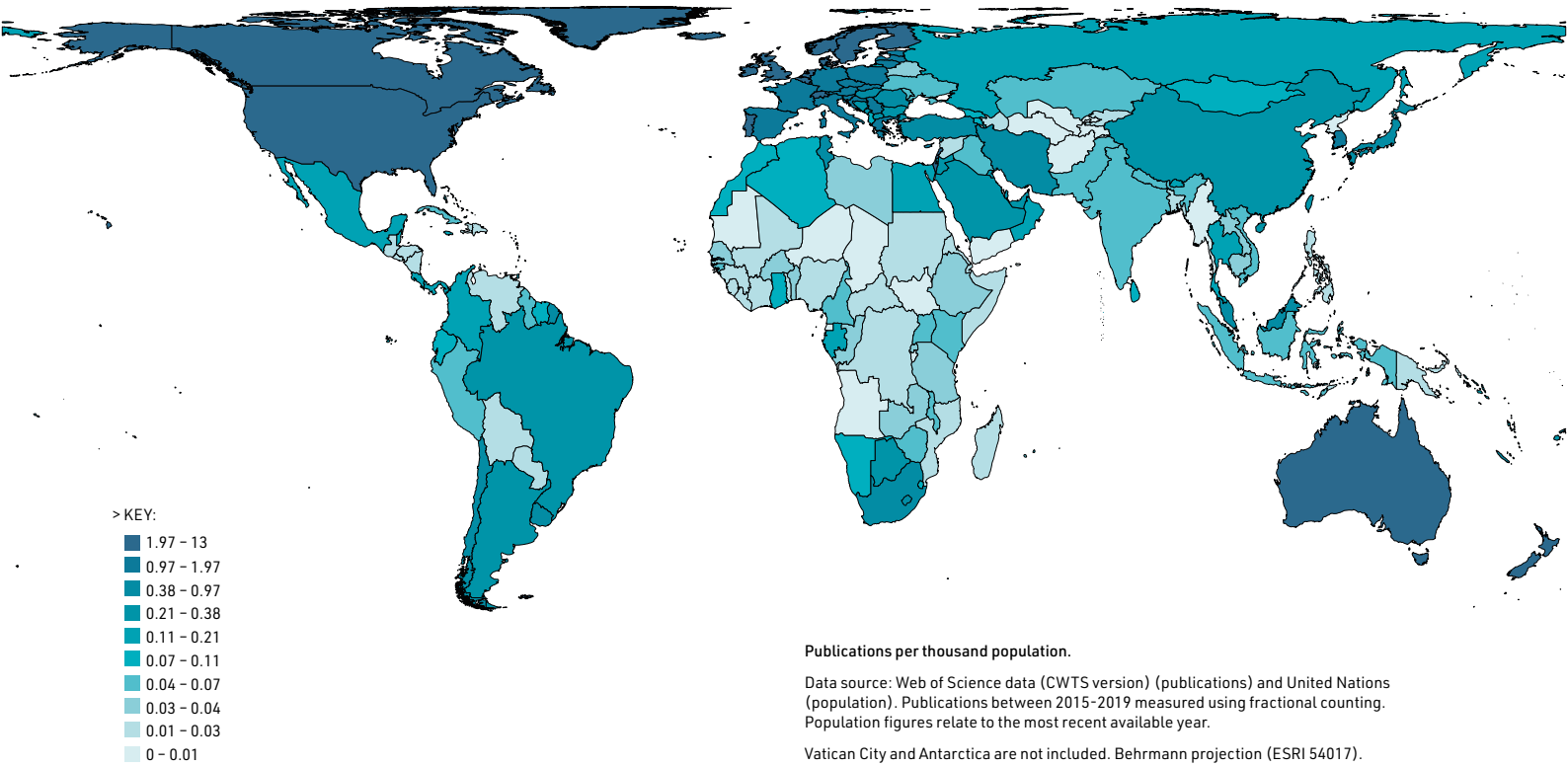
SDG-related research is also highly concentrated in just a few organizations. 50% of SDG-related publications in the WoS are produced by between just 1.9% (for SDGs 4 and 16) and 3.6% (for SDGs 8 and 9) of the 8,000 research organizations in our data.[14]

Those countries that are poorly represented in SDG-related research (LMICs and LICs) are similarly underrepresented in SDG-related research collaborations with the HICs and UMICs that dominate the SDG research agenda, as shown in Tables 4.1 and 4.2. Despite efforts by funding agencies to fund collaborative research with LMICs and LICs, 89% of all co-authored publications are between authors that work in HICs or UMICs.

Collaborations between authors in HICs and LMICs account for just 1.2%, and those between HICs and LICs just 0.2%, of global collaborations (Table 4.1). These represent just 2% of total collaborations for authors in HICs. Meanwhile, 38% of LIC collaborations and 22% of LMIC collaborations are with HICs (Table 4.2). South-South collaborations (between UMICs and LMICs or LICs) are marginal: respectively 0.3% and 0.04% of total collaborations, and 1.2% and 0.2% of all UMIC collaborations.[15]

Such imbalances mean that global and local research priorities and capabilities are directed by a few countries.[16] LICs, which have a relatively high domestic share of publications related to SDG 1 (No poverty) or SDG 2 (Zero hunger), for example, produce far fewer publications in these areas than HICs, which produce a significantly smaller domestic share of research on these topics, but which have high numbers of research organizations and researchers.[17] Similarly, countries at the frontier of military research[18] dominate research on SDG 16 (Peace, justice and strong institutions) although the domestic share of publications on this topic is substantially higher in several fragile LICs and LMICs,[19] which have a significantly smaller research capacity.[20]

Figure 4.5 / SDG-related publications per capita (2015-19)



Publications per thousand population.

