Analysis of Research Related to the Sustainable Development Goals

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Executive summary
Analysis of Research Related to the Sustainable Development Goals

This report, commissioned by the Departamento Administrativo de Ciencia Tecnologia e Innovacion Colciencias, provides an objective, bibliometrics based analyses of Colombia's research on the United Nations (UN) Sustainable Development Goals (SDGs). The analyses presented herein assess the SDG-related publication output of Colombia, Mexico, and Brazil compared to five leading countries in the SDG field during the period 2007-2016. Each of the 17 SDGs have been analysed with regards to publication output and impact, measured by Field-Weighted Citation Impact and Field-Weighted Download Impact. Additionally, we present the most relevant key phrases per SDG to provide insight on the topics of focus for each country's SDG-related research.

The publication output of Colombia ranges from just 19 publications on SDG4 (Quality Education) to 620 publications on SDG13 (Climate Action). However, most of the SDGs range between 100 and 300 publications. In fact, this publication output somewhat reflects the global publication output on the SDG. The ones with the most publications globally do show the highest number in Colombia as well.

All SDG display a double digit annual growth rate across the period, mostly between 20 and 30%. SDG11 (Sustainable Cities) and SDG 12 (Consumption) have the highest annual growth rate with 42% and 40%, respectively. The lowest growth is seen for SDG10-related research (Reduced Inequalities) which has only 12% growth from 2007-2016.

The impact of Colombia's SDG publications, measured by field-weighted citation impact (FWCI), is above the global average for all research for every SDG except SDG4 (FWCI of 0.72). SDG5 (Gender Equality) and SDG3 (Hunger) are the most impactful areas with FWCI values of 2.11 and 1.77. This means, that publications from Colombia within these fields have been cited on average around twice as much as the global average for publications. The rest of the SDG yield FWCI values between 1.01 and 1.40.

Assessing patent counts per SDG reveals interesting trends in terms of where research supports real world applications and where this is less relevant. For SDGs related to the equality and reduction of the wealth gap (that is, SDG1, SDG4, SDG5, SDG8, SDG10, SDG16), very few patents are seen from either Colombia or worldwide. However, numerous patents are observed for SDGs related to climate change, energy efficiency and improved health.

Preface

With a global population of more than 7 billion a sustainable development is more important than ever. Sustainable development is defined as the "ability to make development sustainable – to ensure that the needs of the present are met without compromising the ability of future generations to meet their own needs."[1]

Acknowledging this need, in September 2000 the Millenium Development Goals (MDGs) were agreed by the heads of states at the UN headquarter. The Millennium Development Goals (MDGs) covered peace, the environment, poverty and many other challenges, and the eight goals were to be achieved by 2015. Although some of the goals made progress over the years, it became clear that a revision would be required.

The successors of the MDGs are the Sustainable Development Goals SGDs, which have been developed through a process of international collaboration, resulting in a proposal by the Open Working Group of 17 goals and 169 targets. These constituted a new set of goals that are actionable and aspirational, intended to help UN member states develop policies and set relevant agendas over the next 15 years. Finally, in January 2016, the Sustainable Development Goals (SDGs) replaced the Millennium Development Goals (MDGs). Unlike the MDGs, the SDGs are universal, applying to low-, middle- and high-income countries alike. They also constitute a much more complex agenda than the MDGs, explicitly seeking to integrate poverty alleviation with economic, social and environmental issues, and were the result of an exceptionally inclusive process

However, what has been gained in comprehensiveness with a set of 17 goals and 169 targets, has been lost in brevity. This poses some challenges for countries for the practical applications of the SDGs. How will countries prioritize implementation and resource allocation for different targets and integrate them into their existing plans and policies? How will they set targets that reflect national circumstances and take into account starting points? Equally importantly, how are governments planning to monitor progress and make this information publicly available and comparable at the regional and global level?

Colombia was not only very engaged in the formulation of the SDG agenda but was also one of the first countries to make plans to align its national development objectives with the goals. Already in 2015, still during the debate about the content of the SDGs at UN level, Colombia launched the Inter-Agency Commission for the Preparation and Effective Implementation of the Post2015 Development Agenda and the SDGs. With this step, Colombia's government has ratified its commitment to the SDGs and put itself forward as a partner for this new global agenda.

[1] World Commission on Environment and Development (WCED), Our Common Future (New York: Oxford University Press, (1987), page 8

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Introduction

Colombia was one of the first countries to make plans to align its national development objectives with the Sustainable Development Goals. Already in 2015, still during the debate about the content of the SDGs at UN level, Colombia launched the Inter-Agency Commission for the Preparation and Effective Implementation of the Post2015 Development Agenda and the SDGs. This commission did not start from scratch since Colombia has a National Development Plan that sets out the government's priorities every four years.

The first version of the Plan, "Todos por un nuevo país", was drafted in 2014 and runs to 2018. The Plan should thus form the basis for achieving the political coherence needed for effective SDG implementation at the national level in Colombia.
There is a high level of alignment of the Colombian National Development Plan with the SDGs: 91 of the 169 SDG targets are related to the indicators of the National Development Plan.

In terms of priority policy areas, the National Development Plan outlined three – peace, equity and education – that are clearly linked to the 'five Ps[2] of the SDG agenda.

Research related to SDGs can and will benefit Colombia's efforts in achieving SDG targets and help Colombia in being perceived as on the forefront of sustainable development. An objective, bibliometric assessment should inform on the current state of SDG related research in Colombia and the Departamento Administrativo de Ciencia Tecnologia e Innovacion Colciencias has asked Elsevier to provide them with this analysis. It is designed to support decision making with regards to what areas might benefit from an increase in funding.

As such, in this report, we compare Colombia's research output to that of 5 leading countries in the SDG field. Leaders in the SDG field will be determined based on publication output. Research output measured by publications and scientific impact along with the most prolific authors, institutions, collaboration partners, and journals being published in will be assessed. These analyses are done for each of the 17 SDGs. The SDG is defined by keywords, and the resulting publication sets in Scopus are analyzed according to the parameters below:

- Publications will focus on peer-reviewed publications and are thus defined as articles, reviews, and conference proceedings.
- Patent information analysis will be included according to the availability of information related to the SDGs.
- The study described herein will cover the period 2007-2016 (10 years).
- Included in the analysis will be aggregate level statistics on Colombia and five leading countries in each SDG field.

The National Development Plan 2014-2018 "Todos por un Nuevo país" (…) seeks to build a peaceful, equitable and educated Colombia, aligned with the National Government goals, with the best international practices and standards, and with a long-term vision based on the Sustainable Development Goals

(Colombian Congress, 2015)

[2] The 'five Ps' are: prosperity, partnership, peace, people and planet

About the tables and charts

The tables and charts presented in this report use consistent formatting throughout this report to facilitate easy visualization of minimum and maximum values.

For absolute counts and percentages, data in the tables are formatted according to the following approach: the highest value in the column is shaded darkest red with white text and the lowest value is shaded white with black text. For field-weighted citation impact, values below 1.0 are shaded green with white text because these values fall below the world average for all research. CiteScore values below 1.0 are also shaded green with white text to facilitate easy identification of journals for which the average count of citations for articles in the past 3 years is fewer than 1. An example of the data formatting is shown below.

		Publication count
		4
Minimum value for column (if multiple minimum values, cell is same color for all)	>	0
		11
		53
		285
		0
		5
Maximum value for column	>	1784
		23
		188
		78
		0

		FWCI
		1.77
Minimum value for column (if multiple minimum values, cell is same color for all)	>	1.02
Maximum value for column	>	2.12
Value below 1.0, world average for all research	>	0.95
		1.78

Chapter 1
No Poverty

In this Chapter, we assess research related to SDG1, which aims to end poverty in all its forms everywhere. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

1.1 **Key Findings**

Goal 1: End poverty in all its forms everywhere

WORLD RESEARCH OUTPUT

21,462

Number of SDG1 publications, 2007-2016.

SDG1 PATENTS

21

Number of SDG1 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

114

Colombia's SDG1 publications, 2007-2016.

COLOMBIA RESEARCH OUTPUT CAGR

32%

Compound annual growth rate for Colombia's 2007-2016 SDG1 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

16

Colombia's SDG1 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

1.40

Average field-weighted citation impact for Colombia's SDG1 publications, 2007-2016.

1.2 SDG1 – End poverty in all its forms everywhere

According to the United Nations,

> *"Extreme poverty rates have been cut by more than half since 1990. While this is a remarkable achievement, one in five people in developing regions still live on less than $1.90 a day, and there are millions more who make little more than this daily amount, plus many people risk slipping back into poverty. Poverty is more than the lack of income and resources to ensure a sustainable livelihood. Its manifestations include hunger and malnutrition, limited access to education and other basic services, social discrimination and exclusion as well as the lack of participation in decision-making. Economic growth must be inclusive to provide sustainable jobs and promote equality."*[3]

The targets for SDG 1, according to the United Nations are:

- *"By 2030, eradicate extreme poverty for all people everywhere, measured as people living on less than $1.90 a day.*
- *By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions.*
- *Implement nationally appropriate social protection systems and measures for all, and by 2030 achieve substantial coverage of the poor and the vulnerable.*
- *By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance.*
- *By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters.*
- *Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programmes and policies to end poverty in all its dimensions.*
- *Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions."*[3]

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG1 in general, search terms were used in combination with sustainab* OR "sustainable development goal" in a query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

[3] http://www.un.org/sustainabledevelopment/poverty/

1.3 SDG1: Leaders in the field

1.3.1 Top 5 countries conducting SDG1 research

The top 5 countries publishing on SDG1 based on cumulative publication output from 2007-2016 are shown in Table 1.1 and Figure 1.1. The United States ranks 1st according to Publication Count, Percentage of Global Output, and Citation Count, followed by the United Kingdom, China, Australia and Germany. Among these countries, The United Kingdom ranks 1st in FWCI with 1.66, which is much higher than the world average of 1.05. Except for China, all other countries' FWCI exceeds the average as well.

Table 1.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	4,465	20.80%	57,491	1.45
United Kingdom	2,325	10.83%	33,383	1.66
China	1,495	6.97%	7,991	0.78
Australia	1,345	6.27%	16,254	1.48
Germany	1,100	5.13%	11,019	1.34
World	21,462	100.00%	71,016	1.05

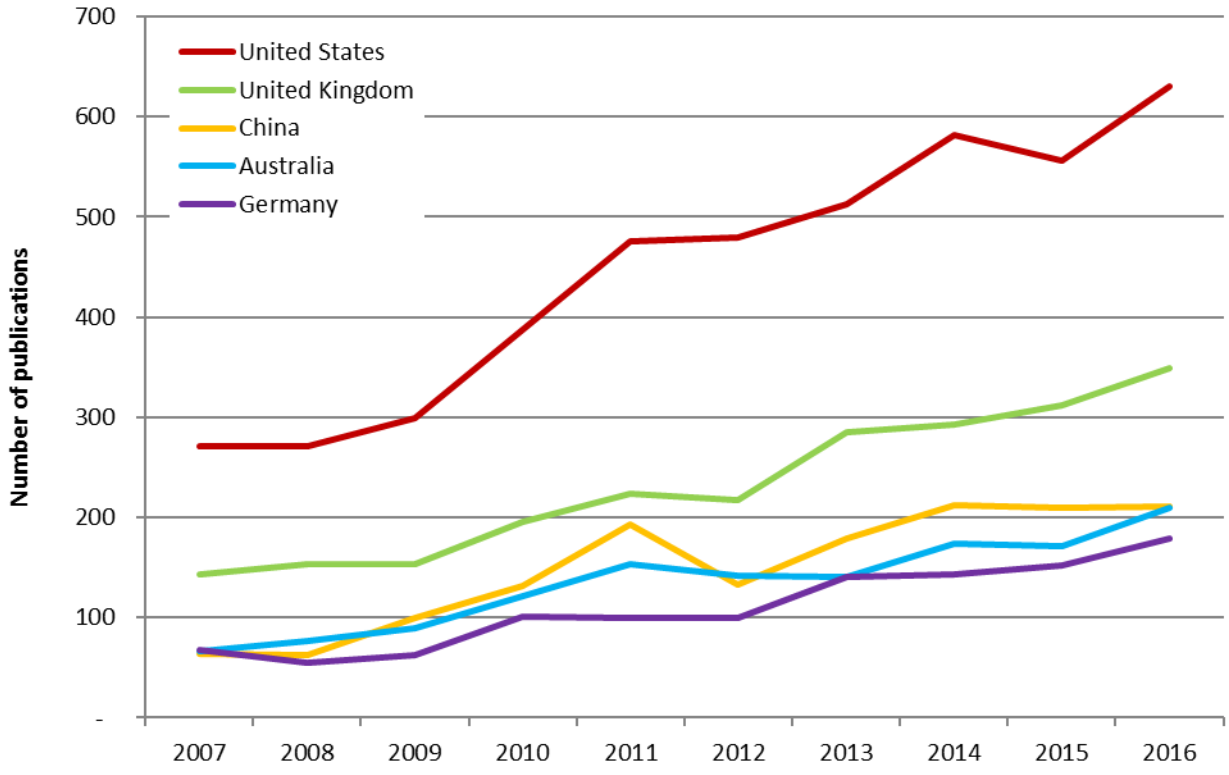


Figure 1.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG1 research. (Source: Scopus)*

1.3.2 Top 20 institutes conducting SDG1 research

A list of the top 20 research institutes publishing SDG1-related research is shown in Table 1.2. Wageningen University & Research ranks 1st in Publication Count and surpasses the next ranked institute by 80 publications. Eight institutes among the top 20 have published between 100-160 publications and the remaining top 20 have published 80-100 publications. Among the top 20 institutes, University of Minnesota has the highest FWCI at over three times the world average. Except for University of Pretoria, all the top 20 institutes have a mean FWCI above world average in this research field. The trends in publication output from 2007-2016 are shown in Figure 1.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Wageningen University & Research (Netherlands)	238	4,179	2.31
2	Chinese Academy of Sciences (China)	158	1,640	1.22
3	Harvard University (United States)	145	2,908	2.73
4	University of Queensland (Australia)	134	1,669	1.73
5	World Health Organization (Switzerland)	114	2,264	2.48
6	University of British Columbia (Canada)	113	1,978	1.86
7	United Nations (United States)	106	1,514	1.38
8	University of Cambridge (United Kingdom)	104	1,775	2.03
9	University of Oxford (United Kingdom)	103	2,361	2.79
10	CIRAD (France)	99	1,549	1.63
11	University College London (United Kingdom)	98	2,450	2.38
12	Arizona State University (United States)	95	2,247	3.12
13	University of Cape Town (South Africa)	92	1,417	1.58
14	World Bank (United States)	89	1,874	1.78
15	University of Pretoria (South Africa)	88	907	0.95
16	University of Leeds (United Kingdom)	85	1,355	1.84
17	University of Minnesota (United States)	85	1,986	3.29
18	University of Melbourne (Australia)	84	1,101	1.31
19	Imperial College London (United Kingdom)	84	2,214	2.75
20	Australian National University (Australia)	83	1,221	2.08

Table 1.2— *Top 20 research Institutes ranked based on SDG1 publication output and FWCI from 2007-2016. (Source: Scopus)*

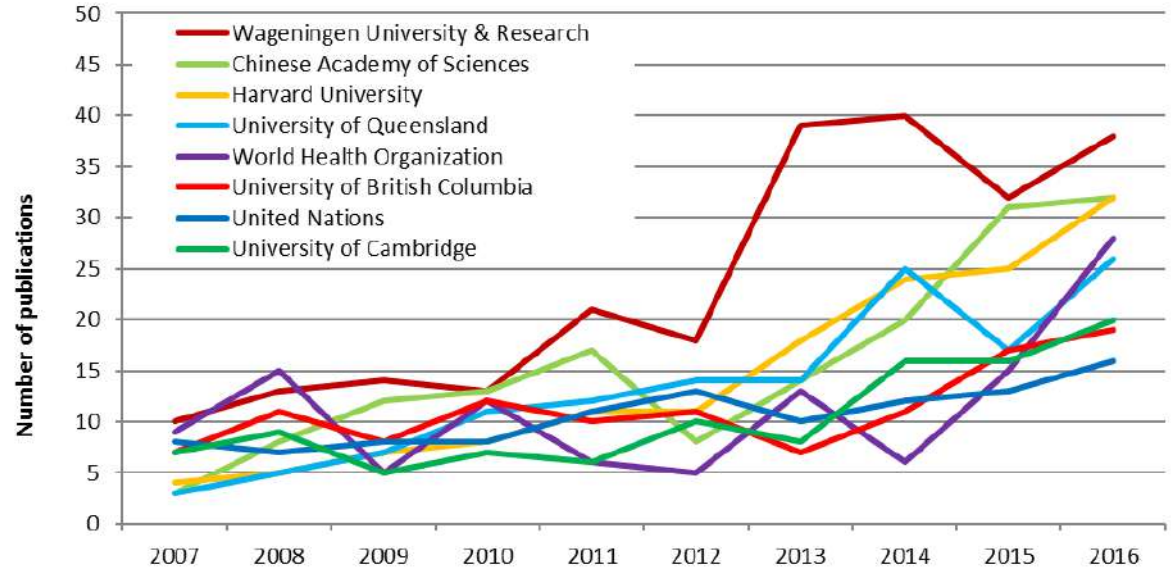


Figure 1.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG1. (Source: Scopus)*

1.3.3 Top 20 researchers conducting SDG1 research

A list of the top 20 researchers publishing in the SDG1 field based on publication output from 2007-2016 is shown in Table 1.3. Salvati L. ranks 1st in Publication Count followed by Giller K. and Bellen J. Note that the vast majority of Bellen J's publications were from 2016 and therefore any citations to this author's work are not captured in this analysis.
Giller K., Thornton P., and Herrero M. are the top 3 researchers in this list in terms of H-index.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Salvati L.	Council for Agricultural Research and Economics (CREA) (Italy)	27	186	1.12	27
2	Giller K.	Wageningen University and Research Centre (Netherlands)	22	468	2.47	54
3	Bellen J.	Hyundai Engineering and Construction Co. Ltd. (Singapore)	18	-	0.00	-
4	Siwar C.	Universiti Kebangsaan Malaysia (Malaysia)	17	43	0.29	12
5	Sovacool B.	Aarhus Universitet (Denmark)	13	409	2.35	36
6	Herrero M.	Commonwealth Scientific and Industrial Research Organization (Australia)	12	575	4.56	37
7	Erenstein O.	Centro Internacional de Mejoramiento de Maiz y Trigo (Mexico)	12	266	3.47	16
8	Ajayi O.	World World Agroforestry Centre (ICRAF) (Malawi)	12	329	2.28	17
9	Dollery B.	University of New England Australia (Australia)	12	55	1.00	18
10	Kocmanová A.	Vysoke uceni technicke v Brne (Czech Republic)	12	40	0.95	7
11	Tittonell P.	Instituto Nacional de Tecnologia Agropecuaria Buenos Aires (Argentina)	11	312	4.28	29
12	Thornton P.	International Livestock Research Institute Nairobi (Kenya)	11	598	4.06	38
13	Witter S.	Queen Margaret University (United Kingdom)	11	247	1.99	21
14	Akinnifesi F.	Food and Agriculture Organization of the United Nations (Italy)	11	306	1.61	21
15	Pavlakova Docekalova M.	Vysoke uceni technicke v Brne (Czech Republic)	11	36	0.97	4
16	Bostan I.	Information not available	11	29	0.30	5
17	Friel S.	Australian National University (Australia)	10	1,046	5.51	32
18	García-Sánchez I.	Universidad de Salamanca (Spain)	10	282	4.27	23
19	Allison E.	University of Washington, Seattle (United States)	10	220	2.87	27
20	Sileshi G.	Plot 1244 Ibex Hill (Zambia)	10	186	1.73	23

Table 1.3— *Top 20 researchers publishing SDG1 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG1 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

1.3.4 **Top 10 journals publishing SDG1 research**

A list of the top 10 journals publishing SDG1-related research from 2007-2016 is shown in Table 1.4. *Sustainability* published 241 SDG1 related publications, making it the highest ranked journal in terms of SDG1 publications. The FWCI and CiteScore for *Sustainability* is just below one. *Journal of Cleaner Production* ranks 1st in terms of FWCI and second in terms of publication count while *Renewable and Sustainable Energy Reviews* sits in the 1st place in terms of CiteScore and third in terms of publication count. Over half of the top 10 most prolific journals publishing SDG1 research have an FWCI below the world average.

Rank	Journal	Publication count	FWCI	CiteScore
1	Sustainability	247	0.99	0.92
2	Journal of Cleaner Production	186	2.77	3.70
3	Renewable and Sustainable Energy Reviews	170	1.00	7.66
4	WIT Transactions on Ecology and the Environment	137	0.09	0.08
5	Energy Policy	123	1.69	3.52
6	Acta Horticulturae	111	0.99	0.20
7	Ecological Economics	109	2.52	3.42
8	Advanced Materials Research	109	0.71	0.17
9	Land Use Policy	102	2.10	2.89
10	Proceedings of the 28th International Business Information Management Association Conference - Vision 2020: Innovation Management, Development Sustainability, and Competitive Economic Growth	96	0.07	0.00

Table 1.4— *Top 10 journals based on SDG1 publication output from 2007-2016. FWCI is mean FWCI for any SDG1 publications in the journal during the period; CiteScore is based on data for the journal as a whole (Source: Scopus)*

1.4 Research efforts focused on SDG1

1.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 1.3, the United States is by far the leader in terms of research output related to SDG1. The United Kingdom follows, along with China, Australia, and Germany. Among comparators, Colombia has the lowest output in this field, just below Mexico. However, as shown in Table 1.5, Colombia has seen the greatest growth in research output in this field with a Compound Annual Growth Rate[4] (CAGR) of 32.4%. All countries analysed have a CAGR above 9% in this field.

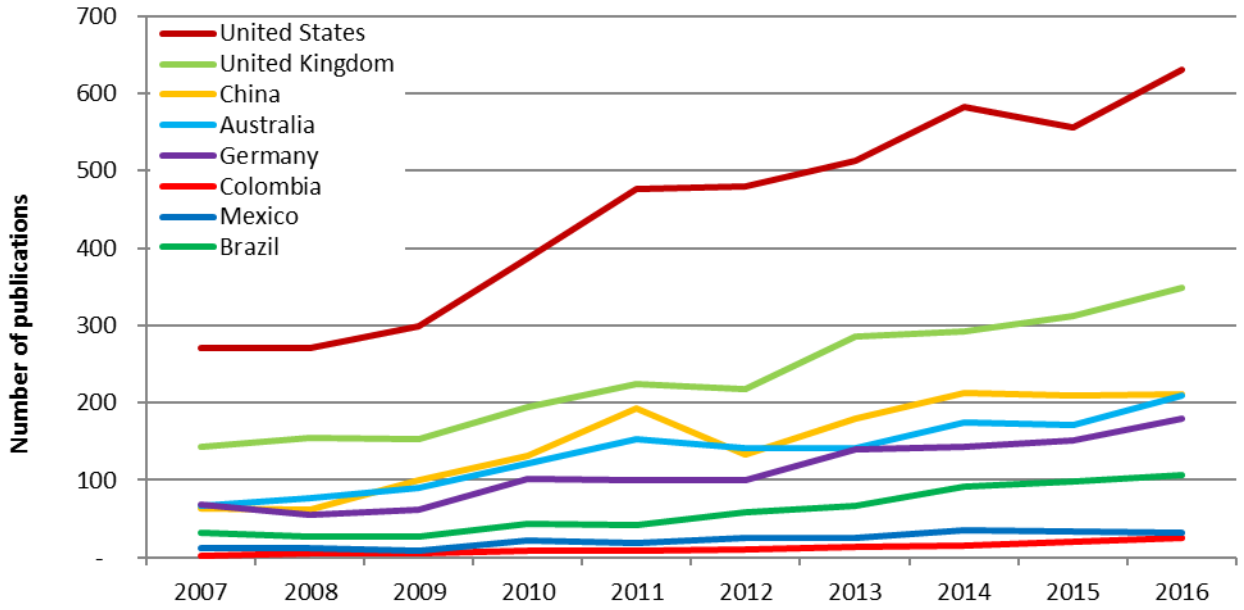


Figure 1.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	4,465	9.80%
United Kingdom	2,325	10.40%
China	1,495	14.20%
Australia	1,345	13.50%
Germany	1,100	11.40%
Colombia	114	32.40%
Mexico	222	11.50%
Brazil	591	14.40%
World	21,462	10.30%

Table 1.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

[4] Compound annual growth rate (CAGR) is defined as the year-over-year constant growth rate over a specified period of time. Starting with the first value in any series and applying this rate for each of the time intervals yields the amount in the final value of the series.