Data source: Web of Science data (CWTS version) (publications) and United Nations (population). Publications between 2015-2019 measured using fractional counting. Population figures relate to the most recent available year.

Vatican City and Antarctica are not included. Behrmann projection (ESRI 54017).

Table 4.1 / Collaborative SDG-related publications within and between each country group (as a percentage of global collaborations)

COUNTRY GROUPS	HIC	UMIC	LMIC	LIC
HIC	66.32%			
UMIC	3.65%	18.69%		
LMIC	1.19%	0.28%	3.78%	
LIC	0.24%	0.04%	0.06%	0.30%
TOTAL	3,121,395 (71.40%)	990,797 (22.66%)	231,707 (5.30%)	27,607 (0.63%)

Table 4.2 / Collaborative SDG-related publications within and between each country group (as a percentage of a country group's total collaborations)

COUNTRY GROUPS	HIC	UMIC	LMIC	LIC
HIC	92.89%	5.12%	1.67%	0.33%
UMIC	16.12%	82.48%	1.23%	0.18%
LMIC	22.43%	5.25%	71.27%	1.04%
LIC	37.65%	6.31%	8.75%	47.29%

1a: This shows what proportion of all global collaborative publications occurred within (diagonal) and between (off the diagonal) country groups. For example, a publication co-authored by authors in the USA and the UK (both HICs) would contribute to the percentage in the top left cell. A publication co-authored by authors in the USA and Brazil (between HIC and UMIC) would contribute to the second row of the first column). The sum of all cells equals 100%.

1b: This shows what proportion of the collaborations within each country group occurred within and between country groups. For example, the first row shows the country groups involved in all collaborative research undertaken by HIC. The row total sums to 100%.

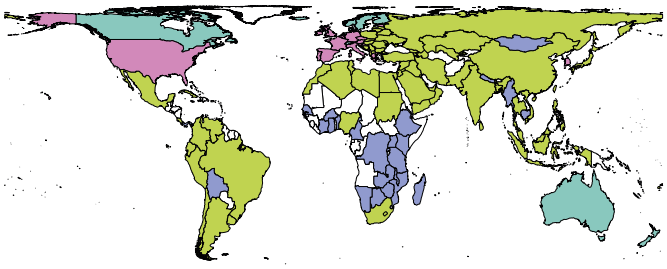
HIC: High-income countries; UMIC: Upper-middle-income countries; LMIC: Lower-middle-income countries; LIC: Low-income countries.

Figures are based on WoS data (CWTS version), 2015-19.

Which disciplines contribute to SDG-related research?
The involvement of different disciplines varies substantially across SDGs,[21] and not all disciplines publish on SDG-related issues. Because of the predominance of health-related publications in our sample, the 10 academic disciplines with the highest share of SDG-related publications are almost exclusively linked to health – for example, oncology, tropical medicine and parasitology. The 10 disciplines with the lowest share of SDG-related publications include basic sciences such as astronomy, astrophysics, physics and quantum science, and some of the humanities, including classics, medieval studies and literature.[22]

To investigate which disciplines may be relevant to more than one SDG, we calculated the median share of SDG-related publications for each discipline.[23] The 20 disciplines that relate to more than one SDG are predominantly in the social sciences, while most of the bottom 20 are disciplines related to health.

Overall, we found that the disciplines that publish on issues relating to one SDG are also likely to publish on issues relating to other SDGs (see Table 4.3 on page 57). For example, the disciplines that publish a high proportion of publications related to SDG 1 also produce a high share of publications related to SDGs 2, 5, 8, 9, 10, 11, 12 and 16. This indicates that funding research in a particular discipline may help to address several, related SDGs.

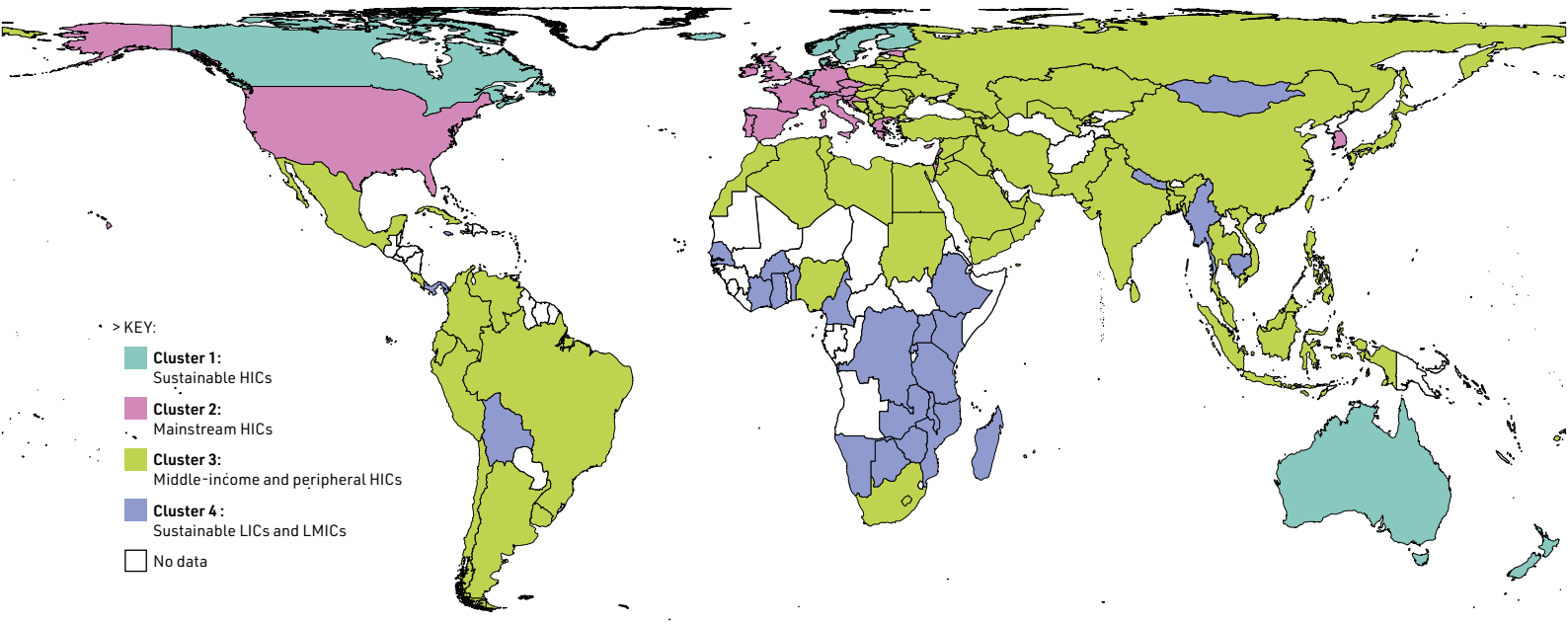


Country clusters

To distinguish different patterns of SDG-related research capabilities, we have identified four country clusters, as shown in Figure 4.6 on page 55.

These are based on common patterns of SDG-related publications, non-SDG-related publications, and overall research capacity (SDG-related publications per capita).[24] This produces a grouping that, while comparable to the World Bank income groups, better distinguishes countries by their capability to address the SDGs.

Figure 4.6 / Country clusters based on publications and research capacity



Cluster 1

SUSTAINABLE HICs

This group comprises the most research-intensive HICs.

Publications per capita:	3.6
2021 SDG Index ranking*:	80.2
Proportion of SDG-related publications	38%

They have an ***above average*** share of publications related to:

- **SDG 4** (Quality education)
- **SDG 9** (Industry, innovation and infrastructure)
- **SDG 10** (Reduced inequalities)
- **SDG 12** (Responsible consumption and production)
- **SDG 13** (Climate action)
- **SDG 14** (Life below water)

Cluster 2

MAINSTREAM HICs

Countries in this group, with the exception of Lebanon, are all HICs.

Publications per capita:	1.79
2021 SDG Index ranking*:	78.6
Proportion of SDG-related publications	32%

They have an ***above average*** share of publications related to:

- **SDG 4** (Quality education)
- **SDG 8** (Decent work and economic growth)
- **SDG 9** (Industry, innovation and infrastructure)
- **SDG 10** (Reduced inequalities)

They have a ***well below average*** share of publications on the environmental SDGs.

Cluster 3

MIDDLE-INCOME AND PERIPHERAL HICs

This is the largest group, combining those UMICs (47%) and HICs (26%)[25] with a below average number of publications per capita, alongside those LMICs (22%) with a low number of publications per capita.

Publications per capita:	0.3
2021 SDG Index ranking*:	70
Proportion of SDG-related publications	29.5%

Most countries in this group have a ***high*** share of publications related to:

- **SDG 6** (Clean water and sanitation)
- **SDG 7** (Affordable and clean energy)

UMICs and HICs in this cluster also have a ***high*** share of publications related to:

- **SDG 8** (Decent work and economic growth)
- **SDG 9** (Industry, innovation and infrastructure)
- **SDG 12** (Responsible consumption and production)

Cluster 4

SUSTAINABLE LICs and LMICs

This group is composed mainly of LMICs (52%) and LICs (30%).

Publications per capita:	0.06
2021 SDG Index ranking*:	58.7
Proportion of SDG-related publications	LMICs 55% LICs 73%

They have a ***high*** share, particularly in LICs, of publications related to:

- **SDG 1** (No poverty)
- **SDG 2** (Zero hunger)
- **SDG 3** (Good health and well-being)
- **SDG 5** (Gender equality)
- **SDG 6** (Clean water and sanitation)
- **SDG 16** (Peace, justice and strong institutions)

They have an ***above average*** share, particularly in LMICs, of publications related to environmental SDGs.

*The SDG Index measures each country's progress towards achieving the SDGs

Notes on the map: Each colour identifies one cluster of similar countries. A strict interpretation of SDG-related research was used. Countries with less than 500 total SDG-related publications between 2015-19 were not counted because their share of publications per SDG is extremely volatile. Figures based on Web of Science data (CWTS version).

Whose good health and well-being? Research related to SDG 3

Our analysis shows that between 43% and 60% of SDG-related research published between 2015 and 2019 was related to SDG 3 (Good health and well-being). However, this research may make only a limited contribution to sustainable development.

To study the contribution of SDG 3-related publications, we connected them to the main disease on which they focus.[26] We found that most SDG 3-related research does not prioritize the diseases that most affect the health of the 36% of the world population living in low-income countries (LICs) and lower middle-income countries (LMICs), which also shoulder 45% of the global disease burden.