1.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI[5]). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG1 related research from 2006-2017 is 1.05.

Country	FWCI
United States	1.45
United Kingdom	1.66
China	0.78
Australia	1.48
Germany	1.34
Colombia	1.40
Mexico	1.21
Brazil	1.10
World	1.05

Comparing the FWCI of SDG1 publications from each of the eight countries included in this chapter reveals that the United Kingdom leads in terms of FWCI (Table 1.6). The United States, Australia, Germany and Colombia all have an FWCI near 1.4. Among countries analysed, only China has an FWCI below the world average for this subject.

Table 1.6— *FWCI per Comparator, 2007-2016. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

1.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 1.4 and Table 1.7, the United States leads in terms of SDG1 publications with 706 publications that are among the top 10% most cited. The United Kingdom, Australia, and Germany follow in that order. Colombia has 16 publications among the top 10% most cited during this time period. Although China has the lowest count of highly cited publications among the top 5 countries, the high CAGR for China's SDG1 publications during the period suggests that China may surpass Germany and Australia in the near future.

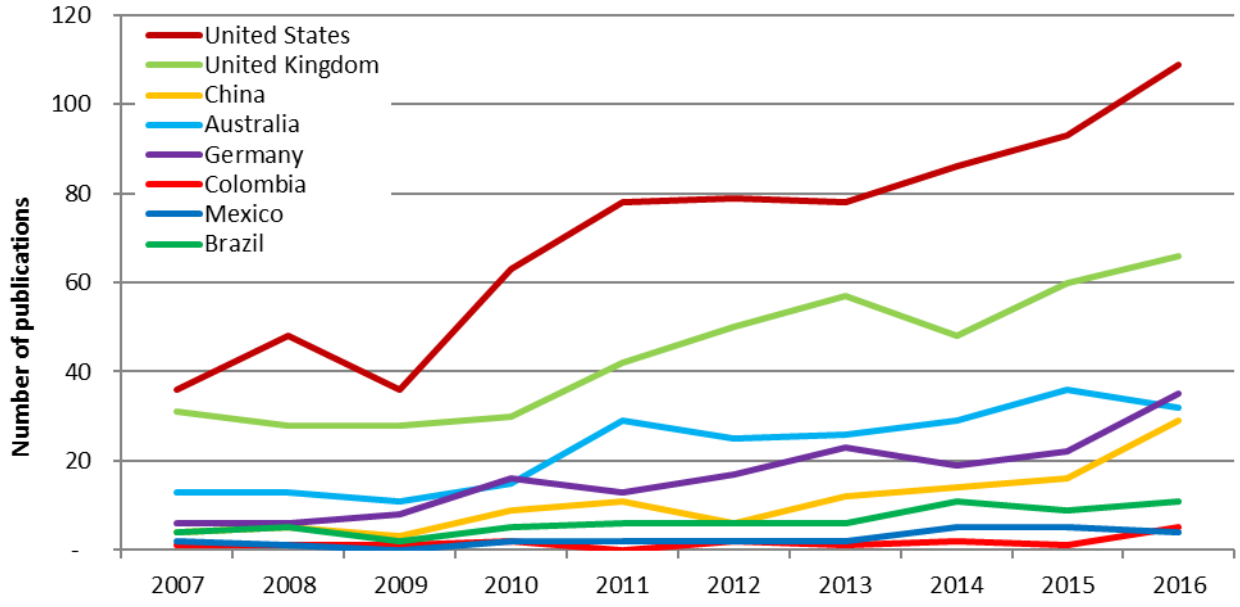


Figure 1.4— *Top 10% most cited publications on SDG1 from 2007-2016 per country. (Source: Scopus)*

[5] Field-weighted citation impact (FWCI) is an indicator of mean citation impact in which the actual number of citations received by an article is compared with the expected number of citations for articles of the same document type (article, review or conference proceeding paper), publication year and subject field.

Country	Count of Top 10% Publications	CAGR
United States	706	13.10%
United Kingdom	440	8.76%
China	109	24.62%
Australia	229	10.53%
Germany	165	21.65%
Colombia	16	19.58%
Mexico	25	8.01%
Brazil	65	11.90%
World	2,427	14.22%

Table 1.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG2 publications from 2007-2016. (Source: Scopus)*

1.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 1.8 provides the count of SDG1 publications from each country that have been cited in patents and the number of patents that have cited these publications. For the United States, 11 US publications on SDG1 have been cited in 31 patents. The United Kingdom, China and Australia also had at least one publication cited in patents. Most countries, including Colombia, have no patent citations.

Country	Patent Cited Publications	Patents Citing Publications
United States	11	31
United Kingdom	4	5
China	1	1
Australia	1	2
Germany	-	-
Colombia	-	-
Mexico	-	-
Brazil	-	-
World	29	51

Table 1.8— *Number of publications cited in USPTO, WIPO, or EPO patents and number of USPTO, WIPO, or EPO patents citing publications on SDG1 from 2007 to 2016. (Source: Scopus and LexisNexis)*

1.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG1. To identify patents relevant to SDG1, we retrieved all the patents citing any SDG1-related publication. Patents retrieved were limited to those in the following patent authorities: World Intellectual Property Organization (WIPO), European Patent Office (EPO), and United States Patent and Trademark Office (USPTO). From 2006 to 2016, the United States had the highest number of SDG1-related patents (both applied for and granted) with 10 patent applications and 19 patents granted (Table 1.9). The United Kingdom and Germany applied for a small number of patents and Colombia neither applied for, nor did it have any granted during the period. Note that China and Australia may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	10	19	29	63.04%
United Kingdom	3	-	3	6.52%
China	-	-	-	0.00%
Australia	-	-	-	0.00%
Germany	2	-	2	4.35%
Colombia	-	-	-	0.00%
Mexico	-	-	-	0.00%
Brazil	-	-	-	0.00%
World	25	21	46	

Table 1.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

1.4.6 **Research Focus**

Within the topic of SDG1-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG1-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field: the United States, United Kingdom, China, Australia, and Germany. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract, and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG1 research is shown in Figure 1.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG1 research from Colombia, terms that stand out as unique to Colombia are 'Economic Valuation', 'Health Care', 'Hospitals', 'Social Aspects', 'Emission Control', 'Agricultural Intensification', and 'Biosphere'. Among the top 50 key phrases the terms 'Smallholder,' 'Developing Countries', 'Ecosystem Service', 'Climate Change', and 'Finance' were common among the countries analyzed. Figure 1.5 provides a visualization of the top 50 key phrases for SDG1 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

Figure 1.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Mexico

Brazil

United States

United Kingdom

China

Australia

Germany

learning
food consumption
landscape
land use
adaptation
Supply chain management
carbon
Manufacture
knowledge
vulnerability
Developing countries
Climate change
innovation
biodiversity
mitigation
poverty alleviation
German
smallholder
Investments
livelihood
debt
resilience
Economics
Greens
Models
Sustainable development
management
Research
farming system
Germany
sustainability
China
Industry
Risks
food production
food security
stakeholder
food
Public policy
Finance
Supply chains
urban development
Renewable energy resources
Food supply
ecosystem service
incentive
land tenure
alternative agriculture
land degradation
empirical analysis
A A A relevance of keyphrase | declining growing (2012-2016)

1.5 The reach of Colombia's SDG1 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI),[6] is also used here.

1.5.1 Downloads

As shown in the Figure 1.6, the mean count of downloads per ScienceDirect publication is similar across all countries. For Colombia, there are some prominent peaks in 2009 and 2015. These peaks are the result of single SD articles in 2009 and 2015 from Colombia that were downloaded more than 5000 times, resulting in a high 'mean' value. It should be noted that for Colombia and Mexico, the results shown are based on very small counts of SD articles (less than 100) and should be interpreted with caution.

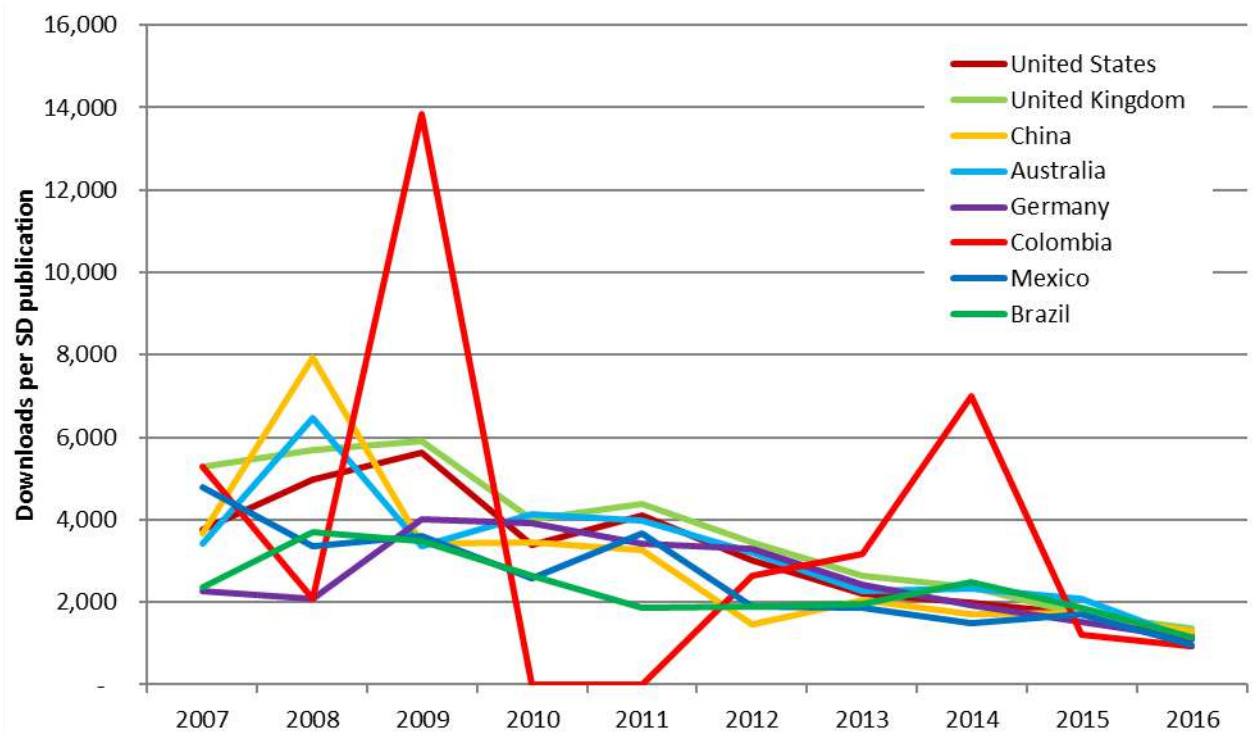


Figure 1.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

[6] Field-weighted download impact (FWDI), is an indicator that compares the actual number of downloads received by an article with the expected number of downloads for articles of the same document type (article, review or conference proceeding paper), publication year and subject field.

1.5.2 **Field Weighted Download Impact (FWDI)**

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. Interestingly, Colombia has the highest mean FWDI for the period of 2007-2016 (Figure 1.7). However, given the very low count of SD publications from Colombia, Mexico, and Brazil (i.e. less than 25 SD publications for the full period) interpretation of this metric should focus on the top 5 countries only. All top 5 countries had a FWDI near the average for all SDG1 research.

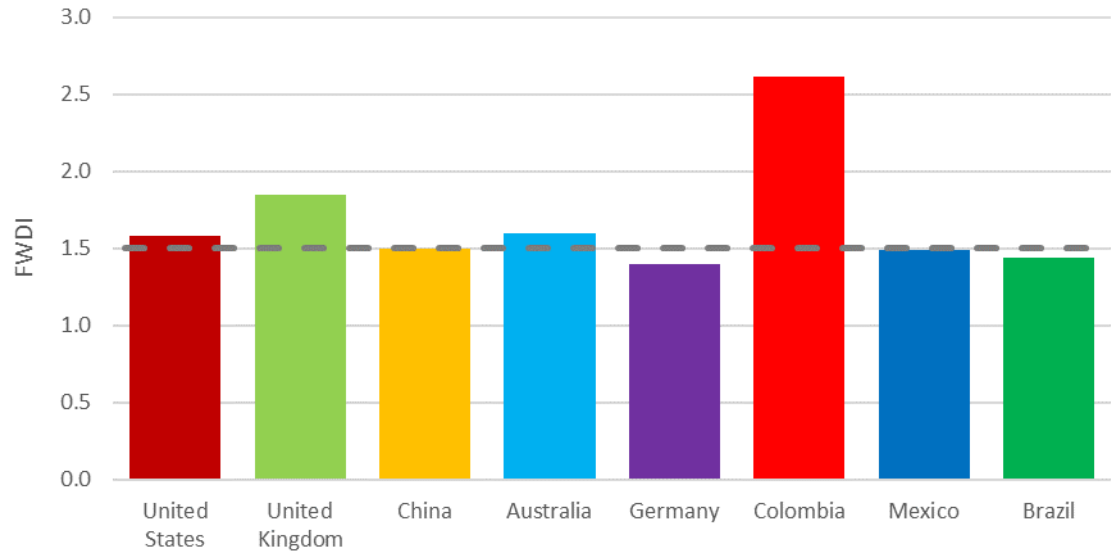


Figure 1.7 — *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. Grey dotted line indicates average for all SDG1 research. (Source: ScienceDirect)*

1.6 SDG1 collaboration network

1.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG1-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 1.10-1.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG1 publications with. Among academic partner institutes, Colombia has published the most SDG1 papers in collaboration with the world Agroforestry Centre and the International Livestock Research Institute (4 publications from 2007-2016). The FWCI for these publications was very high at more than 5 times the world average for SDG1 research.

Country	Institution (Country)	Publication Count	FWCI
Colombia	World Agroforestry Centre (Kenya)	4	7.78
	International Livestock Research Institute (Kenya)	4	5.73
	Food and Agriculture Organization of the United Nations (Italy)	3	10.86
	World Bank (United States)	3	5.48
	Stanford University (United States)	3	2.43
	Princeton University (United States)	3	1.29
	United Nations (United States)	2	14.68
	Imperial College London (United Kingdom)	2	9.97
	University of Zurich (Switzerland)	2	9.58
	Wageningen University & Research (Netherlands)	2	9.06
	International Food Policy Research Institute (United States)	2	7.27
	Arizona State University (United States)	2	7.14
	DePaul University (United States)	2	6.89
	University of Vermont (United States)	2	5.59
	University of Copenhagen (Denmark)	2	4.93
	Yale University (United States)	2	3.94
	CIRAD (France)	2	3.94
	International Institute of Tropical Agriculture (IITA), Ibadan (Nigeria)	2	3.28
	Universidad Nacional Autonoma de Mexico (Mexico)	2	1.83
	Columbia University (United States)	2	1.65

Table 1.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	Wageningen University & Research (Netherlands)	11	1.87
	Ghent University (Belgium)	4	2.07
	Michigan State University (United States)	3	3.14
	Harvard University (United States)	3	1.96
	University of Wisconsin (United States)	3	1.54
	Universidad de Buenos Aires (Argentina)	3	0.39
	Universite Toulouse III - Paul Sabatier (France)	2	21.42
	Universita Cattolica del Sacro Cuore (Italy)	2	21.42
	CHU de Toulouse (France)	2	21.42
	World Health Organization (Switzerland)	2	18.26
	International Maize and Wheat Improvement Center, Harare (Zimbabwe)	2	9.19
	INRA Institut National de La Recherche Agronomique (France)	2	4.51
	CIRAD (France)	2	4.38
	International Institute of Tropical Agriculture (IITA), Ibadan (Nigeria)	2	2.82
	University of Vermont (United States)	2	2.42
	University of Pretoria (South Africa)	2	2.28
	Universitat de Barcelona (Spain)	2	2.24
	University of California at Davis (United States)	2	2.24
	CSIRO (Australia)	2	2.22
	Cornell University (United States)	2	2.11

+

Table 1.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	University of Florida (United States)	14	3.03
	Wageningen University & Research (Netherlands)	12	2.07
	University of Oxford (United Kingdom)	11	6.73
	CIRAD (France)	9	2.68
	World Health Organization (Switzerland)	8	2.01
	Harvard University (United States)	7	11.21
	Indiana University Bloomington (United States)	6	3.48
	Yale University (United States)	6	2.73
	United Nations (United States)	6	2.28
	University of East Anglia (United Kingdom)	5	4.87
	University of Michigan (United States)	5	4.09
	University of Gottingen (Germany)	5	1.98
	Lancaster University (United Kingdom)	5	1.65
	Imperial College London (United Kingdom)	4	15.48
	Stanford University (United States)	4	11.43
	University of California at San Francisco (United States)	4	10.97
	University College London (United Kingdom)	4	9.21
	World Agroforestry Centre (Kenya)	4	5.21
	University of Edinburgh (United Kingdom)	4	5.20
	INRA Institut National de La Recherche Agronomique (France)	4	5.15

Table 1.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	World Health Organization (Switzerland)	55	2.70
	University of Cambridge (United Kingdom)	25	2.93
	University of Oxford (United Kingdom)	24	4.98
	London School of Hygiene and Tropical Medicine (United Kingdom)	24	3.05
	University of Toronto (Canada)	24	2.15
	Imperial College London (United Kingdom)	23	5.30
	University of Cape Town (South Africa)	23	2.97
	University of Queensland (Australia)	22	3.62
	Wageningen University & Research (Netherlands)	22	3.26
	World Agroforestry Centre (Kenya)	21	3.44
	Universidade de Sao Paulo (Brazil)	20	3.32
	University of East Anglia (United Kingdom)	20	3.29
	University of British Columbia (Canada)	20	2.60
	Chinese Academy of Sciences (China)	19	1.82
	McGill University (Canada)	18	5.28
	University of Pretoria (South Africa)	15	1.91
	University of Copenhagen (Denmark)	14	3.69
	International Institute for Applied Systems Analysis, Laxenburg (Austria)	14	2.13
	Food and Agriculture Organization of the United Nations (Italy)	13	5.10
	University College London (United Kingdom)	13	4.51

Table 1.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	Harvard University (United States)	29	6.47
	Wageningen University & Research (Netherlands)	27	3.95
	World Health Organization (Switzerland)	23	4.40
	United Nations (United States)	22	2.56
	University of Cape Town (South Africa)	14	3.29
	University of Copenhagen (Denmark)	13	3.69
	Stockholm Environment Institute (Sweden)	13	1.04
	World Agroforestry Centre (Kenya)	12	3.53
	Australian National University (Australia)	12	2.01
	World Bank (United States)	12	1.81
	University of the Witwatersrand (South Africa)	11	3.98
	Columbia University (United States)	11	3.37
	Lund University (Sweden)	10	6.07
	Ghent University (Belgium)	10	5.30
	Boston University (United States)	10	4.36
	University of Toronto (Canada)	10	2.87
	University of Melbourne (Australia)	10	1.24
	University of Malawi (Malawi)	9	6.74
	University of Queensland (Australia)	9	5.57
	WorldFish (Malaysia)	9	4.32

+

Table 1.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
China	Wageningen University & Research (Netherlands)	15	2.47
	Hong Kong Polytechnic University (Hong Kong)	15	1.93
	City University of Hong Kong (Hong Kong)	10	1.51
	Arizona State University (United States)	9	1.15
	University of Maryland (United States)	8	1.81
	University of Hong Kong (Hong Kong)	8	1.77
	University of Macau (Macao)	7	0.46
	University of California at Davis (United States)	6	8.95
	University of Cambridge (United Kingdom)	6	3.81
	U.S. Department of Agriculture (United States)	5	10.30
	World Health Organization (Switzerland)	5	8.08
	University of East Anglia (United Kingdom)	5	4.62
	Auburn University (United States)	5	3.80
	University of North Carolina (United States)	5	3.22
	Stanford University (United States)	5	2.17
	Leibniz Centre for Agricultural Landscape Research (ZALF), Muncheberg (Germany)	5	1.42
	Texas A and M University (United States)	5	1.17
	Syddansk Universitet (Denmark)	4	7.69
	World Agroforestry Centre (Kenya)	4	6.83
	The Ohio State University (United States)	4	5.68

+

Table 1.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for China. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Australia	University of Oxford (United Kingdom)	14	6.22
	University of Cambridge (United Kingdom)	13	2.67
	World Health Organization (Switzerland)	12	1.96
	Harvard University (United States)	11	5.97
	National University of Singapore (Singapore)	11	3.52
	United Nations (United States)	10	1.87
	University of Cape Town (South Africa)	10	1.28
	Imperial College London (United Kingdom)	9	6.31
	Wageningen University & Research (Netherlands)	9	3.32
	University of Auckland (New Zealand)	9	2.44
	University College London (United Kingdom)	8	2.66
	University of British Columbia (Canada)	8	1.87
	University of Toronto (Canada)	7	1.90
	International Livestock Research Institute (Kenya)	6	3.95
	Chinese Academy of Sciences (China)	6	1.88
	CIRAD (France)	6	1.28
	Arizona State University (United States)	5	16.96
	University of Minnesota (United States)	5	16.45
	Lund University (Sweden)	5	10.44
	University of Copenhagen (Denmark)	5	6.06

+

Table 1.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Australia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Germany	Wageningen University & Research (Netherlands)	24	2.95
	University of Zurich (Switzerland)	15	2.65
	ETH Zurich (Switzerland)	13	3.25
	Ghent University (Belgium)	9	6.23
	Erasmus University Rotterdam (Netherlands)	8	6.55
	University of Oxford (United Kingdom)	8	4.67
	Food and Agriculture Organization of the United Nations (Italy)	8	3.86
	University of Natural Resources and Applied Life Sciences (Austria)	7	3.35
	Harvard University (United States)	7	1.18
	University of Bern (Switzerland)	6	4.67
	European Commission Joint Research Centre Institute (Belgium)	6	2.73
	University of Copenhagen (Denmark)	6	2.57
	Swedish University of Agricultural Sciences (Sweden)	5	6.69
	University of East Anglia (United Kingdom)	5	5.09
	CIRAD (France)	5	3.90
	Ecole Polytechnique Federale de Lausanne (EPFL) (Switzerland)	5	3.84
	Vrije Universiteit (Netherlands)	5	3.57
	World Agroforestry Centre (Kenya)	5	3.54
	University of Southampton (United Kingdom)	5	3.49
	University of British Columbia (Canada)	5	3.42

+

Table 1.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Germany. (Source: Scopus)*

1.6.2 **Collaboration impact analysis**

To visualize the citation impact of collaborations, the ratio of FWCI from SDG1 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG1 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG1 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. For SDG1 research from 2007-2016, the majority of Colombia's collaborations with its top 20 academic partners were mutually beneficial to both Colombia and the collaboration partner (Figure 1.8). The two publications resulting from collaboration with the United Nations have been highly mutually beneficial.