As shown in Figure 4.7, a large proportion of SDG3-related research in LICs and LMICs focuses on diseases that have a substantial impact in those countries, such as infectious and parasitic diseases. However, these countries produce just 6% of all global SDG-related research.

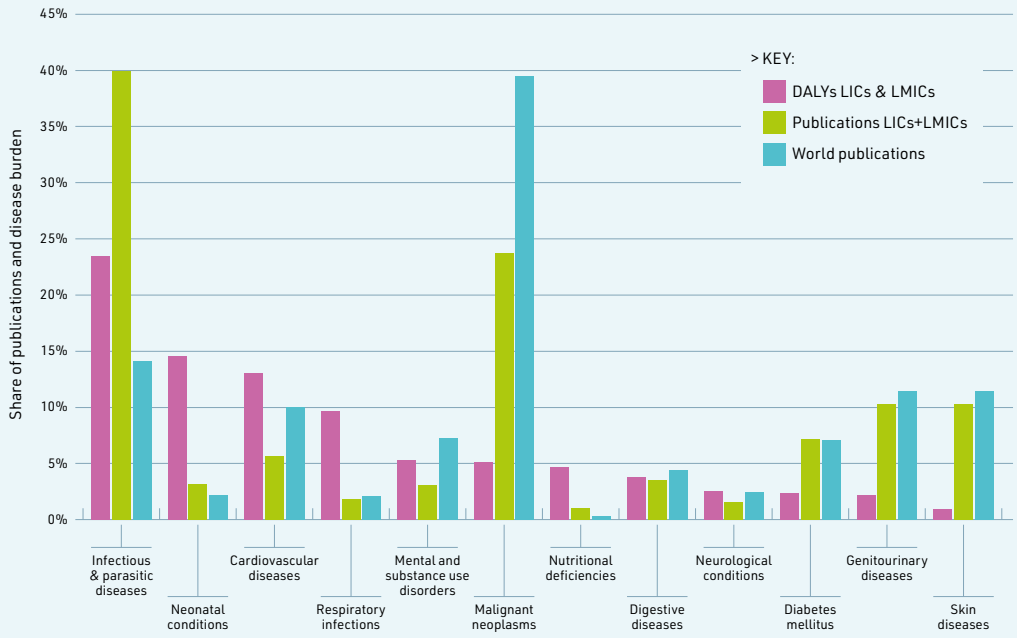
Worldwide, most SDG 3-related research does not prioritize the diseases with the largest impact on the lives of people in LICs and LMICs. Neonatal conditions, respiratory infections and nutritional deficiencies have a relatively high burden in LICs and LMICs, but research on these conditions is severely underrepresented both in these countries and globally.

Conversely, around 40% of global SDG 3-related research is focused on cancer (malignant neoplasms), which accounts for just 5% of the disease burden in LICs and LMICs. The major focus on this disease category in HICs and UMICs (where cancer represents 18% of the disease burden) also influences the focus of research in LMICs, where it accounts for 26% of total SDG 3-related research.

Likewise, diseases that represent 2% or less of the total disease burden in LICs and LMICs – diabetes, genitourinary diseases and skin diseases – account for a significant share of SDG 3-related research both globally and in LMICs.

Our findings indicate that even research that is related to a particular SDG will not always help to achieve SDG targets or meet the most pressing challenges. A substantial effort to include LIC researchers and stakeholders in research may go a long way to better align research funding with global health priorities, by directing funding towards diseases that affect the majority of the population.

Figure 4.7 / Disease burden in LICs and LMICs compared with share of related publications



Pink bars illustrate the burden of a particular disease category in LICs and LMICs, measured using disability-adjusted life years (DALYs), as a proportion of total DALYs across all disease categories in these countries. Only diseases with the highest burden are reported here. DALYs combine the number of years lost due to ill-health, disability or early death. Figures refer to 2010.

Green bars show LIC and LMIC publications that relate to each disease category, shown as a proportion of all LIC and LMIC publications related to SDG 3 that can be connected to particular diseases.

Blue bars represent global publications related to each disease category, shown as a proportion of all publications related to SDG 3 that can be connected to diseases.

Publication figures refer to 2015-19. Based on strict interpretation of SDG-related research. Figures based on WoS data (CWTS version) and on World Health Organization data (WHO, 2017).

Table 4.3 / How SDGs are related via different research disciplines

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.00															
2	*** 0.37	1.00														
3	-0.01	-0.06	1.00													
4	0.04	-0.04	-0.05	1.00												
5	*** 0.39	-0.01	** 0.18	0.10	1.00											
6	0	* 0.14	** -0.16	-0.06	-0.10	1.00										
7	-0.01	0.08	*** -0.27	-0.07	* -0.14	*** 0.39	1.00									
8	*** 0.42	* 0.14	* -0.16	0.05	* 0.12	0	0.06	1.00								
9	*** 0.34	** 0.18	** -0.19	0.03	0.02	0.11	*** 0.22	*** 0.56	1.00							
10	*** 0.44	0.07	-0.03	** 0.17	*** 0.46	-0.05	-0.06	*** 0.62	*** 0.21	1.00						
11	** 0.16	* 0.13	* -0.16	0	0	* 0.13	* 0.16	** 0.18	*** 0.34	** 0.18	1.00					
12	* 0.15	*** 0.25	** -0.20	-0.01	-0.02	*** 0.29	*** 0.44	*** 0.57	*** 0.42	0.06	*** 0.25	1.00				
13	0.08	*** 0.38	*** -0.25	-0.06	-0.10	*** 0.40	** 0.20	0.07	** 0.17	-0.01	*** 0.30	*** 0.23	1.00			
14	-0.05	-0.02	* -0.14	-0.05	-0.10	** 0.17	0.01	-0.04	-0.03	-0.07	0	-0.02	*** 0.33	1.00		
15	-0.02	** 0.18	** -0.16	-0.06	-0.10	*** 0.16	0.02	-0.02	0.01	-0.05	0.07	0.06	*** 0.50	*** 0.50	1.00	
16	* 0.14	0	0.04	0.03	*** 0.48	-0.06	-0.07	0.09	0.04	* 0.16	0.01	-0.02	-0.05	-0.02	-0.05	1.00