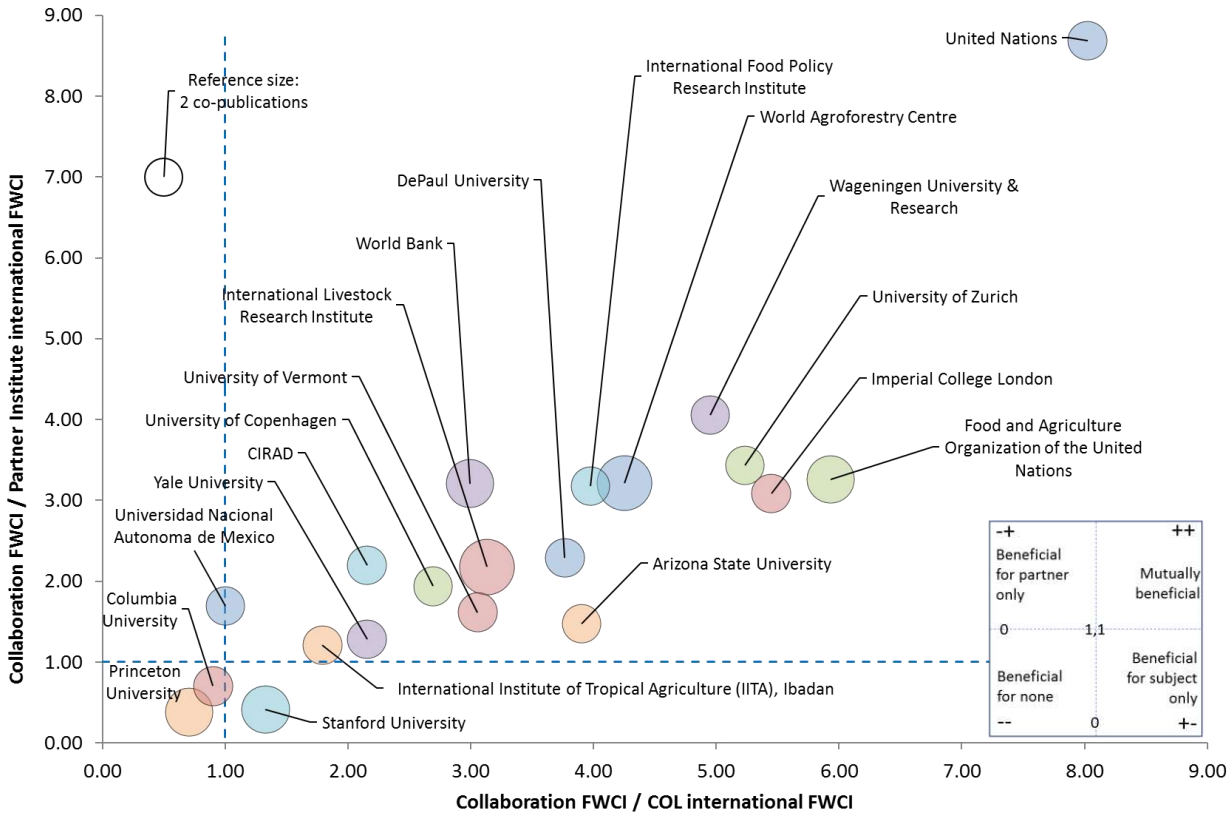


Figure 1.8— *Collaboration quadrant of Colombia's Top 20 collaborations in SDG1-related research with other institutions. Collaboration FWCI refers to the FWCI of all SDG1-related research co-authored by Colombia and the partner institute during the period 2007-2016. Bubble size corresponds to number of co-authored publications (reference bubble depicted at top left of chart). Impact of collaboration between partners can be interpreted based on quadrant position as described in legend on right. (Source: Scopus).*

1.6.3 **Collaboration chart**

Figure 1.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG1. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 1.9 shows where there may be potential to improve output and impact through partnership. Among Colombia's top 20 partners, Wageningen University & Research produces the highest number of SDG1 publications with 238 publications followed by the United Nations, which produces 106 SDG1-related publications. Among Colombia's top 20 partners, Stanford University and Arizona State University have the highest FWCI for SDG1 research. Colombia may want to leverage its existing relationships with these institutes to increase its publication output and impact in SDG1 research.

Figure 1.9— *Chart showing Colombia's top 20 collaborators on SDG1 from 2007-2016. Circle (node) size is proportional to the number of SDG1 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (3.12) and lightest shade of green indicating the lowest FWCI (0.88). (Source: Scopus).*

Chapter 2
Zero Hunger

In this Chapter, we assess research related to SDG2, which aims to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

2.1 **Key Findings**

Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture

WORLD RESEARCH OUTPUT

40,363

Number of SDG2 publications, 2007-2016.

SDG2 PATENTS

434

Number of SDG2 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

240

Colombia's SDG2 publications, 2007-2016.

COLOMBIA RESEARCH OUTPUT CAGR

32%

Compound annual growth rate for Colombia's 2007-2016 SDG2 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

44

Colombia's SDG2 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

1.77

Average field-weighted citation impact for Colombia's SDG2 publications, 2007-2016.

2.2 SDG2 – End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

According to the United Nations,

> *"Right now, our soils, freshwater, oceans, forests and biodiversity are being rapidly degraded. Climate change is putting even more pressure on the resources we depend on, increasing risks associated with disasters such as droughts and floods. Many rural women and men can no longer make ends meet on their land, forcing them to migrate to cities in search of opportunities.*
> *A profound change of the global food and agriculture system is needed if we are to nourish today's 815 million hungry and the additional 2 billion people expected by 2050.*
> *The food and agriculture sector offers key solutions for development, and is central for hunger and poverty eradication."*[7]

The targets for SDG2, according to the United Nations are:

- *"By 2030, end hunger and ensure access by all people, especially the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.*
- *By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons.*
- *By 2030, double the agricultural productivity and income of small-scale food producers, especially women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.*
- *By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.*
- *By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed.*
- *Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries.*
- *Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round.*
- *Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility."*[7]

[7] http://www.un.org/sustainabledevelopment/hunger/

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG2 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

2.3 SDG2: Leaders in the field

2.3.1 Top 5 countries conducting SDG2 research

The top 5 countries publishing on SDG2 based on cumulative publication output from 2007-2016 are shown in Table 2.1 and Figure 2.1. The United States ranks 1st according to Publication Count, Percentage of Global Output, and Citation Count, followed by China, the United Kingdom, Australia and Germany. The United Kingdom ranks 1st in FWCI with an FWCI of 2.12, which is approximately double the world average for SDG2 research. Except for India and China, all other countries' FWCI exceed the global average as well.

Table 2.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	8,040	19.92%	157,156	1.77
China	4,994	12.37%	46,606	1.02
United Kingdom	3,111	7.71%	76,008	2.12
India	3,037	7.52%	31,459	0.95
Australia	2,582	6.40%	48,913	1.78
World	40,363	100.00%	192,492	1.21

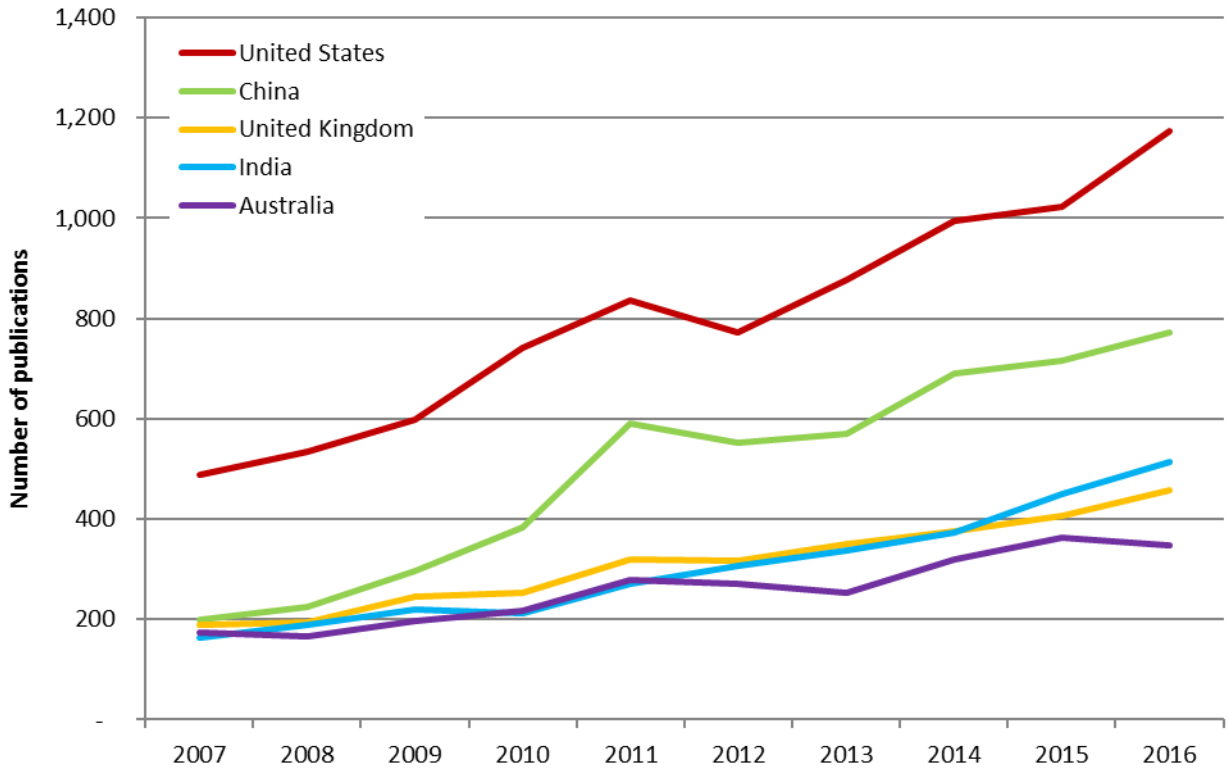


Figure 2.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG2 research. (Source: Scopus)*

2.3.2 Top 20 institutes conducting SDG2 research

A list of the top 20 research institutes publishing SDG2-related research is shown in Table 2.2. The Chinese Academy of Sciences (in China) ranks 1st in Publication Count with over 1,000 SDG2 publications and is closely followed by Wageningen University & Research (from the Netherlands). Four institutes among the top 20 have published above 500 SDG2 publications and the remaining top 20 have published approximately 200-400 SDG2 publications. Among the top 20 institutes, Cornell University (United States) has the highest FWCI at over three times the world average. The trends in publication output from 2007-2016 are shown in Figure 2.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Chinese Academy of Sciences (China)	1,042	13,295	1.14
2	Wageningen University & Research (Netherlands)	900	23,843	2.54
3	U.S. Department of Agriculture (United States)	794	19,058	2.04
4	INRA Institut National de La Recherche Agronomique (France)	695	16,930	2.10
5	China Agricultural University (China)	404	5,067	1.38
6	CSIRO (Australia)	389	13,283	2.37
7	CIRAD (France)	329	5,306	1.62
8	CNRS (France)	307	7,193	2.28
9	Universidade de Sao Paulo (Brazil)	287	4,170	1.73
10	Embrapa - Empresa Brasileira de Pesquisa Agropecuaria (Brazil)	285	3,895	1.31
11	CSIC (Spain)	280	6,319	1.91
12	University of Florida (United States)	272	5,125	1.66
13	University of Queensland (Australia)	270	6,848	2.38
14	University of California at Davis (United States)	263	7,278	2.46
15	Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences (China)	253	3,101	1.16
16	Northwest Agriculture and Forestry University (China)	245	2,363	1.14
17	Swedish University of Agricultural Sciences (Sweden)	242	5,347	1.84
18	Michigan State University (United States)	241	5,259	2.23
19	Ghent University (Belgium)	239	4,533	2.13
20	Cornell University (United States)	236	7,994	2.68

Table 2.2— *Top 20 research Institutes ranked based on SDG2 publication output and FWCI from 2007-2016. (Source: Scopus)*

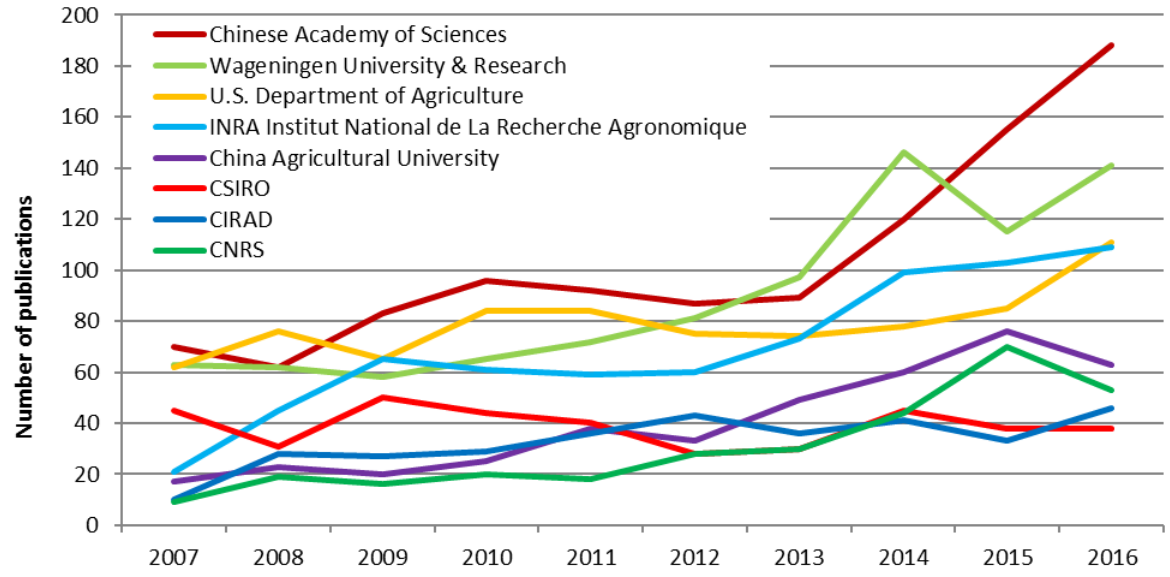


Figure 2.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG2. (Source: Scopus)*

2.3.3 Top 20 researchers conducting SDG2 research

A list of the top 20 researchers publishing in the SDG2 field based on publication output from 2007-2016 is shown in Table 2.3. Lal R. ranks 1st in Publication Count followed by Salvati L. and Zhang F.
Lal R. and Zhang F. also have the highest h-index, along with Smith P.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Lal R.	Ohio State University (United States)	83	1,950	1.99	76
2	Salvati L.	Council for Agricultural Research and Economics (CREA) (Italy)	52	422	1.32	27
3	Zhang F.	China Agricultural University (China)	45	1,398	2.74	72
4	Giller K.	Wageningen University and Research Centre (Netherlands)	33	1,085	2.86	54
5	Smith P.	University of Aberdeen (United Kingdom)	32	1,574	4.50	71
6	van Ittersum M.	Wageningen University and Research Centre (Netherlands)	26	1,559	5.84	35
7	Deckers J.	KU Leuven (Belgium)	25	803	2.01	47
8	Venkateswarlu B.	Central Research Institute for Dryland Agriculture India (India)	25	350	1.50	18
9	Shao H.	Jiangsu Academy of Agricultural Sciences (China)	25	563	0.84	34
10	Stringer L.	University of Leeds (United Kingdom)	24	355	2.10	29
11	Bonari E.	Scuola Superiore Sant'Anna di Studi Universitari e di Perfezionamento (Italy)	23	227	1.20	26
12	Herrero M.	Commonwealth Scientific and Industrial Research Organization (Australia)	22	984	5.60	37
13	Faaij A.	University of Groningen (Netherlands)	22	1,404	5.56	61
14	Cerri C.	Universidade de Sao Paulo - USP (Brazil)	22	420	2.20	29
15	Chauhan B.	University of Queensland (Australia)	22	463	2.20	29
16	Chen B.	Beijing Normal University (China)	22	565	1.95	46
17	YANG Z.	Beijing Normal University (China)	22	418	1.55	50
18	Wani S.	International Crops Research Institute for the Semi-Arid Tropics (India)	22	191	0.72	20
19	Reed M.	Newcastle University, United Kingdom (United Kingdom)	21	508	2.64	35

Table 2.3— *Top 20 researchers publishing SDG2 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG2 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

2.3.4 **Top 10 journals publishing SDG2 research**

A list of the top 10 journals publishing SDG2-related research from 2007-2016 is shown in Table 2.4. *Acta Horticulturae* published 685 SDG2 related publications, making it the top journal in terms of SDG2 publications. The FWCI for *Acta Horticulturae* is just below one and the CiteScore is well below one, indicating that for three years after publication, articles in this journal receive less than one citation on average. *Journal of Cleaner Production* ranks 1st in terms of FWCI and ranks 8th in terms of publication count while *Renewable and Sustainable Energy Reviews* sits in the 1st place in terms of CiteScore and last in terms of publication count.

Rank	Journal	Publication count	FWCI	CiteScore
1	Acta Horticulturae	685	0.95	0.20
2	Sustainability	440	1.00	0.92
3	Acta Ecologica Sinica	352	0.22	0.55
4	Agriculture, Ecosystems and Environment	332	2.67	3.50
5	Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering	326	0.48	0.79
6	PLoS ONE	304	1.56	4.29
7	Agronomy for Sustainable Development	297	1.34	3.17
8	Journal of Cleaner Production	282	2.75	3.70
9	Advanced Materials Research	278	0.38	0.17
10	Renewable and Sustainable Energy Reviews	246	1.30	7.66

Table 2.4— *Top 10 journals based on SDG2 publication output from 2007-2016. FWCI is mean FWCI for any SDG2 publications in the journal during the period; CiteScore is based on data for the journal as a whole (Source: Scopus)*

2.4 Research efforts focused on SDG2

2.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 2.3, the United States is by far the leader in terms of research output related to SDG2. China follows, with more than half the publication count of the United States. The United Kingdom, India and Australia follow with 2,500-3,100 SDG2 publications. Among comparators, Colombia has the lowest output in this field, just below Mexico. However, as shown in Table 2.5, Colombia has seen the greatest growth in research output in this field with a Compound Annual Growth Rate (CAGR) of 32.0%. All other countries analysed here have a CAGR ranging from 8-17%.

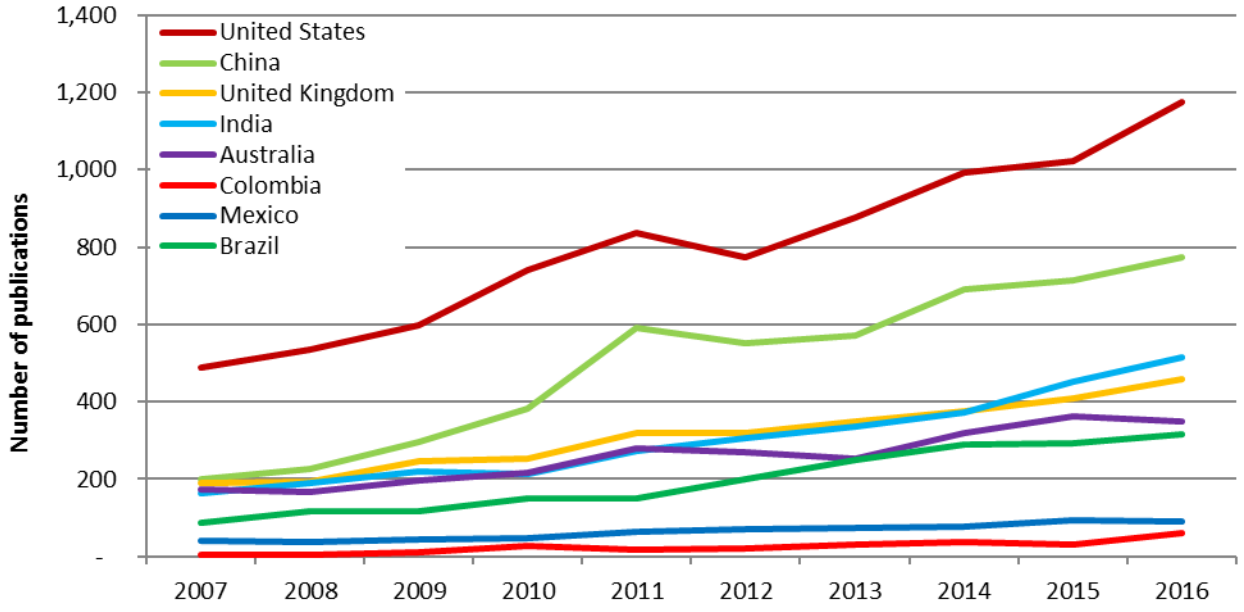


Figure 2.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	8,040	10.20%
China	4,994	16.30%
United Kingdom	3,111	10.40%
India	3,037	13.60%
Australia	2,582	8.10%
Colombia	240	32.00%
Mexico	635	9.40%
Brazil	1,972	15.30%
World	40,363	9.70%

Table 2.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

2.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG2 related research from 2006-2017 is 1.21.

Country	FWCI
United States	1.77
China	1.02
United Kingdom	2.12
India	0.95
Australia	1.78
Colombia	1.77
Mexico	1.39
Brazil	1.18
World	1.21

Comparing the FWCI of SDG2 publications from each of the eight countries included in this chapter reveals that the United Kingdom leads in terms of FWCI (Table 2.6). The United States, Australia, and Colombia all have an FWCI near 1.8. Among countries analysed, China and Brazil have an FWCI below the world average for this subject.

Table 2.6— *FWCI per Comparator, 2007-2016. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

2.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 2.4 and Table 2.7, the United States leads in terms of SDG2 publications with 1,623 publications that are among the top 10% most cited. The United Kingdom lags behind the United States with less than half the number of top 10% publications, followed by Australia and China, which both have a similar count. Colombia had 44 publications among the top 10% most cited during this time period.

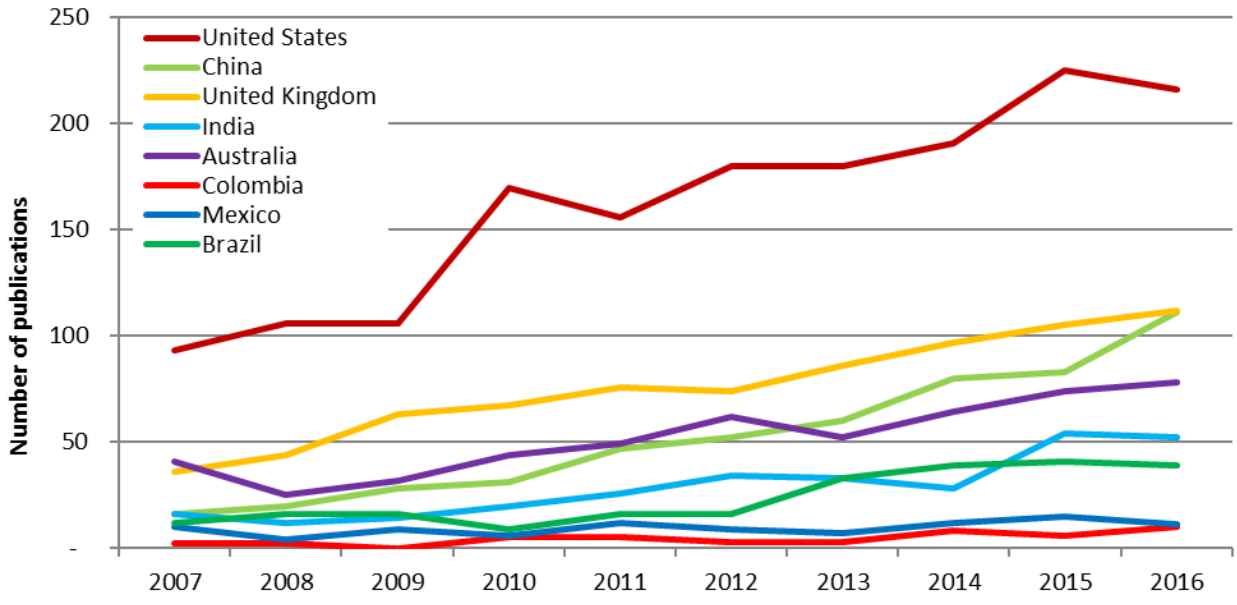


Figure 2.4— *Top 10% most cited publications on SDG2 from 2007-2016 per country. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
United States	1,623	9.82%
China	528	24.01%
United Kingdom	760	13.44%
India	289	13.99%
Australia	521	7.41%
Colombia	44	19.58%
Mexico	95	1.06%
Brazil	237	13.99%
World	5,312	11.50%

Table 2.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG2 publications from 2007-2016. (Source: Scopus)*

2.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 2.8 provides the count of SDG1 publications from each country that have been cited in patents and the number of patents that have cited these publications. The findings show that patent citation count is related to publication count in that the leaders in publication output have the highest patent citation count. Interestingly, Mexico has a large count of patents citing SDG2 publications relative to Mexico's total publications output in SDG2 related research.

Country	Patent Cited Publications	Patents Citing Publications
United States	121	398
China	32	73
United Kingdom	33	62
India	23	44
Australia	26	62
Colombia	3	3
Mexico	8	32
Brazil	6	8
World	344	993

Table 2.8— *Number of publications cited in patent and patents citing publications on SDG2 from 2007 to 2016. (Source: Scopus)*

2.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG2. To identify patents relevant to SDG2, we retrieved all the patents citing any SDG2-related publication. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO. From 2006 to 2016, the United States had the highest number of SDG2-related patents (both applied for and granted) with 139 patent applications and 338 patents granted (Table 2.9). The United Kingdom and Australia had a total of approximately 35 patents each and Colombia applied for one patent, and had one granted during the period. Note that China, India and, Australia may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	139	338	477	59.18%
China	9	6	15	1.86%
United Kingdom	24	14	38	4.71%
India	12	1	13	1.61%
Australia	11	23	34	4.22%
Colombia	1	1	2	0.25%
Mexico	-	-	-	0.00%
Brazil	1	1	2	0.25%
World	372	434	806	

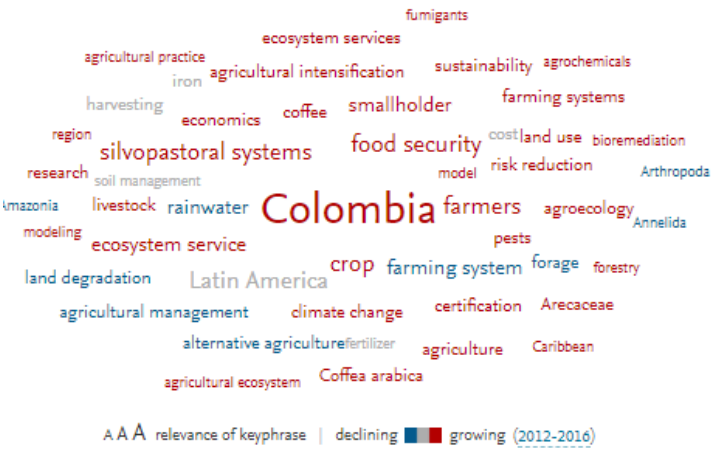
Table 2.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

2.4.6 **Research Focus**

Within the topic of SDG2-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG2-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field: the United States, United Kingdom, China, Australia, and Germany. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG2 research is shown in Figure 2.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG2 research from Colombia, there were no terms that stand out as unique to only Colombia. Terms that were shared with only one comparator are 'Silvopastoral Systems,' and 'Risk Reduction', which were also shared with Mexico; 'Coffee' and Agroecology,' which were also shared with Brazil; and 'Economics,' which was shared with Australia. Among the top 50 key phrases the terms 'Farmers', 'Food Security', 'Alternative Agriculture', were common among the countries analyzed. Figure 2.5 provides a visualization of the top 50 key phrases for SDG2 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

Colombia



Mexico

Figure 2.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Brazil

United States

China

United Kingdom

India

Australia

2.5 The reach of Colombia's SDG2 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

2.5.1 Downloads

As shown in the Figure 2.6, the mean count of downloads per ScienceDirect publication is similar across all countries. For Colombia, there is a prominent peaks in 2008, resulting from a single highly downloaded SD publication.

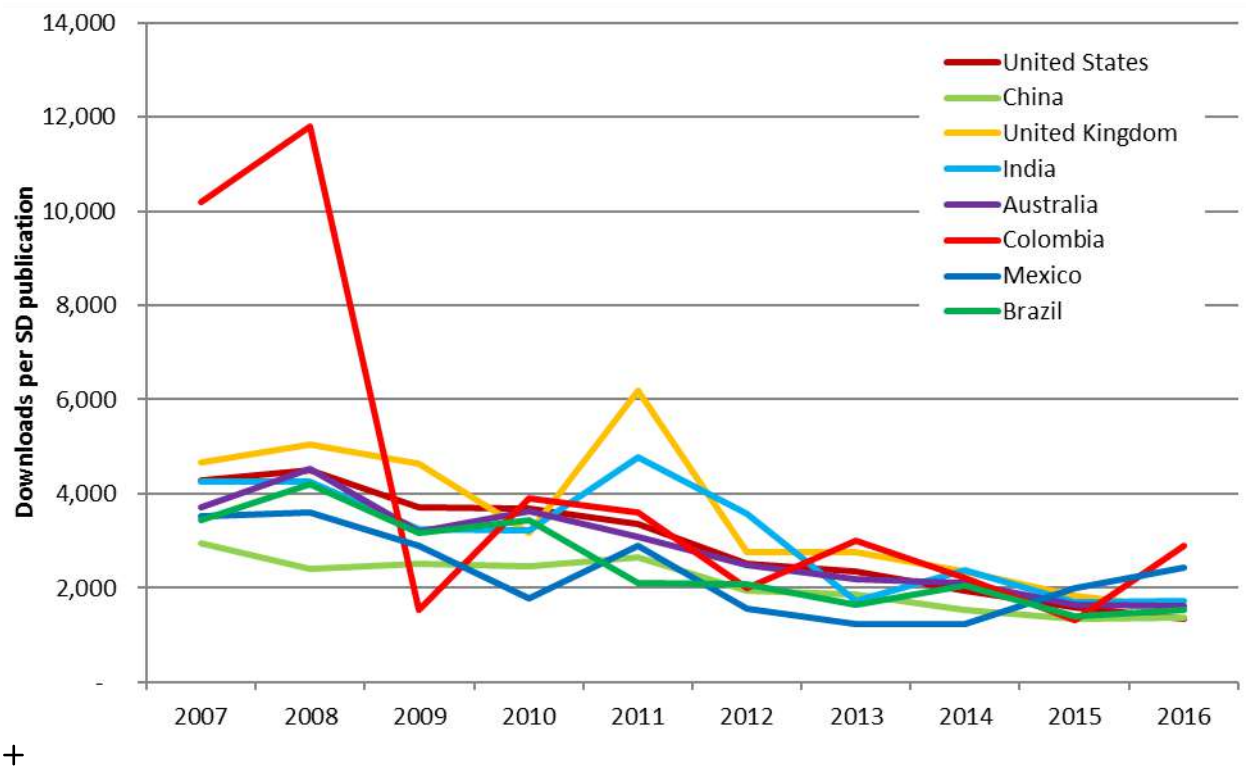


Figure 2.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

2.5.2 **Field Weighted Download Impact (FWDI)**

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. Colombia's high mean FWDI for the period of 2007-2016 is due to the few highly downloaded SD articles mentioned in section 2.5.1 (Figure 2.7). However, given the very low count of SD publications from Colombia and Mexico, (i.e. less than 25 SD publications for the full period) interpretation of this metric should focus on the top 5 countries only. All top 5 countries had an FWDI near the average for all SDG2 research.

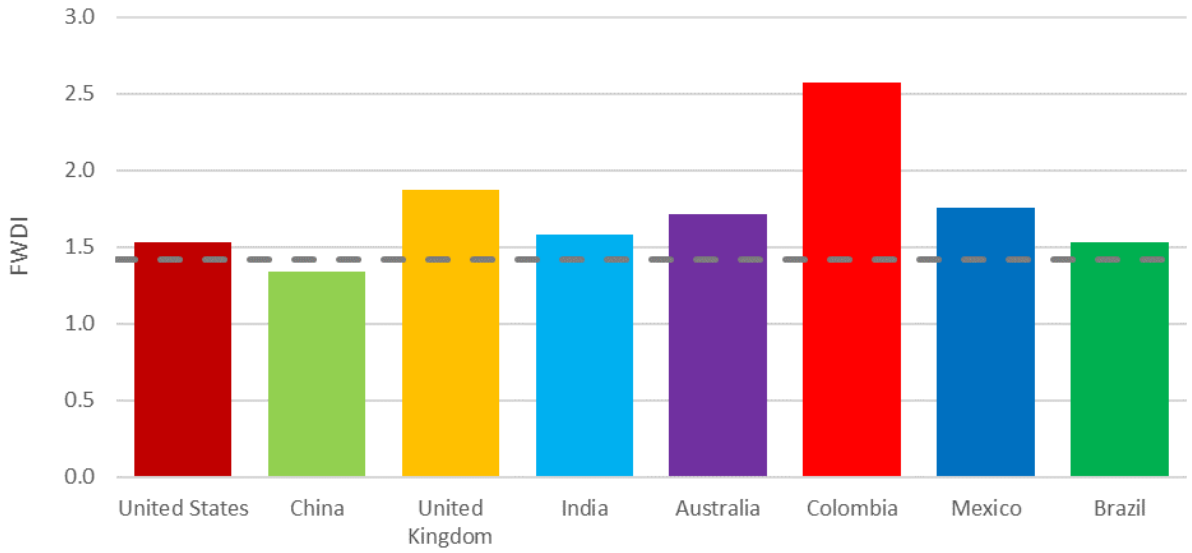


Figure 2.7 — *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. Grey dotted line indicates average for all SDG2 research. (Source: ScienceDirect)*

2.6 SDG2 collaboration network

2.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG2-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 2.10-2.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG2 publications with. Among academic partner institutes, Colombia has published the most SDG2 papers in collaboration with Wageningen University & Research (Netherlands; 14 publications from 2007-2016). The FWCI for these publications was very high at nearly 4 times the world average for SDG2 research. However, the highest mean FWCI results from Colombia's collaborations with the Food and Agriculture Organization of the United Nations, which has a mean FWCI of 14.6.

Country	Institution (Country)	Publication Count	FWCI
Colombia	Wageningen University & Research (Netherlands)	14	5.84
	International Crops Research Institute for the Semi-Arid Tropics (India)	9	4.46
	IRD (France)	8	3.14
	Stanford University (United States)	7	7.95
	United Nations (United States)	6	11.56
	University of Cambridge (United Kingdom)	6	11.03
	INRA Institut National de La Recherche Agronomique (France)	6	9.74
	Aarhus University (Denmark)	6	8.37
	International Food Policy Research Institute (United States)	6	4.31
	CSIC (Spain)	6	3.50
	Universite Pierre et Marie Curie (France)	6	1.99
	Food and Agriculture Organization of the United Nations (Italy)	5	14.62
	University of Melbourne (Australia)	5	13.72
	Universidade de Sao Paulo (Brazil)	5	13.33
	Yale University (United States)	5	11.57
	Columbia University (United States)	5	9.53
	Chinese Academy of Agricultural Sciences (China)	5	8.78
	World Agroforestry Centre (Kenya)	5	6.71
	Universidad Nacional Autonoma de Mexico (Mexico)	5	6.56
	U.S. Department of Agriculture (United States)	5	4.79

+

Table 2.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	Wageningen University & Research (Netherlands)	32	4.71
	KU Leuven (Belgium)	19	2.27
	University of Arizona (United States)	15	3.34
	U.S. Department of Agriculture (United States)	12	3.19
	INRA Institut National de La Recherche Agronomique (France)	11	4.03
	Texas A and M University (United States)	11	1.33
	CSIRO (Australia)	9	5.38
	University of Wisconsin (United States)	9	4.20
	Ghent University (Belgium)	9	3.15
	International Crops Research Institute for the Semi-Arid Tropics (India)	8	3.12
	Cornell University (United States)	7	7.56
	Banaras Hindu University (India)	7	7.38
	Universidade de Sao Paulo (Brazil)	7	6.70
	CNRS (France)	7	4.65
	CSIC (Spain)	7	2.54
	University of California at Davis (United States)	7	1.80
	Mekelle University (Ethiopia)	6	7.79
	The Ohio State University (United States)	6	7.46
	Universidad Nacional de Colombia (Colombia)	6	7.35
	University of East Anglia (United Kingdom)	6	4.79

Table 2.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	U.S. Department of Agriculture (United States)	41	3.04
	Wageningen University & Research (Netherlands)	40	3.90
	INRA Institut National de La Recherche Agronomique (France)	35	4.22
	CIRAD (France)	32	1.95
	University of Florida (United States)	31	2.43
	University of East Anglia (United Kingdom)	21	6.26
	IRD (France)	17	3.26
	CSIRO (Australia)	17	2.77
	Colorado State University (United States)	16	4.45
	University of Oxford (United Kingdom)	14	4.24
	University of Aberdeen (United Kingdom)	12	7.14
	CNRS (France)	12	4.53
	The Ohio State University (United States)	12	4.43
	Universidad Nacional Autonoma de Mexico (Mexico)	12	4.04
	University of Queensland (Australia)	11	7.86
	AgroParisTech (France)	11	5.35
	Yale University (United States)	10	8.36
	University of California at Davis (United States)	10	5.04
	Swedish University of Agricultural Sciences (Sweden)	10	3.22
	Stanford University (United States)	9	8.90

+

Table 2.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	Chinese Academy of Sciences (China)	152	1.93
	Wageningen University & Research (Netherlands)	113	4.69
	CSIRO (Australia)	64	4.37
	China Agricultural University (China)	62	2.18
	Universidade de Sao Paulo (Brazil)	58	2.72
	INRA Institut National de La Recherche Agronomique (France)	49	4.04
	University of British Columbia (Canada)	47	5.78
	Swedish University of Agricultural Sciences (Sweden)	46	3.32
	Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences (China)	46	1.53
	Embrapa - Empresa Brasileira de Pesquisa Agropecuaria (Brazil)	45	1.90
	Food and Agriculture Organization of the United Nations (Italy)	42	6.43
	ETH Zurich (Switzerland)	42	4.22
	University of Oxford (United Kingdom)	41	5.38
	CNRS (France)	40	4.76
	University of Copenhagen (Denmark)	39	4.42
	University of Cambridge (United Kingdom)	37	8.84
	McGill University (Canada)	37	7.91
	World Agroforestry Centre (Kenya)	37	3.76
	University of Queensland (Australia)	36	7.14
	Imperial College London (United Kingdom)	32	4.80

+

Table 2.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
China	U.S. Department of Agriculture (United States)	73	3.35
	Wageningen University & Research (Netherlands)	58	3.24
	AgriFood Canada (Canada)	41	1.83
	CSIRO (Australia)	37	2.25
	Colorado State University (United States)	33	1.41
	University of Western Australia (Australia)	31	3.72
	University of California at Davis (United States)	24	3.86
	Texas A and M University (United States)	23	1.63
	International Institute for Applied Systems Analysis, Laxenburg (Austria)	21	2.40
	Arizona State University (United States)	21	2.09
	University of Melbourne (Australia)	19	4.18
	The Ohio State University (United States)	18	4.61
	University of Florida (United States)	18	2.02
	University of Tokyo (Japan)	17	3.22
	Chinese University of Hong Kong (Hong Kong)	17	2.55
	Purdue University (United States)	17	2.44
	University of British Columbia (Canada)	16	4.24
	University of Queensland (Australia)	16	3.65
	World Agroforestry Centre (Kenya)	16	3.17
	University of Hohenheim (Germany)	16	2.83

+

Table 2.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for China. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	Wageningen University & Research (Netherlands)	120	4.06
	INRA Institut National de La Recherche Agronomique (France)	66	3.44
	CSIRO (Australia)	44	5.16
	University of Copenhagen (Denmark)	40	4.38
	Swedish University of Agricultural Sciences (Sweden)	40	2.82
	CNRS (France)	36	3.66
	Aarhus University (Denmark)	33	3.51
	Chinese Academy of Sciences (China)	33	2.44
	Food and Agriculture Organization of the United Nations (Italy)	30	8.33
	World Agroforestry Centre (Kenya)	29	3.25
	CSIC (Spain)	29	1.74
	James Cook University Queensland (Australia)	28	6.70
	Ghent University (Belgium)	28	4.07
	China Agricultural University (China)	28	3.74
	University of Western Australia (Australia)	25	4.37
	University of Queensland (Australia)	24	9.87
	Harvard University (United States)	24	9.14
	United Nations (United States)	24	4.17
	Universidade de Sao Paulo (Brazil)	24	4.17
	U.S. Department of Agriculture (United States)	24	3.65

+

Table 2.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
India	Wageningen University & Research (Netherlands)	34	4.58
	The Ohio State University (United States)	28	3.42
	International Rice Research Institute (Philippines)	25	2.76
	University of Queensland (Australia)	19	8.93
	International Livestock Research Institute (Kenya)	17	3.24
	International Maize and Wheat Improvement Center (CIMMYT) (Mexico)	15	3.15
	International Water Management Institute (Sri Lanka)	14	2.17
	International Centre for Genetic Engineering and Biotechnology (Italy)	14	2.05
	University of Aberdeen (United Kingdom)	12	8.87
	University of Melbourne (Australia)	12	6.93
	University of Western Australia (Australia)	12	6.03
	University of Oxford (United Kingdom)	11	7.29
	London School of Hygiene and Tropical Medicine (United Kingdom)	11	6.32
	U.S. Department of Agriculture (United States)	11	3.37
	CSIRO (Australia)	11	2.12
	United Nations (United States)	10	7.53
	University of Florida (United States)	10	1.68
	Food and Agriculture Organization of the United Nations (Italy)	9	18.70
	Columbia University (United States)	9	5.65
	World Agroforestry Centre (Kenya)	9	5.00

+

Table 2.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for India. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Australia	Wageningen University & Research (Netherlands)	57	5.65
	Chinese Academy of Sciences (China)	50	2.19
	U.S. Department of Agriculture (United States)	36	3.11
	INRA Institut National de La Recherche Agronomique (France)	20	3.92
	International Rice Research Institute (Philippines)	20	2.51
	China Agricultural University (China)	20	2.41
	Swedish University of Agricultural Sciences (Sweden)	19	3.50
	University of Agriculture Faisalabad (Pakistan)	19	1.90
	Chinese Academy of Agricultural Sciences (China)	19	1.45
	Imperial College London (United Kingdom)	18	6.31
	International Livestock Research Institute (Kenya)	18	5.02
	National University of Singapore (Singapore)	16	5.76
	University of Leeds (United Kingdom)	16	4.50
	International Crops Research Institute for the Semi-Arid Tropics (India)	16	4.12
	International Water Management Institute (Sri Lanka)	16	3.01
	Food and Agriculture Organization of the United Nations (Italy)	15	11.65
	Harvard University (United States)	15	8.63
	University of Copenhagen (Denmark)	15	6.10
	Cornell University (United States)	15	4.57
	University of California at Davis (United States)	15	1.81

+

Table 2.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Australia. (Source: Scopus)*

2.6.2 **Collaboration impact analysis**

To visualize the citation impact of collaborations, the ratio of FWCI from SDG2 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG2 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG2 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. For SDG2 research from 2007-2016, all except one of Colombia's collaborations with its top 20 academic partners were mutually beneficial to both Colombia and the collaboration partner (Figure 2.8). The two publications resulting from collaboration with the United Nations have been highly mutually beneficial in terms of citation impact.

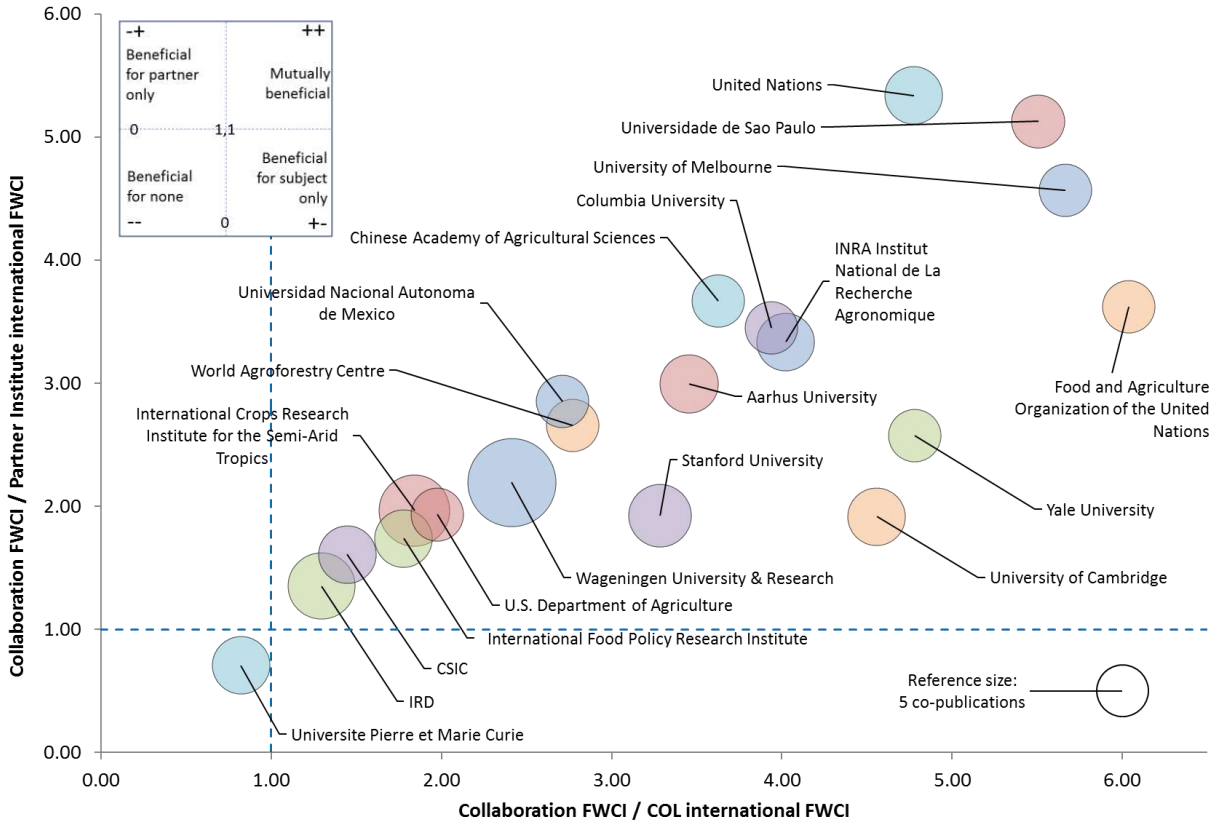


Figure 2.8— *Collaboration quadrant of Colombia's Top 20 collaborations in SDG2-related research with other institutions. Collaboration FWCI refers to the FWCI of all SDG2-related research co-authored by Colombia and the partner institute during the period 2007-2016. Bubble size corresponds to number of co-authored publications (reference bubble depicted at top left of chart). Impact of collaboration between partners can be interpreted based on quadrant position as described in legend on top left. (Source: Scopus).*

2.6.3 **Collaboration chart**

Figure 2.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG2. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 2.9 shows where there may be potential to improve output and impact through partnership. Currently, Colombia produces the most co-authored papers with Wageningen University & Research, which produces the highest number of publications (among Colombia's top 20 partners), with 900 SDG2 publications. INRA Institut National de La Recherche Agronomique is the second most prolific among Colombia's top 20, with 695 publications, 6 of which were collaborations with Colombia. Among Colombia's top 20 partners, University of Cambridge has the highest FWCI for SDG2 research at 4.7. Colombia may want to leverage its existing relationship with INRA Institut National de La Recherche Agronomique and University of Cambridge to increase its publication output and impact in SDG2 research.

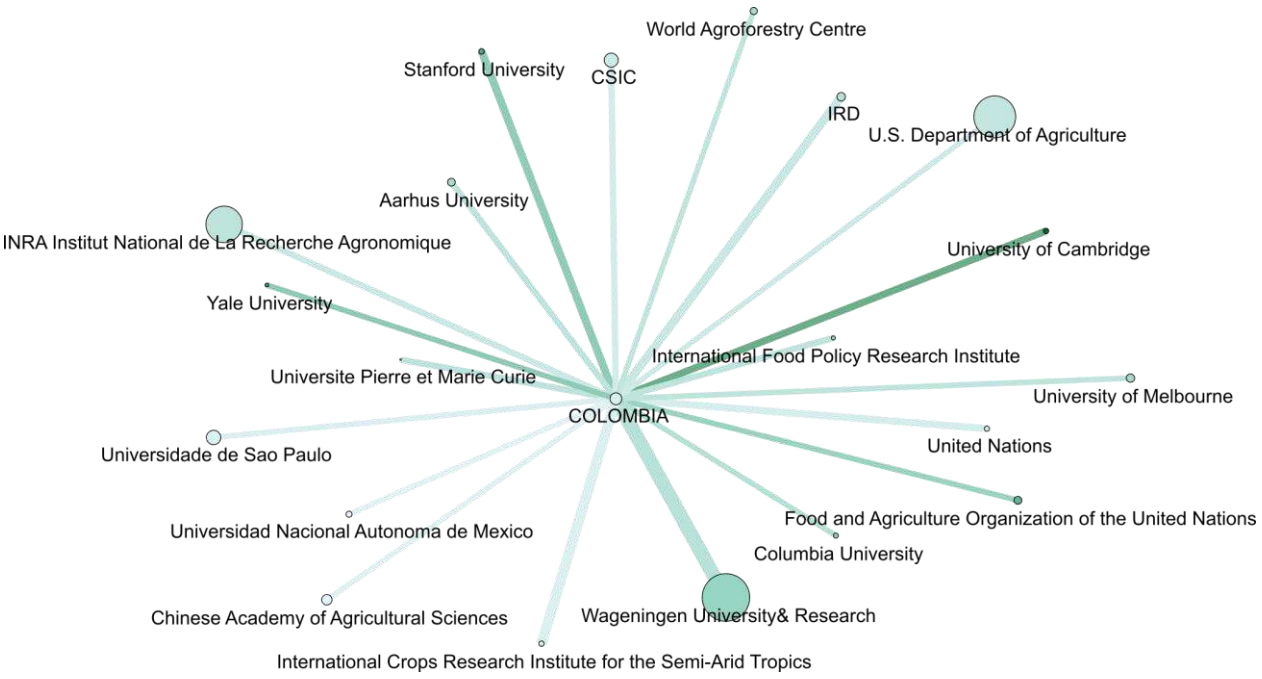


Figure 2.9— *Chart showing Colombia's top 20 collaborators on SDG2 from 2007-2016. Circle (node) size is proportional to the number of SDG2 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (4.70) and lightest shade of green indicating the lowest FWCI (1.55). (Source: Scopus).*

Chapter 3
Good Health and Well-Being

In this Chapter, we assess research related to SDG3, which aims to ensure healthy lives and promote well-being for all at all ages. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

3.1 **Key Findings**

Goal 3: Ensure healthy lives and promote well-being for all at all ages

WORLD RESEARCH OUTPUT

60,034

Number of SDG3 publications, 2007-2016.