The table shows the pairwise correlation between the share of publications related to an SDG across all 254 disciplines (subject categories). Shares computed based on the strict interpretation of SDG-related publications. N=254; *p < 0.05, **p < 0.01, ***p < 0.001.

Figures based on Web of Science data (CWTS version).

Dark grey: A dark grey square indicates that several disciplines publish a similar share of publications related to this pair of SDGs.

White: A white square indicates that most disciplines produce different shares of publications related to this pair of SDGs.

Light grey: No statistically significant relationship in the share of publications of disciplines related to this pair of SDGs.

On the other hand, the fact that research related to some SDGs, such as SDG 4 (Quality education) and SDG 3 (Good health and well-being) is not correlated with research on other SDGs indicates that changes are needed in the research system. Education and health are related to many other sustainability challenges, and may therefore benefit from research in some of the disciplines that produce knowledge on these other challenges.

Also of concern is the fact that, while social sciences is the discipline that contributes to the widest range of SDGs, the SDGs that are most related to societal challenges do not benefit substantially from research in other disciplines.[27] We discuss these low synergies below.

Research synergies across the SDGs

In seeking to address complex sustainable development challenges, knowledge about interconnections between individual SDGs and targets can be as relevant as understanding how to address specific targets.[28] Because our method maps research to SDGs on the basis of research areas (clusters of publications) rather than individual papers, we can study in detail which research areas publish on several SDGs, and are therefore in a position to produce knowledge about the connections and synergies that could help in addressing the goals.[29]

Of the 1,120 research areas we identified as publishing SDG-related research (using our strict interpretation), 830 relate to just a single SDG,[30] while 43 relate to four or more different SDGs.[31] The SDGs that appear most in these synergistic research areas are those related to hunger (SDG 2), water and sanitation (SDG 6), and the environment (SDG 12, SDG 13 and SDG 15).

By analysing the 290 research areas that are related to more than one SDG,[32] we identified that SDG-related research tends to cluster around three areas. The clusters are detailed below. Figure 4.8 illustrates the links between and within these groups of SDGs.

SDGs in the green cluster are more strongly connected to each other than the SDGs in other clusters. Several research areas produce publications that are related to SDG 13, SDG 14

and SDG 15. These SDGs are also connected with SDGs in the yellow cluster, particularly through the connection between research related to SDG 13 (green) and SDGs 7, 12 and 6 (yellow).

Research related to the lilac cluster – people and society – is more isolated from other SDG-related research. The links between different SDGs within this cluster are also weaker than in the other two clusters, suggesting that few synergies are explored in research on these underlying society-related issues.

Within the yellow cluster, we found that research related to building science, technology and innovation (STI) capabilities, promoting inclusive and sustainable industrialization and fostering innovation (SDG 9) – which is the focus of this report

GREEN

A cluster of SDGs related to: the natural environment

SDG 13 Climate action
SDG 14 Life below water
SDG 15 Life on land

These are connected to the lilac cluster via:
SDG 2 Zero hunger

YELLOW

A cluster of SDGs related to: economic growth, infrastructures and technical solutions

SDG 6 Clean water and sanitation
SDG 7 Affordable and clean energy
SDG 8 Decent work and economic growth
SDG 9 Industry, innovation and infrastructure
SDG 12 Responsible consumption and production

LILAC

A cluster of SDGs mainly related to: people and society

SDG 1 No poverty
SDG 4 Quality education
SDG 5 Gender equality
SDG 10 Reduced inequalities
SDG 16 Peace, justice and strong institutions

And the main bridge to the other clusters:
SDG 3 (Good health)

SDG 11 (Sustainable cities and communities) connects to research in all three clusters.