SDG3 PATENTS

888

Number of SDG3 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

284

Colombia's SDG3 publications, 2007-2016.

COLOMBIA RESEARCH OUTPUT CAGR

21%

Compound annual growth rate for Colombia's 2007-2016 SDG3 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

37

Colombia's SDG3 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

1.25

Average field-weighted citation impact for Colombia's SDG3 publications, 2007-2016.

3.2 SDG3 – Ensure healthy lives and promote well-being for all at all ages

According to the United Nations,

> *"Ensuring healthy lives and promoting the well-being for all at all ages is essential to sustainable development. Significant strides have been made in increasing life expectancy and reducing some of the common killers associated with child and maternal mortality. Major progress has been made on increasing access to clean water and sanitation, reducing malaria, tuberculosis, polio and the spread of HIV/AIDS. However, many more efforts are needed to fully eradicate a wide range of diseases and address many different persistent and emerging health issues."*[8]

The targets for SDG3, according to the United Nations are:

- *"By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births.*
- *By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births.*
- *By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.*
- *By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being.*
- *Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol.*
- *By 2020, halve the number of global deaths and injuries from road traffic accidents.*
- *By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes.*
- *Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all.*
- *By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.*
- *Strengthen the implementation of the world Health Organization Framework Convention on Tobacco Control in all countries, as appropriate.*
- *Support the research and development of vaccines and medicines for the communicable and noncommunicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS Agreement and Public Health, which affirms the right of developing countries to use to the full the provisions in the Agreement on Trade Related Aspects of Intellectual Property Rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all.*
- *Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States.*
- *Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks."*[8]

[8] http://www.un.org/sustainabledevelopment/health/

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG3 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

3.3 SDG3: Leaders in the field

3.3.1 Top 5 countries conducting SDG3 research

The top 5 countries publishing on SDG3 based on cumulative publication output from 2007-2016 are shown in Table 3.1 and Figure 3.1. The United States ranks 1st according to Publication Count, Percentage of Global Output, and Citation Count, followed by the United Kingdom, China, Australia and Canada. The United Kingdom ranks 1st in FWCI with 1.92, which is much higher than the world average of 1.18. Except for China, all other countries' FWCI exceeds the average as well.

Table 3.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	15,300	25.49%	258,237	1.69
United Kingdom	6,112	10.18%	114,372	1.92
China	5,576	9.29%	45,802	0.96
Australia	4,044	6.74%	70,541	1.70
Canada	3,220	5.36%	57,484	1.74
World	60,034	100.00%	263,499	1.18

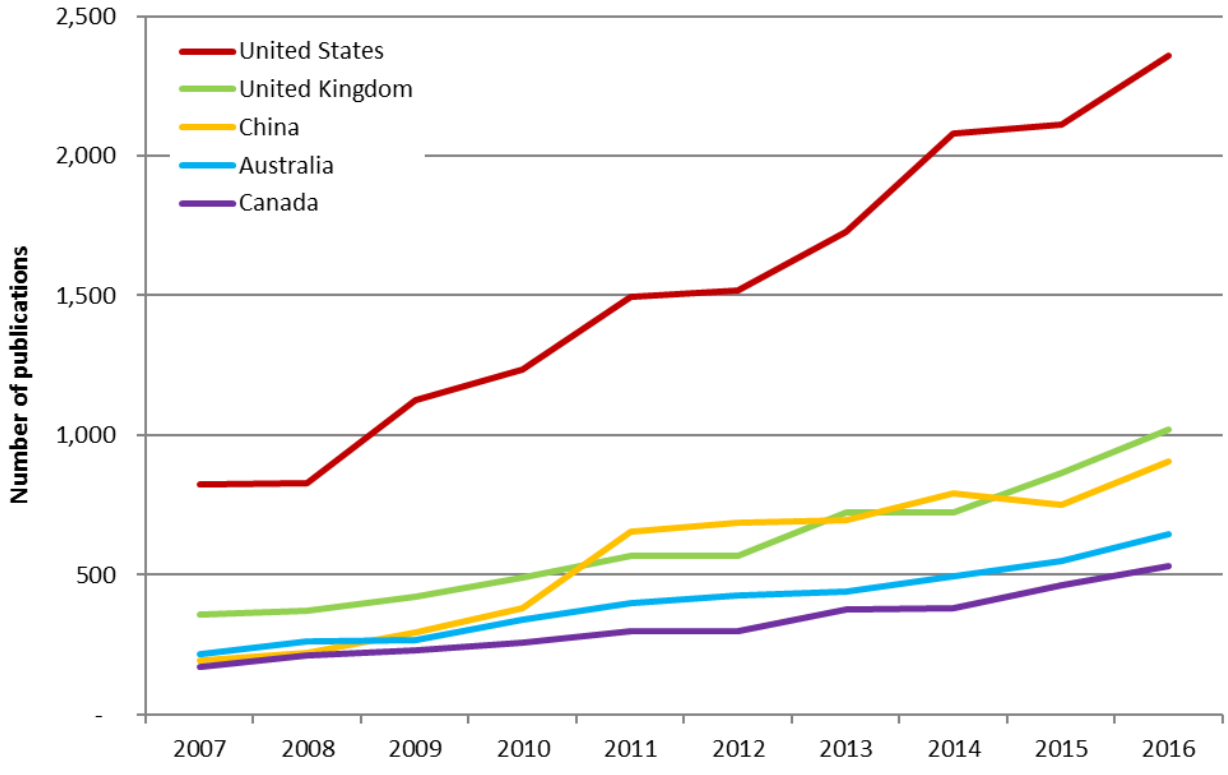


Figure 3.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG3 research. (Source: Scopus)*

3.3.2 Top 20 institutes conducting SDG3 research

A list of the top 20 research institutes publishing SDG3-related research is shown in Table 3.2. The Chinese Academy of Sciences (China) ranks 1st in Publication Count and surpasses the next ranked institute by more than 200 publications. The other 19 top institutes in this research field have published 300-550 SDG3-related publications. Although the Chinese Academy of Sciences ranks highest in terms of publication count, Arizona State University (United States) has the highest FWCI and citation count. All of the top 20 institutes have a mean FWCI above the world average for research in this field. The trends in publication output from 2007-2016 are shown in Figure 3.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Chinese Academy of Sciences (China)	776	9,752	1.32
2	Harvard University (United States)	553	14,217	3.11
3	Wageningen University & Research (Netherlands)	498	14,389	2.49
4	University of Toronto (Canada)	472	7,305	1.80
5	U.S. Department of Agriculture (United States)	441	12,726	2.44
6	University of British Columbia (Canada)	406	11,748	2.58
7	University of Queensland (Australia)	402	9,119	2.41
8	Johns Hopkins University (United States)	399	10,129	2.52
9	University of Washington (United States)	390	9,443	2.71
10	INRA Institut National de La Recherche Agronomique (France)	386	10,695	2.33
11	CNRS (France)	368	10,659	3.16
12	World Health Organization (Switzerland)	352	7,459	2.66
13	University of Sydney (Australia)	337	5,267	2.04
14	Arizona State University (United States)	329	16,850	3.27
15	University College London (United Kingdom)	310	7,262	2.69
16	University of Melbourne (Australia)	309	6,632	2.10
17	Monash University (Australia)	305	4,581	1.81
18	Columbia University (United States)	299	7,976	2.34
19	London School of Hygiene and Tropical Medicine (United Kingdom)	296	6,776	2.60
20	Imperial College London (United Kingdom)	292	9,239	2.93

Table 3.2— *Top 20 research Institutes ranked based on SDG3 publication output and FWCI from 2007-2016. (Source: Scopus)*

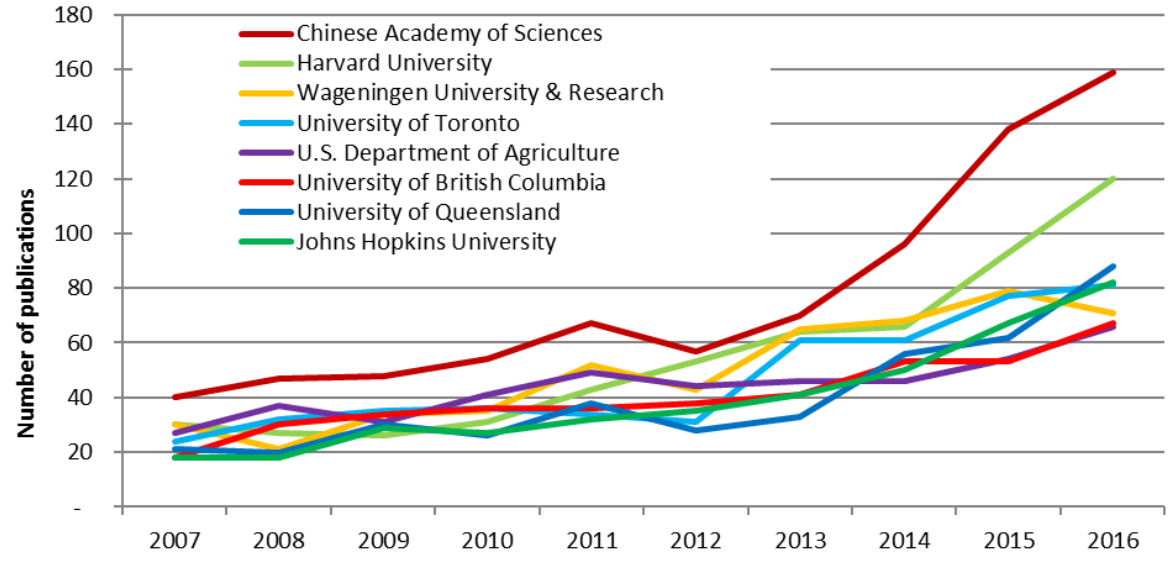


Figure 3.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG3. (Source: Scopus)*

3.3.3 Top 20 researchers conducting SDG3 research

A list of the top 20 researchers publishing in the SDG3 field based on publication output from 2007-2016 is shown in Table 3.3. Yang Z. ranks 1st in Publication Count followed by Blevis E. and Liu J.
Bhutta Z., Manchikanti L., and Polásky S. are the top 3 researchers in this list in terms of H-index.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	YANG Z.	Beijing Normal University (China)	32	531	1.34	50
2	Blevis E.	Indiana University (United States)	31	617	2.77	15
3	Liu J.	Michigan State University (United States)	29	1,804	4.08	44
4	Ouyang Z.	Research Center for Eco-Environmental Sciences Chinese Academy of Sciences (China)	29	1,154	2.15	43
5	Cooke S.	Carleton University (Canada)	26	942	2.88	56
6	Ulgiati S.	Universita degli Studi di Napoli Parthenope (Italy)	26	513	1.70	38
7	Salvati L.	Council for Agricultural Research and Economics (CREA) (Italy)	26	230	1.38	27
8	Bhutta Z.	Hospital for Sick Children University of Toronto (Canada)	24	1,060	10.08	87
9	Polásky S.	University of Minnesota System (United States)	22	2,599	12.20	63
10	Shao H.	Jiangsu Academy of Agricultural Sciences (China)	22	542	0.98	34
11	Wu J.	Arizona State University (United States)	21	2,208	4.01	50
12	Chen B.	Beijing Normal University (China)	21	346	1.66	46
13	Alves R.	Universidade Estadual da Paraiba (Brazil)	20	739	4.65	34
14	Manchikanti L.	Pain Management Center Paducah (United States)	19	533	3.49	78
15	Jabbour C.	Montpellier Research in Management (France)	19	319	2.68	22
16	Razman M.	Universiti Kebangsaan Malaysia (Malaysia)	19	205	2.05	14
17	Scholz R.	Fraunhofer-Institut fur Grenzflachen und Bioverfahrenstechnik - IGB (Germany)	18	399	2.19	39
18	Mihelcic J.	University of South Florida Tampa (United States)	18	253	1.33	26
19	Cesaretti G.	Simone Cesaretti Foundation (Italy)	18	104	0.83	7
20	Bellen J.	Hyundai Engineering and Construction Co. Ltd. (Singapore)	18	-	0.00	-

Table 3.3— *Top 20 researchers publishing SDG3 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG3 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

3.3.4 **Top 10 journals publishing SDG3 research**

A list of the top 10 journals publishing SDG3-related research from 2007-2016 is shown in Table 3.4. *PLoS ONE* published 579 SDG3 related publications, making it the top journal in terms of SDG3 publications, closely followed by *Advanced Materials Research*. *PLoS ONE* also has the highest CiteScore among the top 10 journals publishing SDG3 research. *Journal of Cleaner Production* ranks 1st in terms of FWCI. There was considerable spread in the FWCI for the top 10 journals whereby 4 journals had a mean FWCI below the world average FWCI for all research (1.0. cells highlighted in green) and 4 journals had a mean FWCI above the average for all SDG3 research (1.18).

Rank	Journal	Publication count	FWCI	CiteScore
1	PLoS ONE	579	1.50	4.29
2	Advanced Materials Research	540	0.40	0.17
3	Acta Horticulturae	430	1.14	0.20
4	Sustainability	429	1.04	0.92
5	Acta Ecologica Sinica	376	0.23	0.55
6	Journal of Environmental Management	340	1.42	3.75
7	Journal of Cleaner Production	322	2.97	3.70
8	WIT Transactions on Ecology and the Environment	280	0.07	0.08
9	BMC Public Health	238	1.46	2.62
10	Lecture Notes in Computer Science	227	0.93	0.50

Table 3.4— *Top 10 journals based on SDG3 publication output from 2007-2016. FWCI is mean FWCI for any SDG3 publications in the journal during the period; CiteScore is based on data for the journal as a whole. (Source: Scopus)*

3.4 Research efforts focused on SDG3

3.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 3.3, the United States is by far the leader in terms of research output related to SDG3. The United Kingdom and China both follow with just over one third the publication count of the United States. Among comparators, Colombia has the lowest output in this field, just below Mexico. However, as shown in Table 3.5, Colombia, along with Brazil and China, have seen the greatest growth in research output in this field with a Compound Annual Growth Rate (CAGR) over 18 %. All countries analysed have a CAGR above 12%.

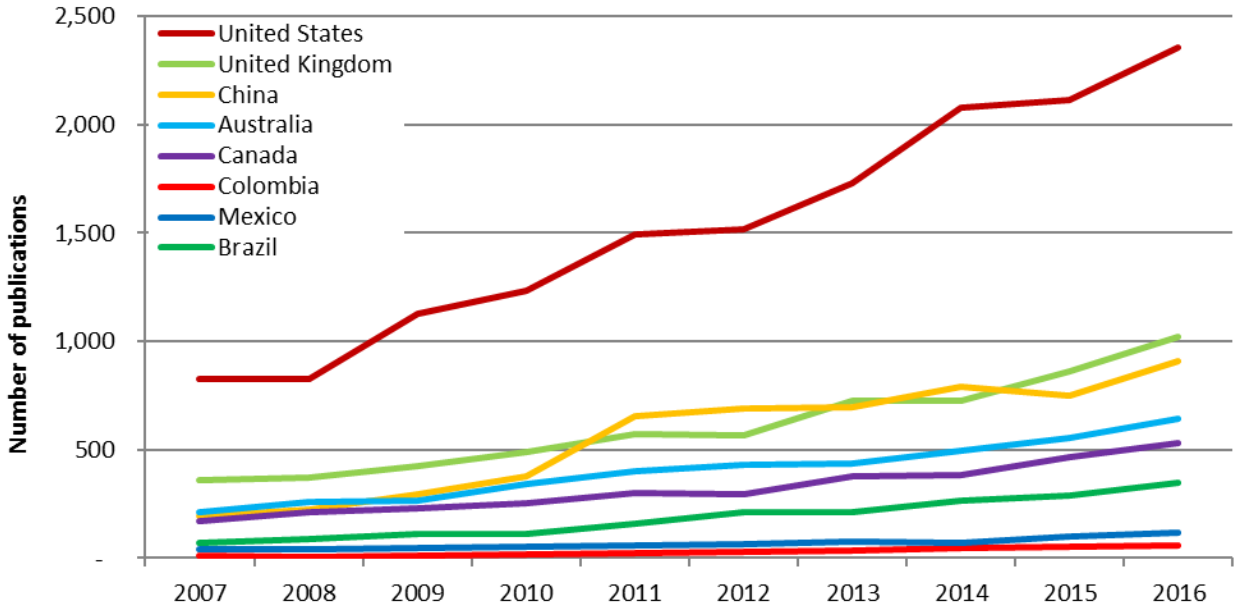


Figure 3.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	15,300	12.40%
United Kingdom	6,112	12.30%
China	5,576	18.80%
Australia	4,044	13.00%
Canada	3,220	13.20%
Colombia	284	21.10%
Mexico	668	12.50%
Brazil	1,860	19.50%
World	60,034	11.60%

Table 3.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

3.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG3 related research from 2006-2017 is 1.18.

Country	FWCI
United States	1.69
United Kingdom	1.92
China	0.96
Australia	1.70
Canada	1.74
Colombia	1.25
Mexico	1.48
Brazil	1.16
World	1.18

Comparing the FWCI of SDG3 publications from each of the eight countries included in this chapter reveals that the United Kingdom leads in terms of FWCI (Table 3.6). The United States, Australia, Germany, and Colombia all have an FWCI close to 1.4. Among countries analysed, only China has an FWCI below the world average for this subject.

Table 3.6— *FWCI per Comparator, 2007-2016. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

3.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 3.4 and Table 3.7, the United States leads in terms of SDG3 publications with 2,717 publications that are among the top 10% most cited. The United Kingdom follows with less than half the number of top 10% publications as the United States. Colombia has 37 publications among the top 10% most cited during this time period.

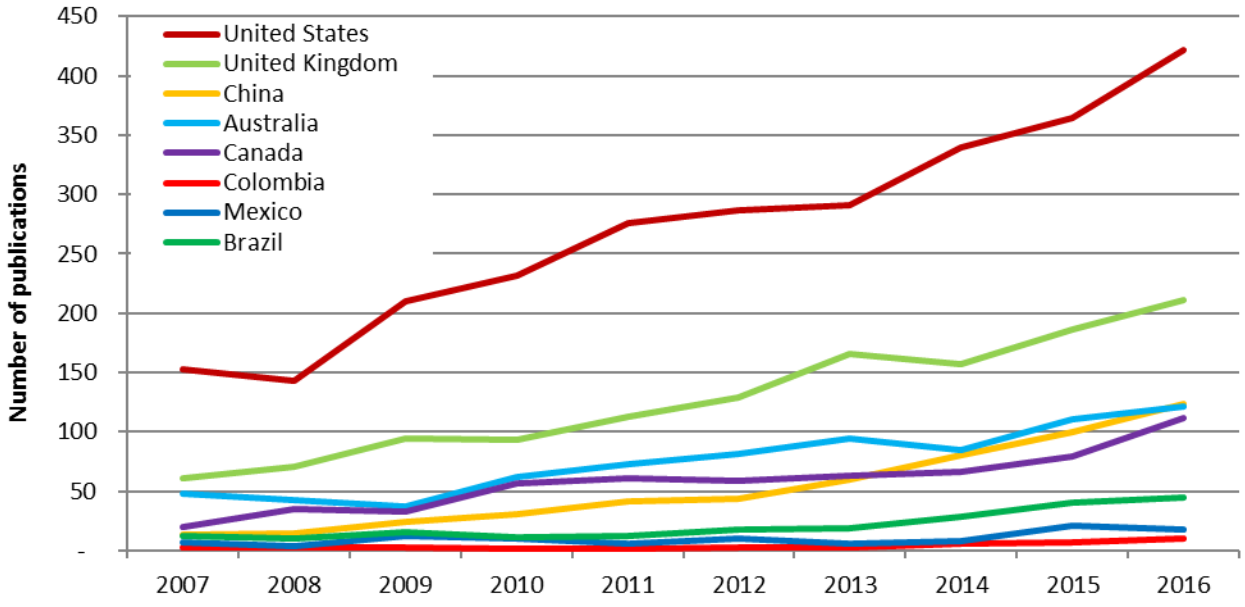


Figure 3.4— *Top 10% most cited publications on SDG3 from 2007-2016 per country. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
United States	2,717	11.93%
United Kingdom	1,280	14.78%
China	530	28.48%
Australia	754	10.82%
Canada	584	21.10%
Colombia	37	19.58%
Mexico	102	11.06%
Brazil	210	15.82%
World	7,377	13.90%

Table 3.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG3 publications from 2007-2016. (Source: Scopus)*

3.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 3.8 provides the count of SDG3 publications from each country that have been cited in patents and the number of patents that have cited these publications. For the United States, 152 US publications on SDG3 have been cited in 401 patents. All countries including Colombia had at least one patent cited publication.

Country	Patent Cited Publications	Patents Citing Publications
United States	152	401
United Kingdom	56	100
China	26	93
Australia	26	53
Canada	21	48
Colombia	1	1
Mexico	8	28
Brazil	8	22
World	416	1,061

Table 3.8— *Number of publications cited in patent and patents citing publications on SDG3 from 2007 to 2016. (Source: Scopus)*

3.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG3. To identify patents relevant to SDG3, we retrieved all the patents citing any SDG3-related publication. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO. From 2006 to 2016, the United States had the highest number of SDG3-related patents (both applied for and granted) with 150 patent applications and 371 patents granted (Table 3.9). Except for Mexico, all countries have patents related to SDG3. Note that China and Australia may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	150	371	521	58.67%
United Kingdom	21	4	25	2.82%
China	10	3	13	1.46%
Australia	11	20	31	3.49%
Canada	16	17	33	3.72%
Colombia	2	-	2	0.23%
Mexico	-	-	-	0.00%
Brazil	1	1	2	0.23%
World	405	483	888	

Table 3.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

3.4.6 **Research Focus**

Within the topic of SDG3-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG3-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG3 research is shown in Figure 3.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG3 research from Colombia, terms that stand out as unique to Colombia are 'Arecaceae,' 'Elaeis guineensis', and 'coffee.' Among the top 50 key phrases the terms 'Conservation of Natural Resources', 'Delivery of Health Care', 'Health', 'Economics', 'Environments', and 'Ecosystem Service' were common among the countries analyzed. Figure 3.5 provides a visualization of the top 50 key phrases for SDG3 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

Colombia

Mexico

Figure 3.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Brazil

United States

United Kingdom

China

Australia

Canada

3.5 The reach of Colombia's SDG3 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

3.5.1 Downloads

As shown in the Figure 3.6, the mean count of downloads per ScienceDirect publication is similar across all countries. For Colombia, there are some prominent peaks in 2007 and 2016 and valleys in 2010-2011. These peaks and valleys are the result of very small counts of SD articles (and no SD articles in 2011) and should not be given too much weight in interpretations. It should be noted that for Colombia and Mexico, the results shown are based on less than 150 SD articles and should be interpreted with caution.

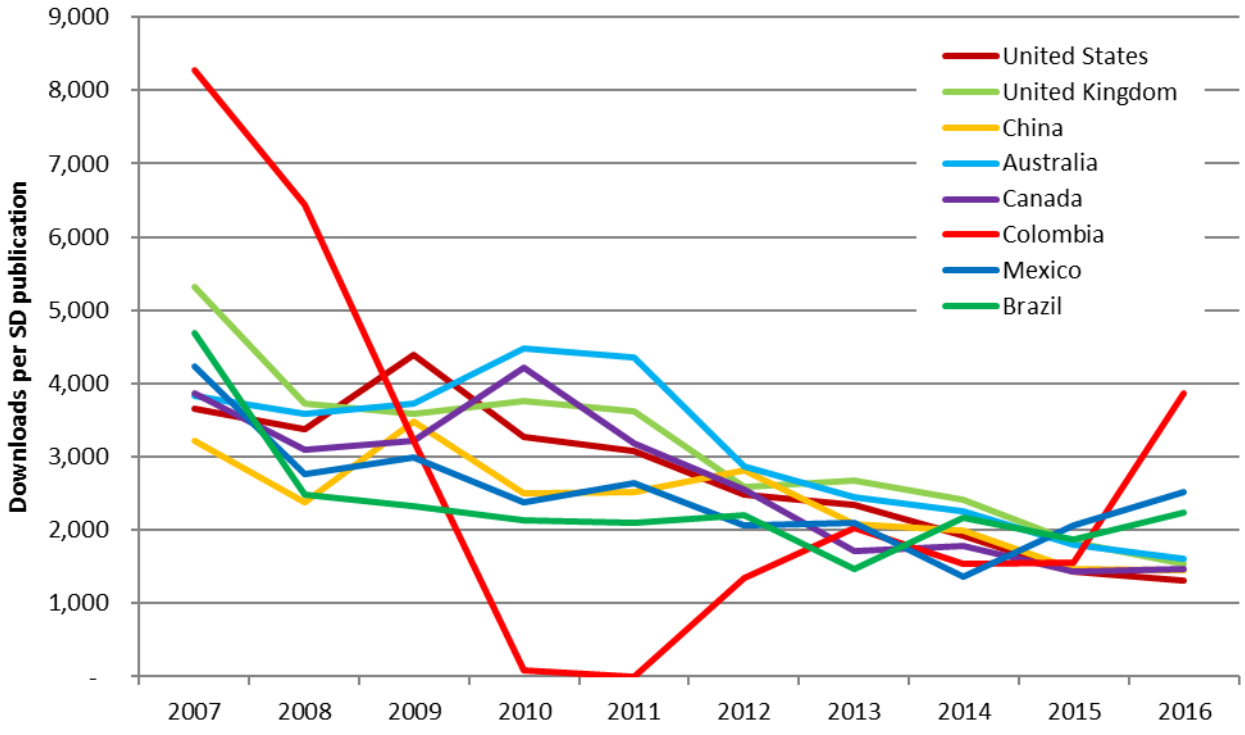


Figure 3.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

3.5.2 Field Weighted Download Impact (FWDI)

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. Interestingly, Colombia has the highest mean FWDI for the period of 2007-2016 (Figure 3.7). However, given the very low count of SD publications from Colombia and Mexico (i.e. less than 150 SD publications for the full period) interpretation of this metric should focus on the top 5 countries only. All top 5 countries had an FWDI above the average for all SDG3 research.

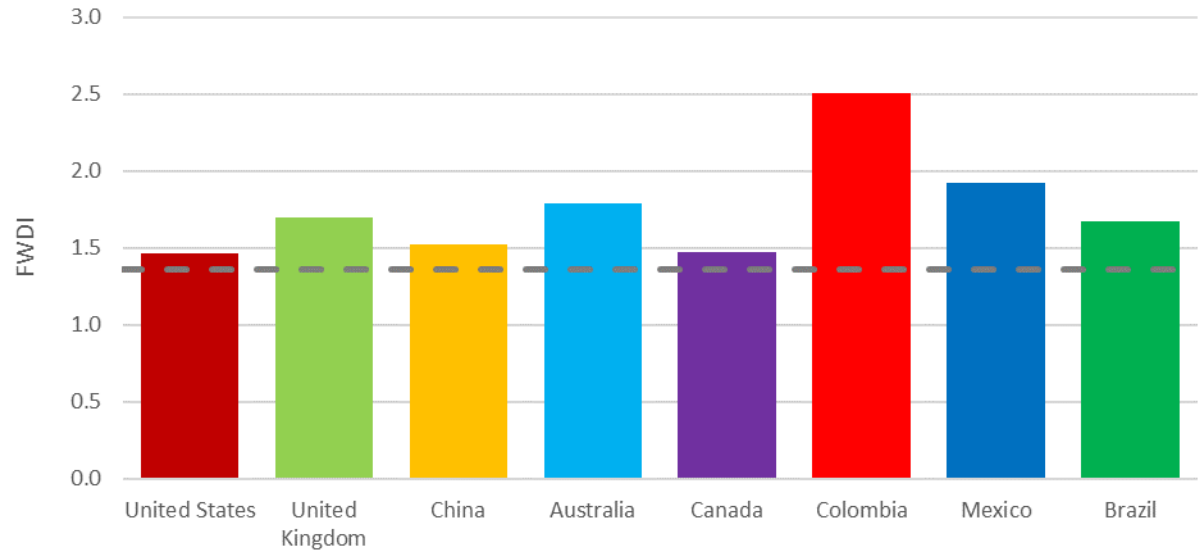


Figure 3.7 — *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. Grey dotted line indicates average for all SDG3 research. (Source: ScienceDirect)*

3.6 SDG3 collaboration network

3.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG3-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 3.10-3.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG3 publications with. Among academic partner institutes, Colombia has published the most SDG3 papers in collaboration with Wageningen University & Research (Netherlands; 10 publications). The highest mean FWCI for collaborated publications came from Colombia's co-authored publications with the University of Sydney (Australia), which yielded a mean FWCI of 17.62.

Country	Institution (Country)	Publication Count	FWCI
Colombia	Wageningen University & Research (Netherlands)	10	8.03
	Aarhus University (Denmark)	9	7.47
	International Crops Research Institute for the Semi-Arid Tropics (India)	9	3.26
	Harvard University (United States)	8	8.54
	IRD (France)	8	2.44
	London School of Hygiene and Tropical Medicine (United Kingdom)	7	9.76
	University of Toronto (Canada)	7	9.62
	University of the Witwatersrand (South Africa)	7	9.47
	University of Melbourne (Australia)	6	14.03
	Queen Mary University of London (United Kingdom)	6	11.18
	University College London (United Kingdom)	6	10.94
	Johns Hopkins University (United States)	6	10.55
	Karolinska Institutet (Sweden)	6	10.26
	United Nations (United States)	6	10.17
	Stanford University (United States)	6	8.90
	INRA Institut National de La Recherche Agronomique (France)	6	3.31
	Cornell University (United States)	6	3.28
	Universitat Politecnica de Catalunya (Spain)	6	1.37
	University of Sydney (Australia)	5	17.62
	Instituto Nacional de Salud Publica (Mexico)	5	13.29

Table 3.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	Wageningen University & Research (Netherlands)	18	6.78
	Texas A and M University (United States)	16	2.42
	Harvard University (United States)	12	5.91
	U.S. Department of Agriculture (United States)	12	4.35
	World Health Organization (Switzerland)	11	10.89
	University of Washington (United States)	11	8.89
	University of Arizona (United States)	11	6.53
	University of Toronto (Canada)	10	9.61
	United Nations (United States)	10	7.51
	University of British Columbia (Canada)	9	10.02
	University of Cape Town (South Africa)	9	9.64
	Universidade de Sao Paulo (Brazil)	9	7.27
	INRA Institut National de La Recherche Agronomique (France)	9	5.16
	Arizona State University (United States)	9	4.23
	KU Leuven (Belgium)	9	2.46
	Imperial College London (United Kingdom)	8	12.93
	Stanford University (United States)	8	9.34
	McGill University (Canada)	8	8.83
	Cornell University (United States)	8	6.95
	CSIRO (Australia)	8	6.15

Table 3.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	Harvard University (United States)	27	8.46
	World Health Organization (Switzerland)	27	4.69
	Wageningen University & Research (Netherlands)	26	5.77
	U.S. Department of Agriculture (United States)	18	5.27
	London School of Hygiene and Tropical Medicine (United Kingdom)	17	6.18
	University of Florida (United States)	17	3.00
	Universidad Nacional Autonoma de Mexico (Mexico)	16	4.67
	Imperial College London (United Kingdom)	15	11.70
	University of Oxford (United Kingdom)	15	9.17
	University of East Anglia (United Kingdom)	15	8.74
	University of Toronto (Canada)	13	8.44
	Yale University (United States)	13	8.31
	University of British Columbia (Canada)	13	8.19
	Columbia University (United States)	13	7.36
	Johns Hopkins University (United States)	13	6.75
	CNRS (France)	13	6.10
	IRD (France)	13	5.49
	CIRAD (France)	13	1.69
	University of Cambridge (United Kingdom)	12	10.61
	James Cook University Queensland (Australia)	12	8.64

Table 3.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	World Health Organization (Switzerland)	160	3.68
	University of Toronto (Canada)	126	2.92
	Chinese Academy of Sciences (China)	117	2.93
	University of British Columbia (Canada)	111	5.42
	London School of Hygiene and Tropical Medicine (United Kingdom)	90	4.24
	Wageningen University & Research (Netherlands)	82	4.91
	University of Oxford (United Kingdom)	79	4.62
	University of Queensland (Australia)	75	5.66
	University of Cambridge (United Kingdom)	69	6.52
	University of Cape Town (South Africa)	68	4.44
	McGill University (Canada)	63	7.05
	Imperial College London (United Kingdom)	61	5.63
	CNRS (France)	55	9.10
	University College London (United Kingdom)	55	5.42
	Stockholm University (Sweden)	52	7.72
	James Cook University Queensland (Australia)	52	6.21
	University of the Witwatersrand (South Africa)	52	3.65
	Makerere University (Uganda)	52	2.57
	CSIRO (Australia)	48	6.35
	Universidade de Sao Paulo (Brazil)	46	4.90

Table 3.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	World Health Organization (Switzerland)	93	4.90
	Wageningen University & Research (Netherlands)	93	4.46
	Harvard University (United States)	74	9.65
	Johns Hopkins University (United States)	58	4.69
	University of Cape Town (South Africa)	58	4.57
	Karolinska Institutet (Sweden)	52	3.55
	University of Queensland (Australia)	51	6.72
	INRA Institut National de La Recherche Agronomique (France)	51	3.97
	Ghent University (Belgium)	50	3.26
	University of British Columbia (Canada)	48	8.05
	University of Toronto (Canada)	47	4.41
	CNRS (France)	46	10.33
	University of Copenhagen (Denmark)	44	5.10
	University of Melbourne (Australia)	42	4.24
	University of Washington (United States)	41	7.67
	Columbia University (United States)	40	6.92
	University of the Witwatersrand (South Africa)	40	4.15
	University of Sydney (Australia)	38	4.94
	European Commission Joint Research Centre Institute (Belgium)	36	5.34
	Vrije Universiteit (Netherlands)	36	4.47

Table 3.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
China	University of Hong Kong (Hong Kong)	44	3.27
	Hong Kong Polytechnic University (Hong Kong)	35	1.10
	U.S. Department of Agriculture (United States)	34	4.00
	Arizona State University (United States)	32	2.80
	Wageningen University & Research (Netherlands)	30	4.13
	Chinese University of Hong Kong (Hong Kong)	27	1.60
	CSIRO (Australia)	23	2.98
	University of Queensland (Australia)	22	5.00
	National University of Singapore (Singapore)	22	2.95
	City University of Hong Kong (Hong Kong)	22	1.67
	Harvard University (United States)	21	8.23
	World Health Organization (Switzerland)	20	10.54
	Georgia Institute of Technology (United States)	19	7.09
	Texas A and M University (United States)	19	1.05
	Stanford University (United States)	18	8.24
	University of Western Australia (Australia)	18	7.04
	Cornell University (United States)	18	5.35
	University of Minnesota (United States)	18	5.23
	University of Toronto (Canada)	18	5.04
	Colorado State University (United States)	18	1.42

Table 3.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for China. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Australia	World Health Organization (Switzerland)	48	4.31
	University of British Columbia (Canada)	43	6.89
	Imperial College London (United Kingdom)	42	5.56
	Wageningen University & Research (Netherlands)	41	6.15
	University of Toronto (Canada)	37	3.39
	University College London (United Kingdom)	36	4.13
	Harvard University (United States)	34	8.83
	Chinese Academy of Sciences (China)	32	2.80
	University of Cape Town (South Africa)	30	4.92
	University of Washington (United States)	29	8.35
	University of Oxford (United Kingdom)	29	7.41
	Stanford University (United States)	28	9.12
	University of Cambridge (United Kingdom)	27	9.68
	University of Auckland (New Zealand)	27	3.16
	U.S. Department of Agriculture (United States)	25	5.54
	Johns Hopkins University (United States)	24	6.14
	National University of Singapore (Singapore)	24	5.42
	University of Alberta (Canada)	23	3.44
	London School of Hygiene and Tropical Medicine (United Kingdom)	22	6.00
	NOAA (United States)	22	3.67

Table 3.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Australia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Canada	Harvard University (United States)	49	6.81
	University of Washington (United States)	38	6.08
	Stanford University (United States)	37	9.00
	University of Cape Town (South Africa)	35	5.52
	Johns Hopkins University (United States)	34	5.52
	World Health Organization (Switzerland)	32	4.52
	Arizona State University (United States)	29	10.62
	U.S. Department of Agriculture (United States)	29	3.03
	University of Queensland (Australia)	28	9.28
	University of Sydney (Australia)	27	5.97
	Cornell University (United States)	27	4.22
	Columbia University (United States)	26	6.53
	Wageningen University & Research (Netherlands)	25	8.28
	Chinese Academy of Sciences (China)	24	3.14
	University of Minnesota (United States)	23	14.37
	Stockholm University (Sweden)	23	12.38
	London School of Hygiene and Tropical Medicine (United Kingdom)	23	6.85
	James Cook University Queensland (Australia)	23	6.60
	University of East Anglia (United Kingdom)	23	4.93
	University of Michigan (United States)	22	7.57

Table 3.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Germany. (Source: Scopus)*

3.6.2 **Collaboration impact analysis**

To visualize the citation impact of collaborations, the ratio of FWCI from SDG3 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG3 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG3 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. For SDG3 research from 2007-2016, the majority of Colombia's collaborations with top 20 academic partners were mutually beneficial to both Colombia and the collaboration partner (Figure 3.8).

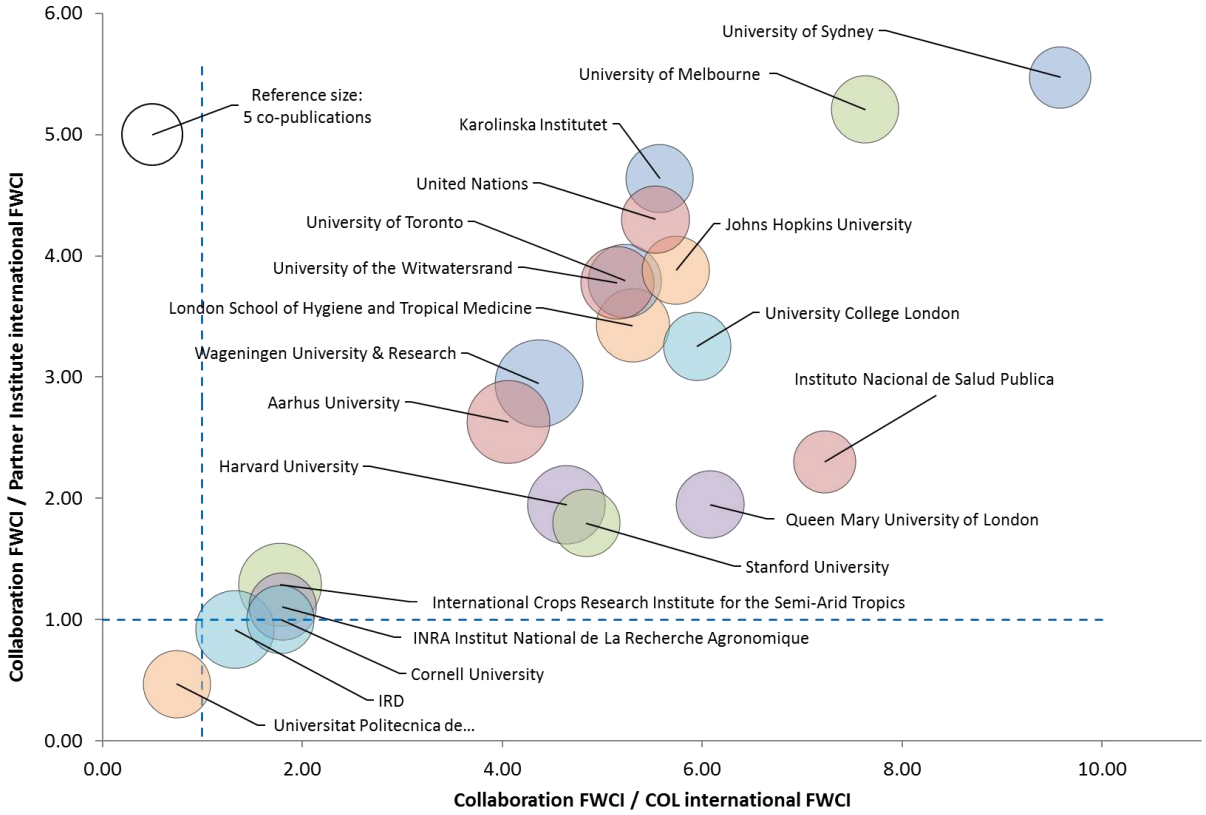


Figure 3.8— *Collaboration quadrant of Colombia's Top 20 collaborations in SDG3-related research with other institutions. Collaboration FWCI refers to the FWCI of all SDG3-related research co-authored by Colombia and the partner institute during the period 2007-2016. Bubble size corresponds to number of co-authored publications (reference bubble depicted at top left of chart). Impact of collaboration between partners can be interpreted based on quadrant position as described in legend on right. (Source: Scopus).*

3.6.3 **Collaboration chart**

Figure 3.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG3. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 3.9 shows where there may be potential to improve output and impact through partnership. Colombia is already collaborating with the most prolific institutes among its top 20 partners. Among Colombia's top 20 partners, Stanford University and Queen Mary University of London have the highest FWCI for SDG3 research. Colombia may want to leverage its existing relationships with these institutions to increase its publication impact in SDG3 research.

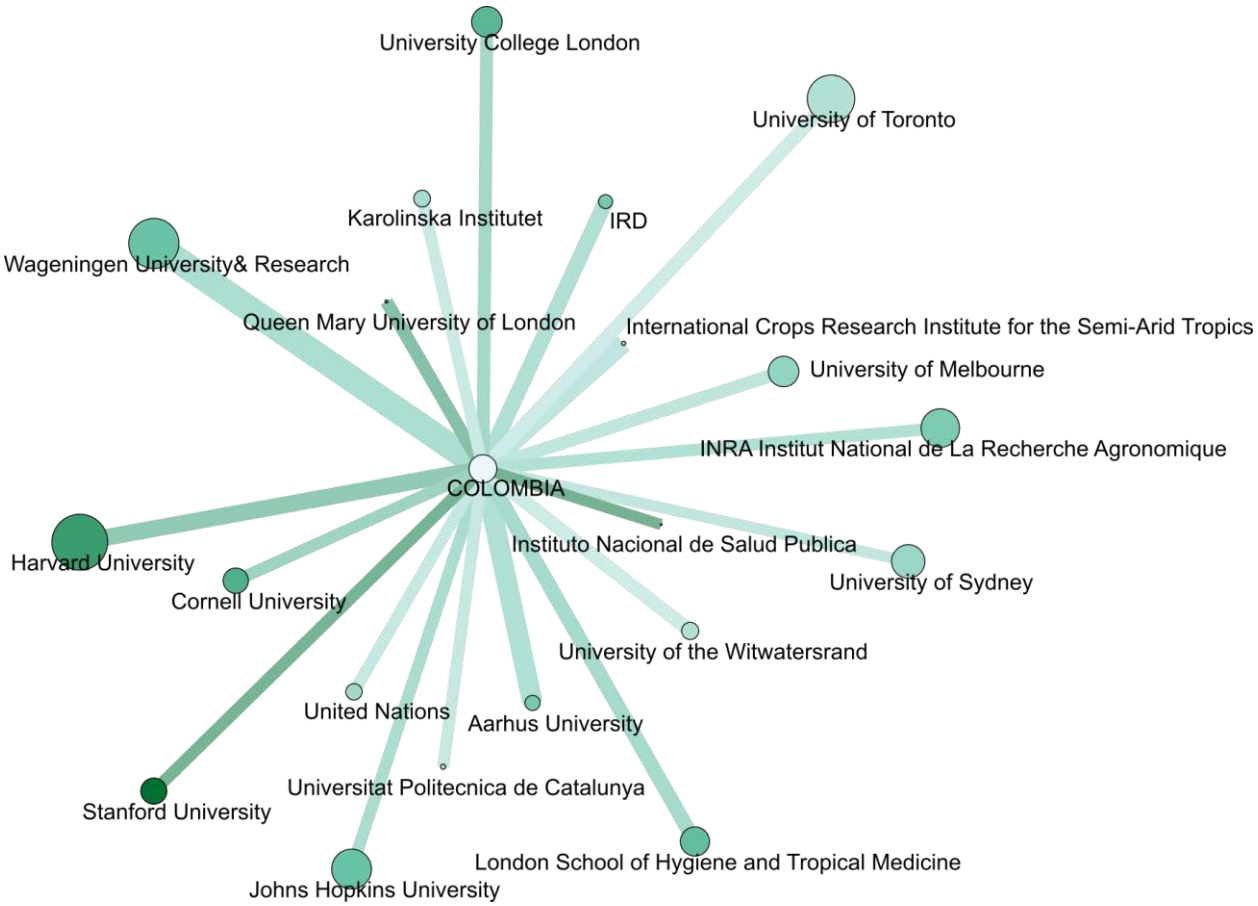


Figure 3.9— *Chart showing Colombia's top 20 collaborators on SDG3 from 2007-2016. Circle (node) size is proportional to the number of SDG3 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colours of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (3.80) and lightest shade of green indicating the lowest FWCI (1.80). (Source: Scopus).*

Chapter 4
Quality Education

In this Chapter, we assess research related to SDG4, which aims to ensure inclusive and quality education for all and promote lifelong learning. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

4.1 Key Findings

Goal 4: Ensure inclusive and quality education for all and promote lifelong learning

WORLD RESEARCH OUTPUT

5,204

Number of SDG4 publications, 2007-2016.

SDG4 PATENTS

1

Number of SDG4 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

19

Colombia's SDG4 publications, 2007-2016.

COLOMBIA RESEARCH OUTPUT CAGR

20%

Compound annual growth rate for Colombia's 2007-2016 SDG4 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

2

Colombia's SDG4 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

0.72

Average field-weighted citation impact for Colombia's SDG4 publications, 2007-2016.

4.2 SDG4 – Ensure inclusive and quality education for all and promote lifelong learning

According to the United Nations,

> *"Obtaining a quality education is the foundation to improving people's lives and sustainable development. Major progress has been made towards increasing access to education at all levels and increasing enrolment rates in schools particularly for women and girls. Basic literacy skills have improved tremendously, yet bolder efforts are needed to make even greater strides for achieving universal education goals. For example, the world has achieved equality in primary education between girls and boys, but few countries have achieved that target at all levels of education."*[9]

The targets for SDG4, according to the United Nations are:

- *"By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and Goal-4 effective learning outcomes.*
- *By 2030, ensure that all girls and boys have access to quality early childhood development, care and preprimary education so that they are ready for primary education.*
- *By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university.*
- *By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship.*
- *By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations.*
- *By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy.*
- *By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development.*
- *Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, nonviolent, inclusive and effective learning environments for all.*
- *By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries.*
- *By 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing states."*[9]

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG4 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a

[9] http://www.un.org/sustainabledevelopment/education/

query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

4.3 SDG4: Leaders in the field

4.3.1 Top 5 countries conducting SDG4 research

The top 5 countries publishing on SDG 4 based on cumulative publication output from 2007-2016 is indicated by Table 4.1 and Figure 4.1. The United States ranks 1st in Publication Count, Percentage of Global Output, and Citation Count, followed by the United Kingdom and Australia, which each published approximately half the number of publications as the United States. Canada ranks 1st in FWCI with 1.17, which is higher than the world average. All other countries' FWCI exceed the world average as well.