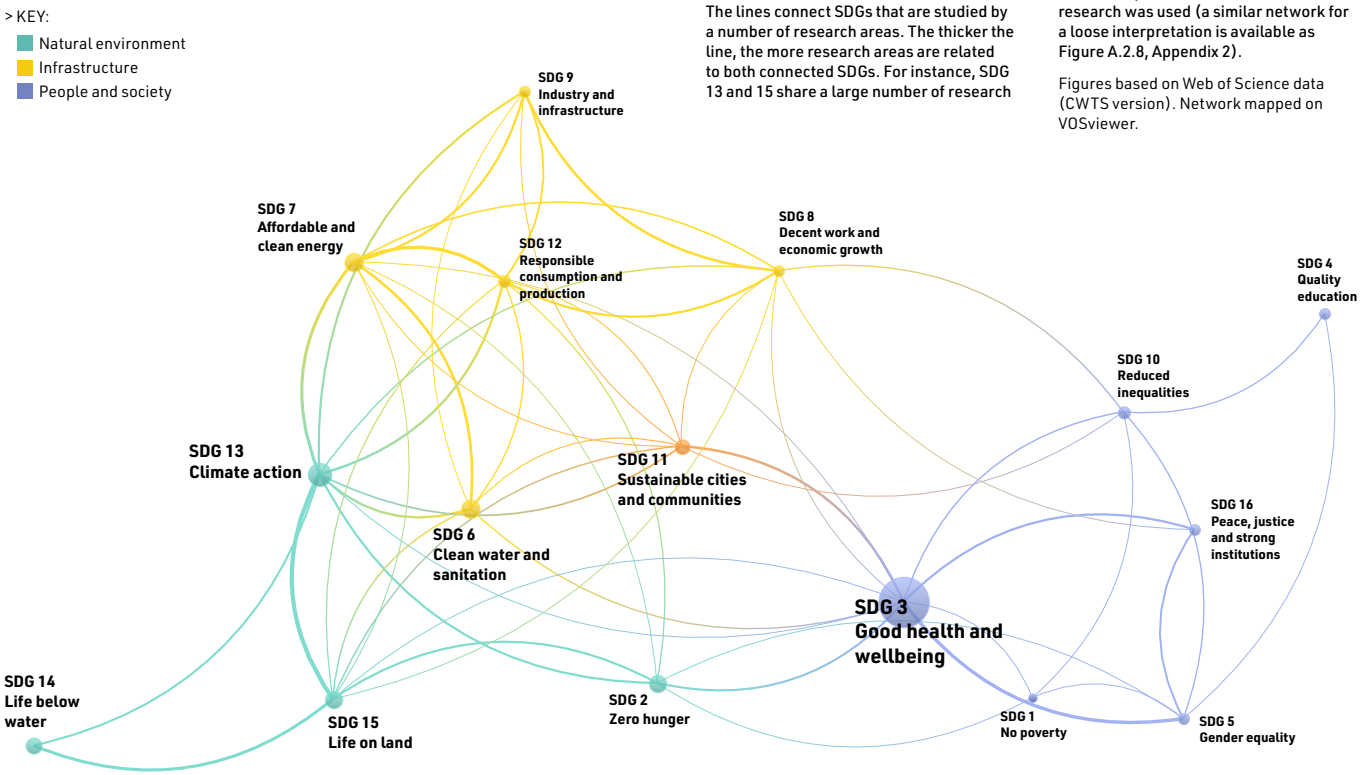
Figure 4.8 / Research synergies across SDGs

Each node identifies one SDG (the size of the node is proportional to the number of publications relating to that SDG). Each colour identifies one cluster of SDGs.

The lines connect SDGs that are studied by a number of research areas. The thicker the line, the more research areas are related to both connected SDGs. For instance, SDG 13 and 15 share a large number of research areas and publications, while SDG 4 shares only a small number of research areas and publications with SDG 10.

Strict interpretation of SDG-related research was used (a similar network for a loose interpretation is available as Figure A.2.8, Appendix 2).

Figures based on Web of Science data (CWTS version). Network mapped on VOSviewer.



– does not tend to be conducted in association with research related to the lilac cluster, and only to a limited extent in association with research related to the green cluster. There are, however, strong connections between research on SDG 9 and technological solutions for affordable and clean energy (SDG 7), decent work and economic growth (SDG 8) and responsible production and consumption (SDG 12).

The disconnects between research areas can be problematic as they limit the understanding of the complex underlying society-related issues that lie behind many SDG challenges. Our case studies (Chapters 8 and 9), for example, show that access to resources below water and on land (SDGs 14 and 15) is deeply connected to peace, justice and institutions (SDG 16), and that governance issues (SDG 16) and education (SDG 4), are central to addressing neglected diseases such as Chagas (SDG 3).

A typology of SDG research

We set out to understand the specific characteristics of SDG-related research, including whether it is more or less likely to have an impact than other research, and whether there are specific types of research that are more likely to be SDG-related and that research funders should therefore target to support the SDGs.

To understand whether research related to SDGs differs from non-SDG-related research in its potential for societal impacts,[33] we classified all publications according to the following four features:[34]

- **Collaborations and funding,** measured by the extent of international collaborations, access to funding, and collaboration with industry[35]
- **Academic reputation,** measured by standard indicators of academic citations[36]
- **Public and industry use,** measured by citations in patents, policy documents, news stories, and Twitter posts[37]
- **Open access and multidisciplinarity,** measured according to the share of publications that are open access and the Rao-Stirling diversity index of disciplines within research areas[38]

We measured the proportion of publications related to each SDG that possessed each of the above characteristics. This resulted in three clusters of SDGs, similar to those grouped by synergies described above (Figure 4.8).[39]

The features of each cluster are described below and illustrated in Figure 4.9.

Collaborations and funding

Overall, SDG-related publications are less likely (45% of publications) than the average publication in the WoS (54%) to acknowledge external funding. This differs for different clusters: 60% of publications relating to the natural environment and health SDGs acknowledge external funding, compared with 52% for the social functions and technical solutions cluster and just 31% for the people and society cluster. Even accounting for disciplinary differences in acknowledging funding, these figures point to difficulties in attracting research funding for the people- and society-related SDGs. This should be further investigated.