Table 4.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	1,263	24.27%	9,374	1.04
United Kingdom	662	12.72%	4,700	1.03
Australia	603	11.59%	4,004	1.12
Canada	273	5.25%	2,260	1.17
Germany	207	3.98%	1,440	1.11
World	5,204	100.00%	10,159	0.95

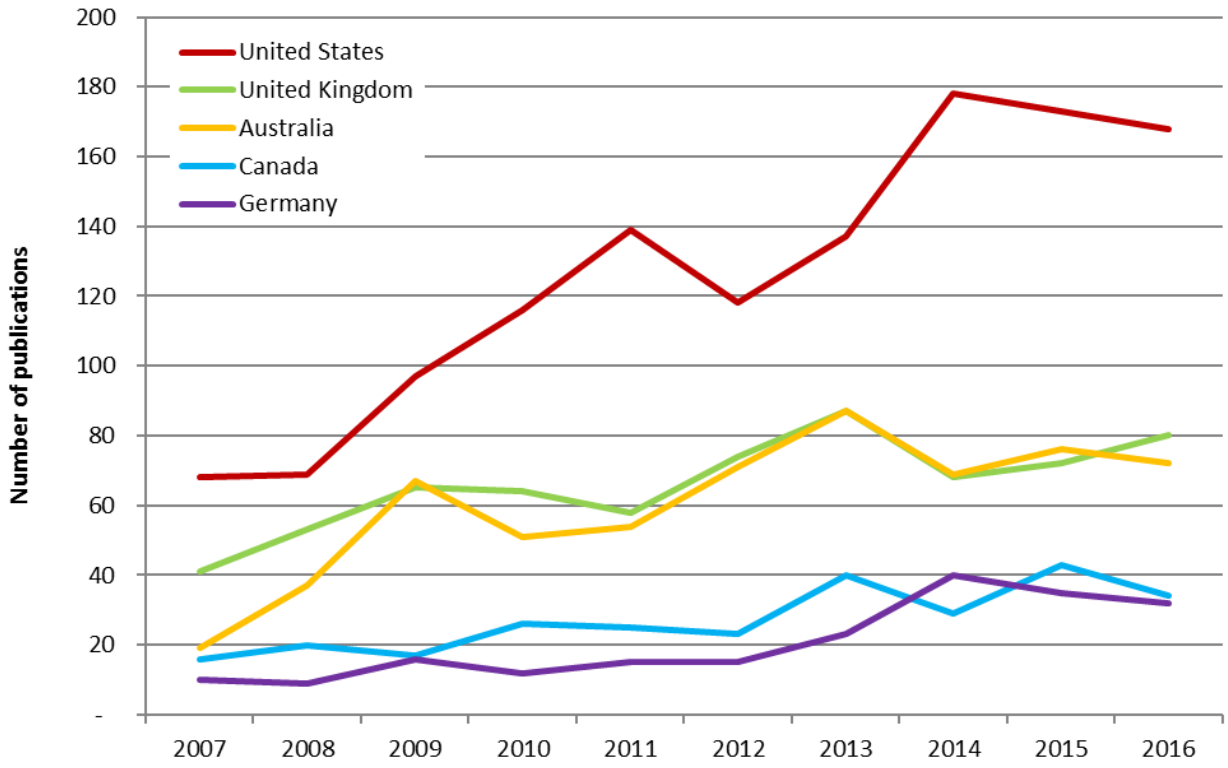


Figure 4.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG4 research. (Source: Scopus)*

4.3.2 Top 20 institutes conducting SDG4 research

A list of the top 20 research institutes publishing in the SDG field based on publication output from 2007-2016 is shown in Table 4.2. Australian institutes lead in the field, representing the top 6 institutes by publication count, 7 of the top 10, and 9 of the top 20. Royal Melbourne Institute of Technology University (Australia) ranks 1st (47) in Publication Count followed by Griffith University Queensland (Australia) (46), Queensland University of Technology (Australia) (45). Arizona State University (United States) sits in the 1st place in Citation Count with 587 followed by the University of Plymouth (United Kingdom) (480) and Royal Melbourne Institute of Technology University (Australia) (461). Arizona State University also had the largest FWCI at 2.41, much higher than the world average. The trends in publication output from 2007-2016 are shown in Figure 4.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Royal Melbourne Institute of Technology University (Australia)	47	461	1.29
2	Griffith University Queensland (Australia)	46	357	1.01
3	Queensland University of Technology (Australia)	45	305	1.35
4	UTS University of Technology Sydney (Australia)	38	333	1.53
5	Monash University (Australia)	37	326	1.70
6	Deakin University (Australia)	33	268	1.90
7	University College London (United Kingdom)	33	188	1.07
8	University of Plymouth (United Kingdom)	33	480	1.64
9	University of Toronto (Canada)	33	307	1.71
10	James Cook University Queensland (Australia)	32	186	1.19
11	University of Florida (United States)	32	232	0.94
12	Virginia Polytechnic Institute and State University (United States)	31	374	2.03
13	Curtin University of Technology (Australia)	29	144	1.06
14	Daugavpils University (Latvia)	29	84	0.58
15	University of British Columbia (Canada)	28	415	1.52
16	Arizona State University (United States)	28	587	2.41
17	Delft University of Technology (Netherlands)	27	252	1.05
18	University of South Australia (Australia)	26	126	0.74
19	Universitat Politecnica de Catalunya (Spain)	26	339	1.24
20	University of Wisconsin (United States)	26	171	0.81

Table 4.2— *Top 20 research institutes ranked based on SDG4 publication output and FWCI from 2007-2016. (Source: Scopus)*

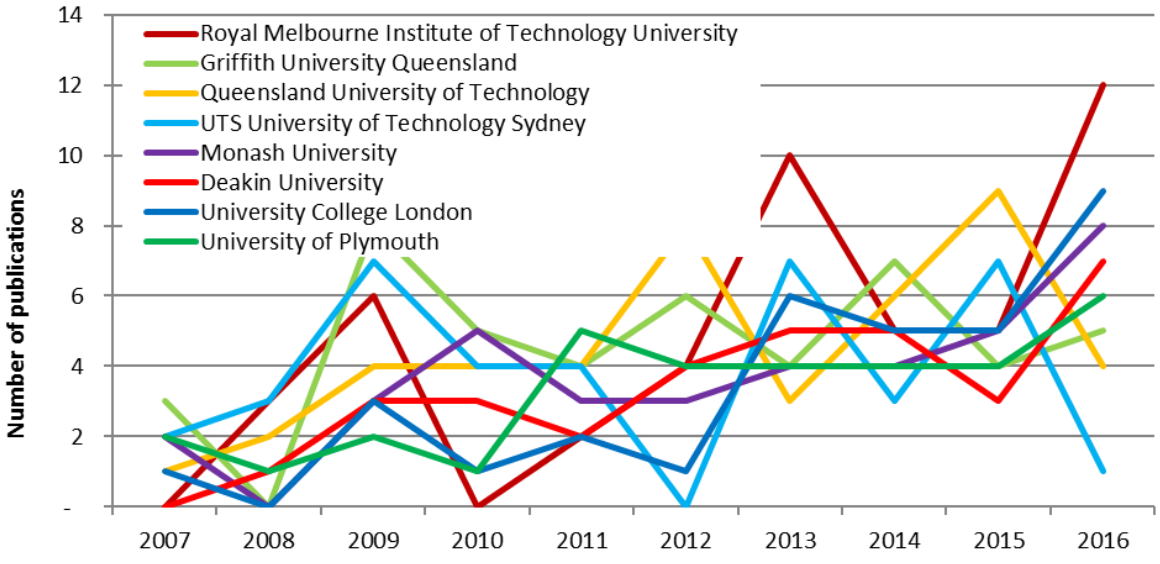


Figure 4.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG4. (Source: Scopus)*

4.3.3 Top 20 researchers conducting SDG4 research

A list of the top 20 researchers publishing in the SDG4 field based on publication output from 2007-2016 is shown in Table 4.3. Kopnina H. ranks 1st in Publication Count followed by Davis J. and Wright T.
Wiek A., Sinclair A., Svanström M., Ferrer-Balas D., and Eilks I. are the top researchers according to h-index with values of 30, 19, 16, 16 and 16, respectively.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Kopnina H.	Leiden University (Netherlands)	15	217	3.09	12
2	Davis J.	Queensland University of Technology QUT (Australia)	12	107	1.82	8
3	Wright T.	Dalhousie University (Canada)	12	186	1.50	13
4	Thomas I.	RMIT University (Australia)	11	161	1.34	10
5	Shephard K.	University of Otago (New Zealand)	10	205	2.15	11
6	Sinclair A.	University of Manitoba (Canada)	10	200	2.11	19
7	Bögeholz S.	Universitat Gottingen (Germany)	10	63	0.96	9
8	Wiek A.	Leuphana Universitat Luneburg (Germany)	9	482	4.80	30
9	Svanström M.	Chalmers University of Technology (Sweden)	9	273	2.86	16
10	Pace P.	University of Malta (Malta)	9	45	0.97	5
11	Ferrer-Balas D.	Universitat Politecnica de Catalunya (Spain)	8	304	2.84	16
12	Eilks I.	University of Bremen (Germany)	8	113	2.80	16
13	Ferreira J.	Southern Cross University (Australia)	8	71	1.89	4
14	Filho W.	Manchester Metropolitan University (United Kingdom)	8	68	1.56	9
15	Lotz-Sisitka H.	Rhodes University (South Africa)	8	36	0.97	6
16	Gericke N.	Karlstads universitet (Sweden)	7	61	3.71	8
17	Mulder K.	Delft University of Technology (Netherlands)	7	209	2.95	14
18	Barth M.	University of Applied Science Ostwestfalen-Lippe (United Kingdom)	7	300	2.94	10
19	Segalàs J.	Universitat Politecnica de Catalunya (Spain)	7	207	2.84	7
20	Cotton D.	University of Plymouth (United Kingdom)	7	124	2.24	10

Table 4.3— *Top 20 researchers publishing SDG4 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG4 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

4.3.4 **Top 10 journals publishing SDG4 research**

A list of the top 10 journals publishing SDG4-related research from 2007-2016 is shown in Table 4.4. *International Journal of Sustainability in Higher Education* published the most SDG4 publications (236) followed by *Environmental Education Research* (121), and *IEEE Global Engineering Education Conference, EDUCON* (115). *IEEE Global Engineering Education Conference, EDUCON* ranks 1st in FWCI (2.61) followed by *Environmental Education Research* (2.18), and *International Journal of Engineering Education* (1.40) in the 2nd and 3rd place, respectively. As for CiteScore, *International Journal of Sustainability in Higher Education* sits in the 1st place by a small margin with an FWCI of 1.70.

Rank	Journal	Publication count	FWCI	CiteScore
1	International Journal of Sustainability in Higher Education	236	1.38	1.70
2	Environmental Education Research	121	2.18	0.88
3	IEEE Global Engineering Education Conference, EDUCON	115	2.61	0.00
4	Sustainability	105	0.65	0.92
5	Journal of Teacher Education for Sustainability	91	0.46	0.25
6	Proceedings - Frontiers in Education Conference, FIE	61	0.50	0.06
7	Australian Journal of Environmental Education	57	0.73	0.46
8	Sustainability	53	0.14	0.12
9	International Journal of Sustainability Education	38	0.09	0.07
10	International Journal of Engineering Education	37	1.40	0.75

Table 4.4— *Top 10 journals based on SDG4 publication output from 2007-2016. FWCI is mean FWCI for any SDG4 publications in the journal during the period; CiteScore is based on data for the journal as a whole.*

4.4 Research efforts focused on SDG4

4.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 4.3, the United States is by far the leader in terms of research output related to SDG4. The United Kingdom follows along with Australia. Among comparators, Colombia has the lowest output in this field, just below Mexico. However, as shown in Table 4.5, Colombia and Brazil have seen the greatest Compound Annual Growth Rate (CAGR) in this field of research at 19.6%. Australia, Germany, Mexico, and the United States also see marked increases in publication output with a CAGR above 10%.

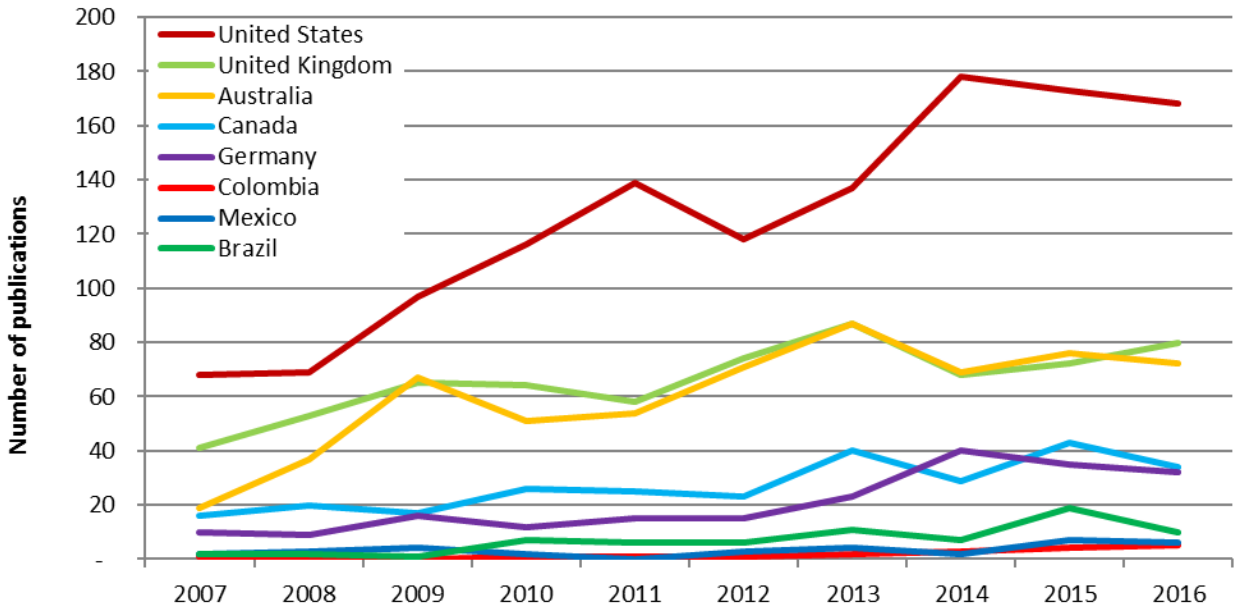


Figure 4.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	1,263	10.60%
United Kingdom	662	7.70%
Australia	603	16.00%
Canada	273	8.70%
Germany	207	13.80%
Colombia	19	19.60%
Mexico	33	13.00%
Brazil	71	19.60%
World	5,204	7.90%

Table 4.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

4.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG4 related research from 2006-2017 is 0.95.

Country	FWCI
United States	1.04
United Kingdom	1.03
Australia	1.12
Canada	1.17
Germany	1.11
Colombia	0.72
Mexico	0.61
Brazil	0.69
World	0.95

Comparing the FWCI of publications from each of the eight countries included in this chapter reveals some differences and similarities in terms of citation impact (Table 4.6). Most notably, Canada achieves the highest FWCI among comparator countries. Australia and Germany have FWCI values higher than the world average. While the United States leads in publication count, its FWCI is close to world average at 1.04.

Table 4.6— *FWCI for SDG4 research from 2007-2016 per country and world. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

4.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 4.4 and Table 4.7, the United States leads in terms of top cited SDG4 publications with 148 publications that are among the top 10% most cited. Colombia had 2 publications among the top 10% most cited during this time period.

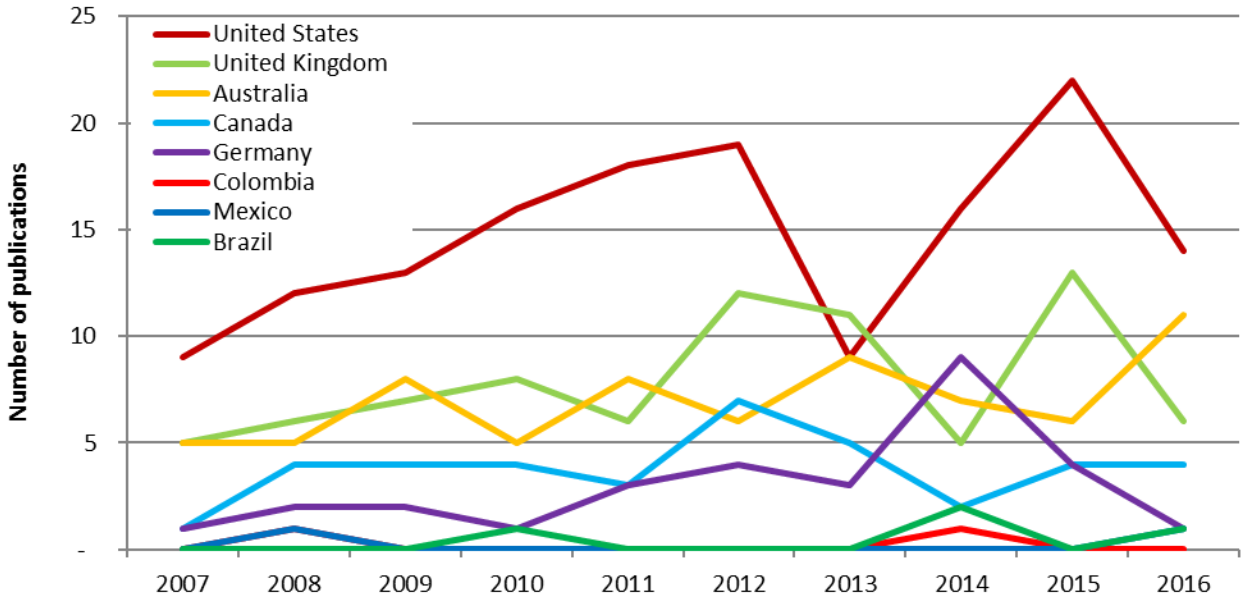


Figure 4.4— *Top 10% most cited publications on SDG4 from 2007-2016 per country. CAGR shown at top of each bar. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
United States	148	5.03%
United Kingdom	79	2.05%
Australia	70	9.16%
Canada	38	16.65%
Germany	30	0.00%
Colombia	2	-
Mexico	2	-
Brazil	4	-
World	525	10.17%

Table 4.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG4 publications from 2007-2016. (Source: Scopus)*

4.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 4.8 provides the count of SDG4 publications from each country that have been cited in patents and the number of patents that have cited these publications. No country analyzed for this report, including Colombia, has patent citations related to SDG4.

Country	Patent Cited Publications	Patents Citing Publications
United States	-	-
United Kingdom	-	-
Australia	-	-
Canada	-	-
Germany	-	-
Colombia	-	-
Mexico	-	-
Brazil	-	-
World	1	1

Table 4.8— *Number of publications cited in USPTO, WIPO, or EPO patents and number of USPTO, WIPO, or EPO patents citing publications on SDG4 from 2007 to 2016. (Source: Scopus and LexisNexis)*

4.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG4. To identify patents relevant to SDG4, we retrieved all the patents citing any SDG4-related publication. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO. From 2006 to 2016, none of the countries analyzed had any patents related to SDG4 during the period. Note that Australia may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	-	-	-	0.00%
United Kingdom	-	-	-	0.00%
Australia	-	-	-	0.00%
Canada	-	-	-	0.00%
Germany	-	-	-	0.00%
Colombia	-	-	-	0.00%
Mexico	-	-	-	0.00%
Brazil	-	-	-	0.00%
World	1	-	1	

Table 4.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

4.4.6 **Research Focus**

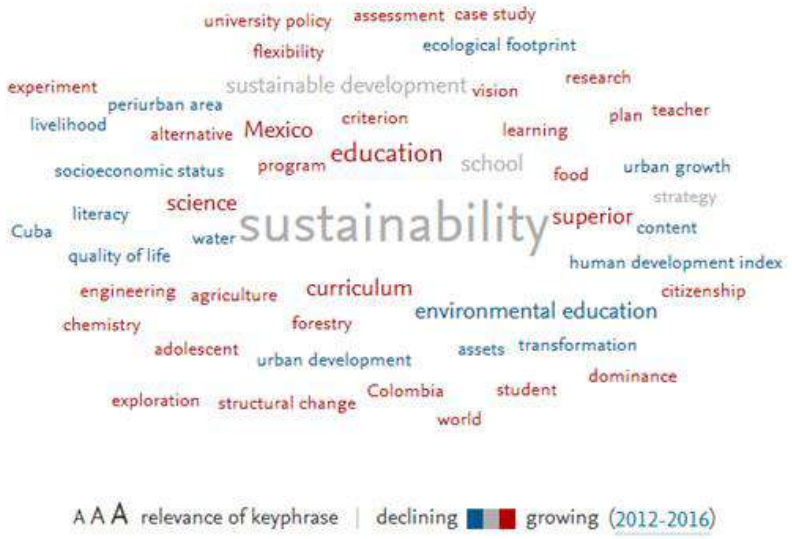
Within the topic of SDG4-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG4-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG4 research is shown in Figure 4.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG4 research from Colombia, terms that stand out as unique to Colombia are 'Analog Circuits', 'Ecology', 'Electronics Engineering', 'Social Sciences', 'Software Architecture', 'Social Aspects', 'Product Design', and 'Prisons'. Among the top 50 key phrases the terms 'Education', 'Teacher', and 'Environmental Education' were common among the countries analyzed. Figure 4.5 provides a visualization of the top 50 key phrases for SDG4 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

Colombia

Figure 4.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Mexico



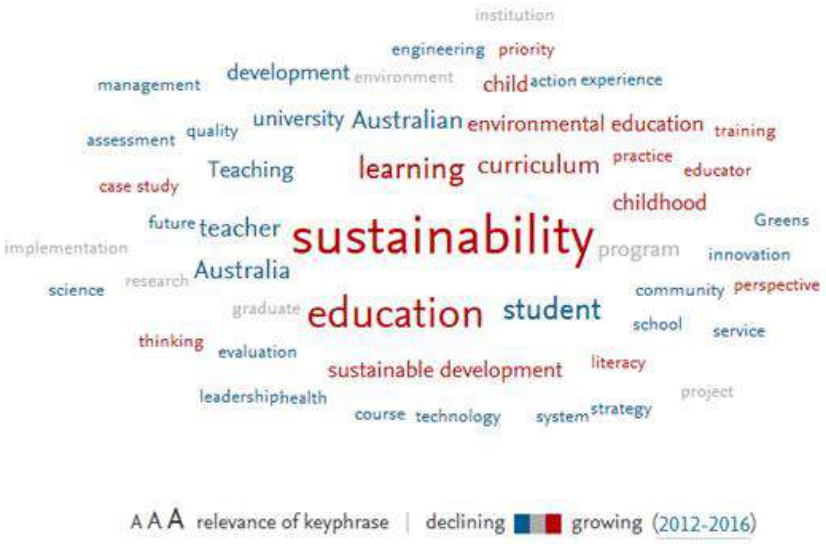
Brazil

United States

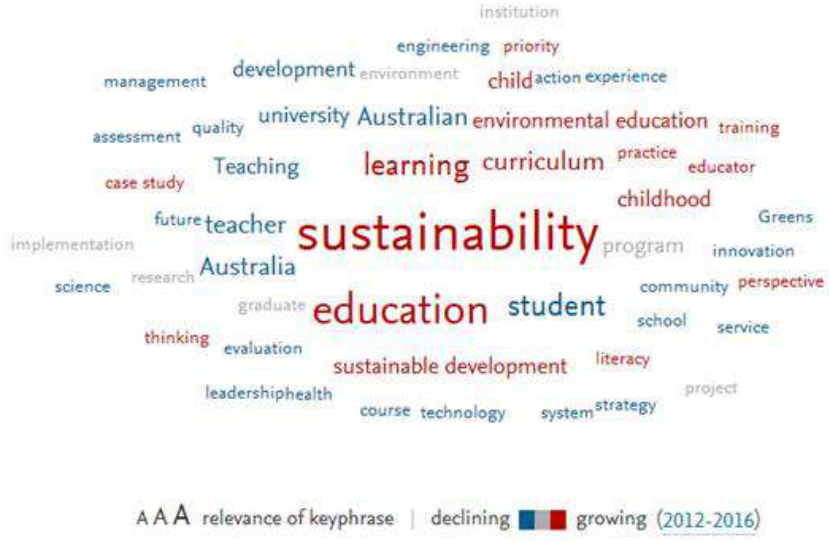
United Kingdom

Germany

Australia



Canada



4.5 The reach of Colombia's SDG4 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

4.5.1 Downloads

As shown in the Figure 4.6, the mean count of downloads per ScienceDirect publication is similar across all countries. For Colombia, Australia, and the United Kingdom, there is are prominent peaks resulting from a small number of SD articles in those peak years. It should be noted that for all countries, the results shown are based on very small counts of SD articles (less than 100 publications) and should be interpreted with caution.