We also find differences in the extent of international collaborations. Publications related to natural environment and health SDGs are the most likely to be written in collaboration across countries (33%), including between HICs and other countries (15%) – more than those relating to social functions and technical solutions SDGs (27% and 15%) or the people- and society-related SDGs (23% and 9%), which are below the

LILAC

A cluster of SDGs related to people and society

SDG 1 No poverty

SDG 4 Quality education

SDG 5 Gender equality

SDG 10 Reduced inequalities

SDG 16 Peace, justice and strong institutions

Also including

SDG 8 Decent work and economic growth

SDG 9 Industry, innovation and infrastructure

YELLOW

A cluster of SDGs related to social functions and technical solutions

SDG 6 Clean water and sanitation

SDG 7 Affordable and clean energy

SDG 11 Sustainable cities and communities

SDG 12 Responsible consumption and production

Also including

SDG 2 Zero hunger

GREEN

A cluster of SDGs related to the natural environment and health

SDG 13 Climate action

SDG 14 Life below water

SDG 15 Life on land

These share features with health publications

SDG 3 Good health

> KEY: **Sustainable Development Goals**

SDG 1 No poverty
SDG 2 Zero hunger
SDG 3 Good health and well-being
SDG 4 Quality education
SDG 5 Gender equality
SDG 6 Clean water and sanitation
SDG 7 Affordable and clean energy
SDG 8 Decent work and economic growth
SDG 9 Industry, innovation and infrastructure
SDG 10 Reducing inequality
SDG 11 Sustainable cities and communities
SDG 12 Responsible consumption and production
SDG 13 Climate action
SDG 14 Life below water
SDG 15 Life on land
SDG 16 Peace, justice, and strong institutions
SDG 17 Partnerships for the Goals

WoS average (25% and 12%). The relatively low figures raise questions about the transfer of capabilities across countries in crucial areas of SDG-related research.[40]

SDG-related publications are substantially less likely to be produced in collaboration with industry than the average publication in the WoS (5% of publications). The highest levels of industry participation are in research related to the social functions and technical solutions SDGs (4%) and to SDG 3 (5%),[41] which is more focused on applied technological solutions.

Academic reputation

Publications related to the social functions and technical solutions SDGs and to industry, innovation and infrastructure (SDG 9) are more likely than the WoS average (13% versus 10%) to be in the top 10% most cited publications in their WoS category. For publications related to the natural environment and health SDGs and the people- and society-related SDGs, this measure of academic reputation is no different from the WoS average, with the exception of SDG 9.

Open access and multidisciplinarity

SDG-related publications are no more likely to be open access than the WoS average (43%). Only publications relating to the natural environment and health SDGs are slightly more accessible to all readers than average (50%), while those linked to people- and society-related SDGs (42%) and to social functions and technical solutions SDGs (39%) are less open access than average. These results indicate that there is a limited transfer of knowledge to those countries that most need to advance towards the SDGs and have limited research capacity and limited resources to access costly academic publications.

On the other hand, publications related to SDGs do have a higher degree of multidisciplinarity (52%) than the WoS average (43%). Publications connected to the people- and society-related SDGs are the most multidisciplinary (56%), followed by those related to social functions and technical solutions SDGs (52%) and natural environment and health SDGs (47%). This indicates that research related to people- and society-related SDGs may be better placed to address the complexity of SDG challenges.[42]

Public and industry use

SDG-related publications across all three clusters are used substantially more in policy reports (11% are used in this way), news articles (5%) and social media (40%) than the average publication in WoS (2%, 4% and 33% respectively). This is particularly the case for publications linked to the people- and society-related group of SDGs (25%, 7% and 48% of publications in the case of SDG 1, for example). Of all the SDG-related publications, those relating to the social functions and technical solutions SDGs attract the least policy (6%), media (3%) and social media (27%) interest.

Figure 4.9 / Characteristics of SDG-related publications

	CLUSTERS: People and society (SDGs 1, 4, 5, 8, 9, 10, 16)	Social functions and technical solutions (SDGs 2, 6, 7, 11, 12)	Natural environment and health (SDGs 3, 13, 14, 15)	WoS average (%)
International collaborations	↓	=	↑↑	25%
Collaborations involving HICs	↓	↑↑	↑	11.7%
Funded	↓↓	=	↑	53.6%
Industry	↓↓↓↓	↓↓	↓↓	5%
Reputation	=	↑	=	10.3%
Use in patents	↓↓↓↓	↓↓	↓↓	0.4%
Use in policy	↑↑↑↑↑	↑↑↑	↑↑↑	2.4%
Use in news stories	↑↑	↓↓	↑↑	2.8%
Use on Twitter	↑↑	↓↓	↑	3.3%
Open access	=	↓	↑	43.3%
Multidisciplinarity	↑	↑	=	43.4%

The table illustrates, for 11 features, whether the share of publications in a given cluster of SDGs is higher (↑), lower (↓), or similar (=) to the average of all WoS publications. For example, for all three clusters, the share of publications authored with organisations from industry (Industry) is lower than the WoS average.

Indicators are defined as follows:

International collaborations: share of publications with an author from at least two countries

Collaborations involving HICs: share of publications with at least one author from a HIC and one author from any other income group

Funded: share of publications that acknowledge funding from any source

Industry: share of publications with at least one author from industry

Reputation: share of top 10% most cited publications in any WoS category

Use in patents: share of publications cited in patents

Use in policy: share of publications cited in policy reports

Use in news stories: share of publications mentioned in the news

Use on Twitter: share of publications mentioned in Twitter

Open access: share of publications in open access journals

Multidisciplinarity: Rao-Stirling diversity index based on WoS categories

> KEY:

↑ less than 50% higher than average
↑↑ 50-100% higher than average
↑↑↑ around 100% higher than average
↑↑↑↑ at least 4x higher than average
= similar to the WoS average
↓ around 50% of the average
↓↓ between 50% and 33% of average
↓↓↓ between 50% and 33% of average
↓↓↓↓ less than 25% of average

Based on strict interpretation of SDG-related research. Figures based on Web of Science data (CWTS version).

These findings indicate that, in terms of the SDGs, research linked to the people- and society-related SDGs is of more immediate relevance than technical solutions to policy-makers and society. It might also be the case that basic science research and technical solutions are less likely to use terms related to SDGs, and are therefore less likely to be captured by our SDG-related queries.

We find the opposite pattern in relation to industry use of research. While all SDG-related publications are less likely to be cited in patents (0.1%) than the WoS average (0.4%), those relating to social functions and technical solutions SDGs are closer to the average (0.16%). The main exceptions are health-related publications, which are 50% more likely to be cited in patents than the WoS average (0.6%).

Overview and implications

Compared with the average publication in the WoS, and with the rest of SDG-related research, research linked to the people- and society-related SDGs is more used in policy, potentially more impactful in society, more multidisciplinary, and of at least as high quality.

Research related to the social functions and technical solutions SDGs is the most focused on basic sciences and technology applications, and the closest to industry. However, it does not attract much public or policy interest.

Research related to the natural environment and health SDGs is highly used in policy and society, attracts the most funding, and is most likely to be co-authored internationally and to be open access.

Taken together, these findings indicate a need for greater public funding for research that focuses on the complex societal determinants of sustainability, to complement, rather than follow, private funding.

Notes

1. Confraria and Wang, 2020; Yegros-Yegros et al., 2020.
2. Koning et al., 2021; Wallace and Ràfols, 2018.
3. Bromham et al., 2016.
4. Pinheiro et al., 2021.
5. Among others: Vanderfeesten and Otten, 2017; Colciencias, 2018; Nakamura et al., 2019; Wastl et al., 2020; Elsevier, 2020; LaFleur, 2019; Duran-Silva et al., 2019.
6. We use the location of the researchers rather than on the geography focus of the research, for which data is not systematically available.
7. See Figure A.2.4, Appendix 2.
8. See Armitage et al., 2020; Schmidt and Vanderfeesten, 2021 for evidence of radical differences in assigning publications to SDGs across different methods.
9. We excluded SDG 17 because it was not possible to identify a reliable set of terms related to this SDG.
10. Waltman and van Eck, 2012.
11. This research area is described with the following keywords: Gini index; poverty dynamic; deprivation; income mobility.
12. Chavarro et al., 2018; Ràfols et al., 2019.
13. See Figures S1-S16, Supplementary Figures for detail on the number and share of publications for individual countries and income groups for all SDGs.
14. See Figures S17-S32, Supplementary Figures for details of the organizations publishing in relation to each SDG and their contribution to global SDG-related research.
15. LICs are only slightly more represented in SDG-related collaborative research than in collaborations in all Web of Science collaborations (Appendix 2, Table A.2.2, panel A).
16. Evans et al., 2014; Kraemer-Mbula et al., 2020; Mormina, 2019; Mutapi, 2019; Yegros-Yegros et al., 2020.
17. Figures S1-S2, Supplementary Figures.
18. Mowery, 2012.
19. Hoogeveen and Pape, 2019; United Nations and World Bank, 2018.
20. Figure S16, Supplementary Figures.
21. To visualise the extent to which different SDGs relate to different disciplines, see Figures S33-S48, Supplementary Figures. Figure A.2.7, Appendix 2 plots the map of WoS categories with equal weights. Figures S49-S64, Supplementary Materials show details of each discipline's contributions to each SDG.
22. Table A.2.3, Appendix 2.
23. Table A.2.4, Appendix 2.
24. See Country clustering section (2.1.2) in Appendix 2 for method details. Tables A.2.5 and A.2.6, Appendix 2 show the value of each variable by cluster and by country. Figure A.2.6, Appendix 2 plots the hierarchical clustering dendrogram (distance between clusters).
25. Mainly Arab states of the Persian Gulf and Eastern European countries.
26. Among the publications related to SDG3, according to the strict interpretation of SDG-related research, 27% can be connected to a disease.
27. This may also be due to our method to assign publications to the SDGs, which relies on terms more commonly used in social sciences. See Chapter 12.
28. Independent Group of Scientists appointed by the Secretary-General, 2019.
29. Barbier and Burgess, 2019; Le Blanc, 2015; Nilsson et al., 2016.
30. Figure A.2.9, Appendix 2.
31. Figures A.2.10 and A.2.11, Appendix 2, show details of these research areas. To explore the research areas, please see web tool discussed in Chapter 12.
32. See Synergies section (2.1.3), Appendix 2 for a description of methods.
33. Bornmann, 2013; Molas-Gallart et al., 2002.
34. See Table A.2.7, Appendix 2 for detailed figures for each SDG.
35. Confraria and Vargas, 2017; Confraria and Wang, 2020; Etzkowitz and Leydesdorff, 2000.
36. Kraemer-Mbula et al., 2020; Yin et al., 2021.
37. Noyons, 2019; Yin et al., 2021.
38. Årdal and Røttingen, 2012; Arza and Fressoli, 2018; Bromham et al., 2016; Poole et al., 2021.
39. The similarity of these clusters to those based on synergies, described above (Figure 4.8), suggests robustness of our methods, and that research areas that overlap (synergies) also share similar characteristics.
40. Mormina, 2019.
41. Table A.2.7, Appendix 2.
42. Messerli et al., 2019; UNESCO, 2021.