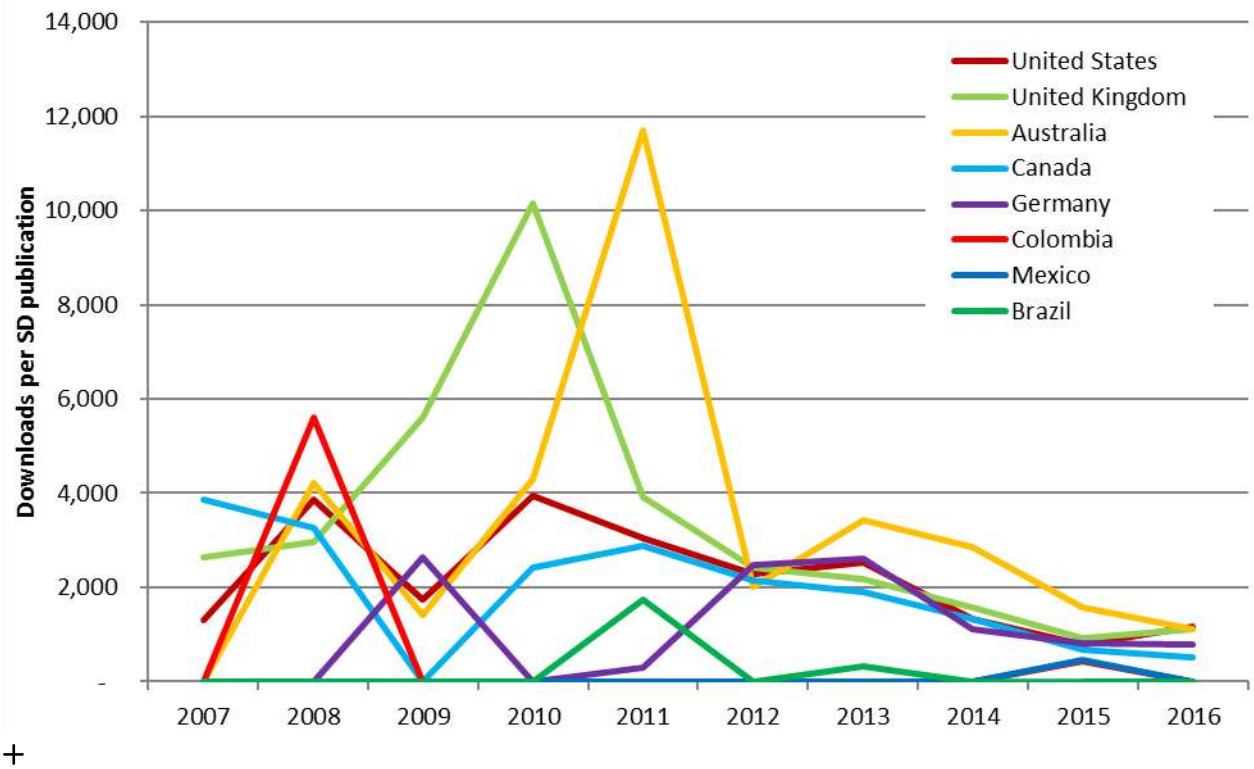


Figure 4.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

4.5.2 **Field Weighted Download Impact (FWDI)**

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. Interestingly, the United Kingdom has the highest mean FWDI for the period of 2007-2016 (Figure 4.7). However, given the very low count of SD publications from all countries analyzed (i.e. less than 100 SD publications for the full period) interpretation of this metric should be done with caution.

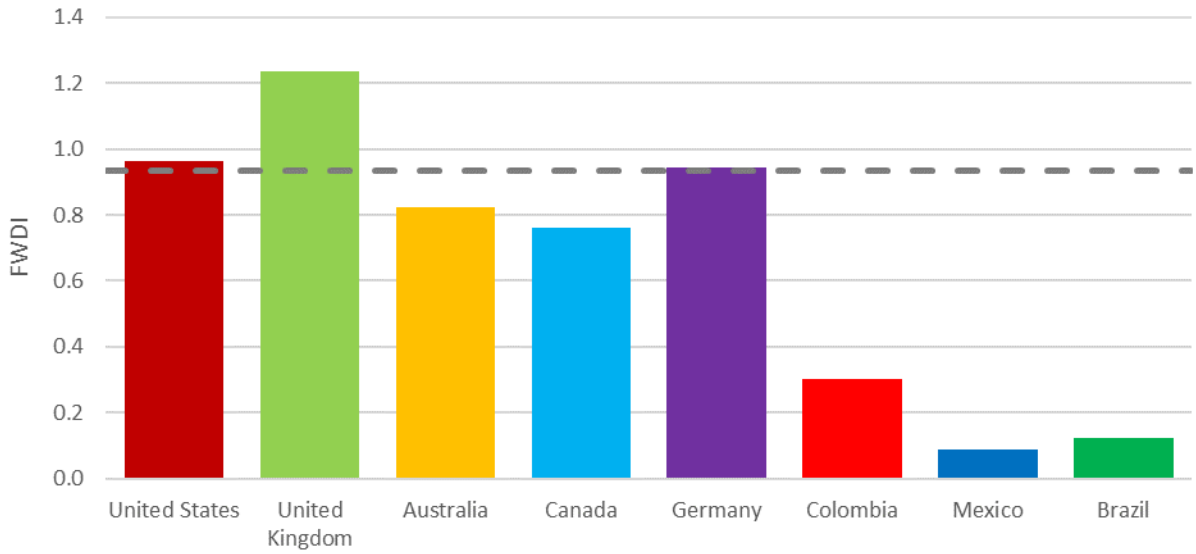


Figure 4.7— *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. Grey dotted line indicates average for all SDG4 research. (Source: ScienceDirect)*

4.6 SDG4 collaboration network

4.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG4-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 4.10-4.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG4 publications with. Among academic partner institutes, Colombia published one highly cited SDG4 paper with Stanford University and one uncited paper with the other five institutions (Table 4.10).

Country	Institution (Country)	Publication Count	FWCI
Colombia	Stanford University (United States)	1	3.75
	University of Florida (United States)	1	0.14
	University of Toronto (Canada)	1	0.00
	University College London (United Kingdom)	1	0.00
	Columbia University (United States)	1	0.00
	Universitat Politecnica de Catalunya (Spain)	1	0.00

Table 4.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	University of Tennessee, Knoxville (United States)	2	1.16
	Universitat Autonoma de Barcelona (Spain)	2	1.07
	Arizona State University (United States)	2	0.58
	Chalmers University of Technology (Sweden)	1	4.66
	Deakin University (Australia)	1	1.85
	ICREA (Spain)	1	1.85
	University of Cambridge (United Kingdom)	1	1.85
	University of Tubingen (Germany)	1	1.84
	University of Hohenheim (Germany)	1	1.84
	University of Kiel (Germany)	1	1.84
	Humboldt-Universitat zu Berlin (Germany)	1	1.84
	Universidad de Santiago de Compostela (Spain)	1	0.51
	Flemish Institute for Technological Research (Belgium)	1	0.43
	KU Leuven (Belgium)	1	0.43
	Universidad Tecnologica Metropolitana (Chile)	1	0.00
	Universidad Nacional de Educacion a Distancia (Spain)	1	0.00
	University of Parma (Italy)	1	0.00
	King Abdulaziz University (Saudi Arabia)	1	0.00
	Universitat Politecnica de Catalunya (Spain)	1	0.00
	University of Massachusetts Lowell (United States)	1	0.00

Table 4.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	University of Minho (Portugal)	3	0.78
	Columbia University (United States)	2	1.14
	University of York (United Kingdom)	1	3.84
	Malmo University (Sweden)	1	3.84
	University of Bremen (Germany)	1	3.84
	Philipps-Universitat Marburg (Germany)	1	1.46
	Tokyo Medical and Dental University (Japan)	1	1.26
	University of Texas Health Science Center at San Antonio (United States)	1	1.26
	Makerere University (Uganda)	1	1.26
	Trinity College Dublin (Ireland)	1	1.26
	University of Ghana (Ghana)	1	1.26
	Cardiff University (United Kingdom)	1	1.26
	Universidad Nacional de Cordoba (Argentina)	1	1.26
	Muhimbili University of Health and Allied Sciences (Tanzania)	1	1.26
	Universite Cheikh Anta Diop (Senegal)	1	1.26
	University of Dundee (United Kingdom)	1	1.26
	University of Rwanda (Rwanda)	1	1.26
	University of Massachusetts Dartmouth (United States)	1	1.08
	Manchester Metropolitan University (United Kingdom)	1	1.08
	University of Birmingham (United Kingdom)	1	1.03

Table 4.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	Makerere University (Uganda)	6	1.14
	University of Zimbabwe (Zimbabwe)	5	0.80
	University of Toronto (Canada)	4	4.28
	University of London (United Kingdom)	4	3.14
	Technion-Israel Institute of Technology (Israel)	4	2.69
	Instituto Tecnologico de Estudios Superiores de Monterrey (Mexico)	4	1.75
	University College London (United Kingdom)	4	1.61
	London School of Hygiene and Tropical Medicine (United Kingdom)	4	1.15
	McMaster University (Canada)	4	0.58
	Deakin University (Australia)	3	1.39
	Curtin University of Technology (Australia)	3	0.82
	University of Manchester (United Kingdom)	3	0.60
	Imperial College London (United Kingdom)	3	0.55
	University of York (United Kingdom)	3	0.42
	University of Queensland (Australia)	2	4.51
	Tel Aviv University (Israel)	2	3.70
	Massey University (New Zealand)	2	3.67
	Ewha Womans University (South Korea)	2	2.03
	University of Southampton (United Kingdom)	2	1.95
	Auckland University of Technology (New Zealand)	2	1.64

Table 4.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	Wageningen University & Research (Netherlands)	5	4.91
	Hult International Business School (United States)	4	2.57
	Aarhus University (Denmark)	4	1.62
	University of Wisconsin (United States)	4	1.19
	Griffith University Queensland (Australia)	4	0.50
	University of Cyprus (Cyprus)	3	2.69
	University of North Carolina (United States)	3	2.54
	University of Central Florida (United States)	3	1.68
	Universitat Politecnica de Catalunya (Spain)	3	1.12
	University of New England (United States)	3	0.88
	Columbia University (United States)	3	0.86
	University of Toronto (Canada)	3	0.85
	Trinity College Dublin (Ireland)	3	0.47
	Fudan University (China)	3	0.31
	University of Gothenburg (Sweden)	2	6.13
	Aalto University (Finland)	2	3.90
	Tufts University (United States)	2	3.73
	University of Malta (Malta)	2	2.97
	Democritus University of Thrace (Greece)	2	2.77
	Universidad de Jaen (Spain)	2	2.72

+

Table 4.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Australia	University of Auckland (New Zealand)	3	2.58
	Auckland University of Technology (New Zealand)	3	0.93
	Democritus University of Thrace (Greece)	3	0.80
	Aarhus University (Denmark)	3	0.49
	Leuphana Universitat Luneburg (Germany)	2	2.90
	Aalborg University (Denmark)	2	2.76
	Beijing Normal University (China)	2	2.24
	National Defense Medical Center Taiwan (Taiwan)	2	1.96
	Tongji University (China)	2	1.70
	Sunway University (Malaysia)	2	1.17
	University of Saskatchewan (Canada)	2	1.11
	University of Texas at Austin (United States)	2	0.99
	Ghent University (Belgium)	2	0.83
	University of Waikato (New Zealand)	2	0.19
	Hong Kong Polytechnic University (Hong Kong)	2	0.12
	Universidad de Chile (Chile)	2	0.00
	Virginia Commonwealth University (United States)	2	0.00
	Universidad de Zaragoza (Spain)	1	12.79
	Oregon State University (United States)	1	7.45
	Bocconi University (Italy)	1	4.02

+

Table 4.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Australia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Canada	University of Pennsylvania (United States)	3	5.36
	University of Wisconsin (United States)	3	1.58
	University of Pittsburgh (United States)	2	3.96
	University of London (United Kingdom)	2	3.49
	United Nations (United States)	2	2.68
	University of California at Davis (United States)	2	2.67
	Duke University (United States)	2	1.75
	Monash University (Australia)	2	1.60
	Nanyang Technological University (Singapore)	2	0.89
	Chinese Academy of Sciences (China)	2	0.77
	University of Tasmania (Australia)	2	0.57
	La Trobe University (Australia)	2	0.51
	University of Hong Kong (Hong Kong)	2	0.40
	University of Edinburgh (United Kingdom)	2	0.10
	Christiana Care Health System (United States)	1	15.40
	University of California at San Francisco (United States)	1	15.40
	University of Delaware (United States)	1	15.40
	Tufts University (United States)	1	6.14
	Karolinska Institutet (Sweden)	1	6.14
	Tribhuvan University (Nepal)	1	5.05

+

Table 4.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Canada. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Germany	Ghent University (Belgium)	3	0.66
	Maastricht University (Netherlands)	3	0.13
	United Nations (United States)	2	1.66
	Utah State University (United States)	2	0.65
	Open University of the Netherlands (Netherlands)	2	0.57
	Griffith University Queensland (Australia)	2	0.47
	Intel (United States)	2	0.30
	University of Plymouth (United Kingdom)	2	0.20
	Institut Pertanian Bogor (Indonesia)	2	0.08
	Umea University (Sweden)	1	4.92
	Royal Melbourne Institute of Technology University (Australia)	1	4.87
	University of Craiova (Romania)	1	4.15
	Universidade Federal de Sao Carlos (Brazil)	1	3.84
	University of York (United Kingdom)	1	3.84
	Malmo University (Sweden)	1	3.84
	The Ohio State University (United States)	1	3.60
	Qingdao University of Science and Technology (China)	1	3.12
	University of Nairobi (Kenya)	1	2.71
	Kenyatta University (Kenya)	1	2.71
	King's College London (United Kingdom)	1	2.49

+

Table 4.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Germany. (Source: Scopus)*

4.6.2 **Collaboration impact analysis**

To visualize the citation impact of collaborations, the ratio of FWCI from SDG4 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG4 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG4 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. As shown in Figure 4.8, Stanford University sits at the upper top right indicating that they've developed a best mutually beneficial collaboration with Colombia in terms of citation impact. Other institutes are all in the bottom left quadrant, likely because the publication received no or few citations.

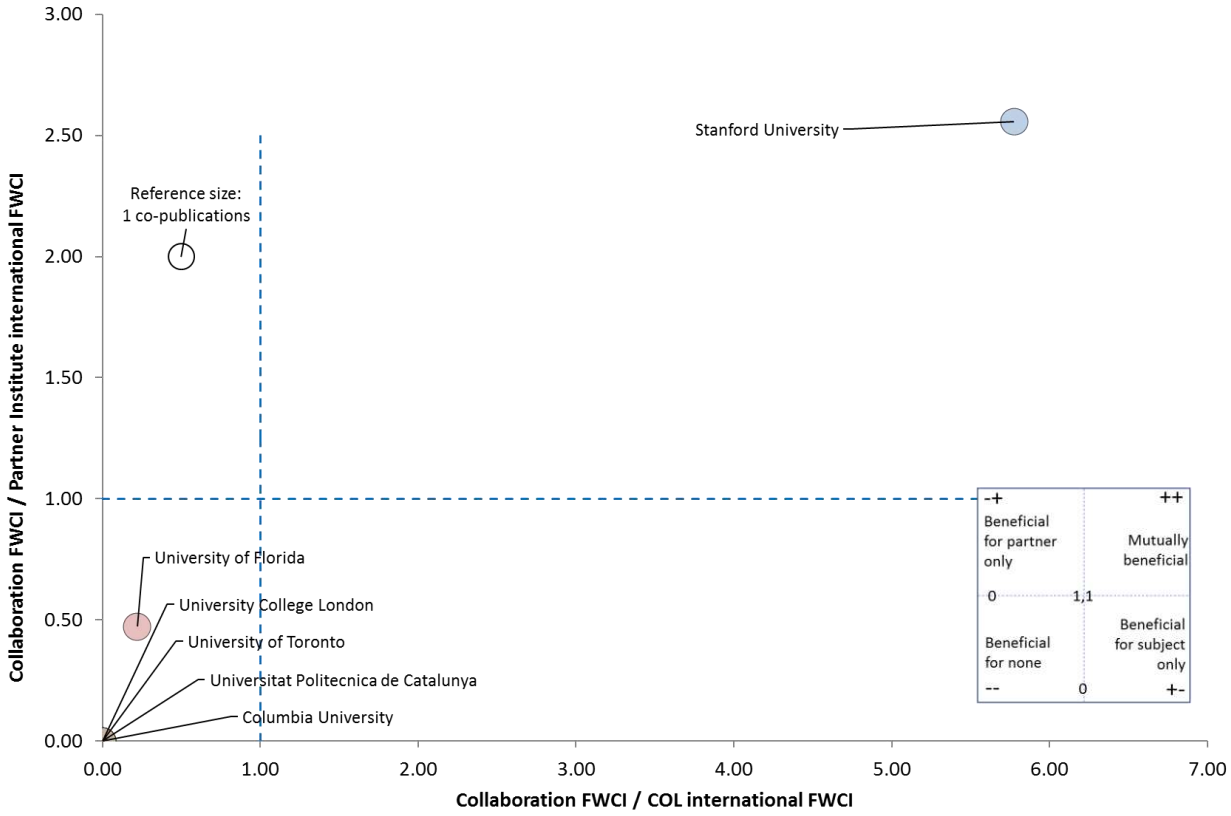


Figure 4.8— *Collaboration quadrant of Colombia's Top 20 collaborations in SDG4-related research with other institutions. Collaboration FWCI refers to the FWCI of all SDG4-related research co-authored by Colombia and the partner institute during the period 2007-2016. Bubble size corresponds to number of co-authored publications (reference bubble depicted at top left of chart). Impact of collaboration between partners can be interpreted based on quadrant position as described in legend on right. (Source: Scopus).*

4.6.3 **Collaboration chart**

Figure 4.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG4. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 4.9 shows where there may be potential to improve output and impact through partnership. Colombia has co-authored SDG4 publications with only 6 international institutes. Among these, University of Toronto, University of Florida, and University College of London are the most prolific. Columbia University and University of Toronto have the highest FWCI for SDG4 research. Colombia may want to leverage its existing relationships with these institutes to increase its publication output and impact in SDG4 research.

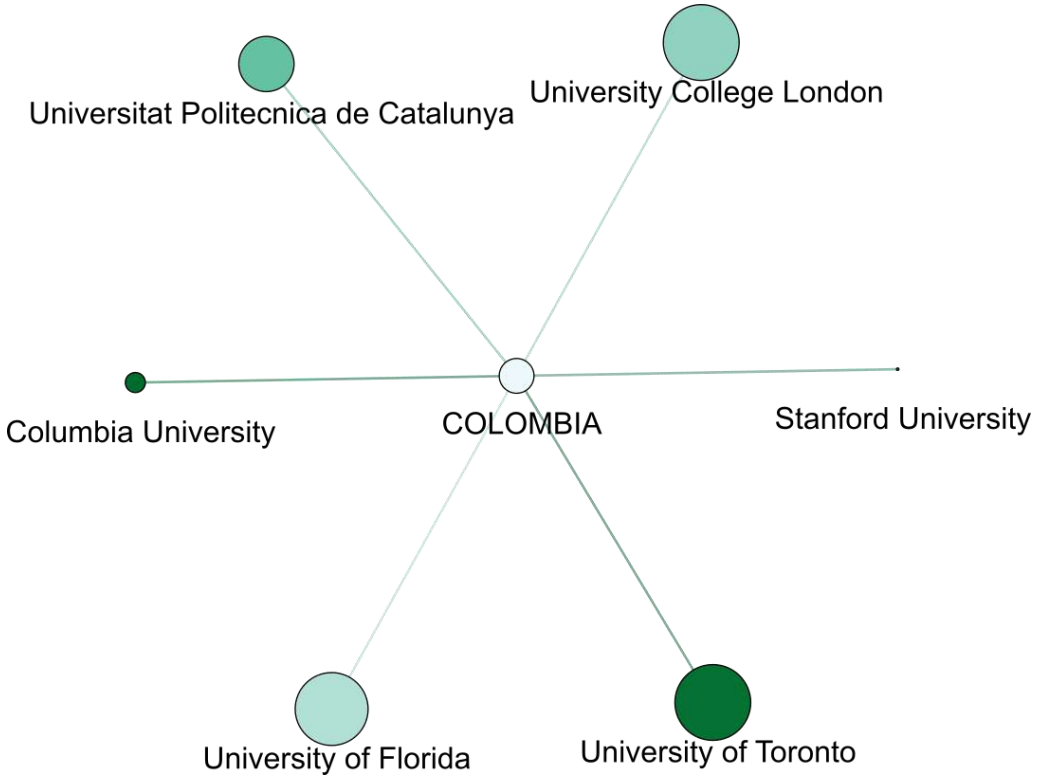


Figure 4.9— *Chart showing Colombia's top 20 collaborators on SDG4 from 2007-2016. Circle (node) size is proportional to the number of SDG4 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (1.74) and lightest shade of green indicating the lowest FWCI (0.92). (Source: Scopus).*

Chapter 5
Gender Equality

In this Chapter, we assess research related to SDG5, which aims to achieve gender equality and empower all women and girls. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

5.1 **Key Findings**

Goal 5: Achieve gender equality and empower all women and girls

WORLD RESEARCH OUTPUT

6,810

Number of SDG5 publications, 2007-2016.

SDG5 PATENTS

19

Number of SDG5 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

37

Colombia's SDG5 publications, 2007-2016.

COLOMBIA RESEARCH OUTPUT CAGR

31%

Compound annual growth rate for Colombia's 2007-2016 SDG5 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

5

Colombia's SDG5 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

2.11

Average field-weighted citation impact for Colombia's SDG5 publications, 2007-2016.

5.2 SDG5 – Achieve gender equality and empower all women and girls

According to the United Nations,

> *"While the world has achieved progress towards gender equality and women's empowerment under the Millennium Development Goals (including equal access to primary education between girls and boys), women and girls continue to suffer discrimination and violence in every part of the world.*
> *Gender equality is not only a fundamental human right, but a necessary foundation for a peaceful, prosperous and sustainable world.*
> *Providing women and girls with equal access to education, health care, decent work, and representation in political and economic decision-making processes will fuel sustainable economies and benefit societies and humanity at large."*[10]

The targets for SDG5, according to the United Nations are:

- *"End all forms of discrimination against all women and girls everywhere.*
- *Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation.*
- *Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation.*
- *Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate.*
- *Ensure women's full and effective participation and equal opportunities for leadership at all levels of decisionmaking in political, economic and public life.*
- *Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences.*
- *Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws.*
- *Enhance the use of enabling technology, specifically, information and communications technology, to promote the empowerment of women.*
- *Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels."*[10]

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG5 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

[10] http://www.un.org/sustainabledevelopment/gender-equality/

5.3 SDG5: Leaders in the field

5.3.1 Top 5 countries conducting SDG5 research

The top 5 countries publishing on SDG 5 based on cumulative publication output from 2007-2016 is indicated by Table 5.1 and Figure 5.1. The United States ranks 1st in Publication Count, Percentage of Global Output, and Citation Count, followed by the United Kingdom and then Australia, Canada and India. The United Kingdom ranks 1st in FWCI with a value of 1.90, which is higher than the world average. All other countries' FWCI exceed the world average as well.

Table 5.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	1,874	27.52%	21,662	1.59
United Kingdom	835	12.26%	12,989	1.90
Australia	452	6.64%	4,947	1.48
Canada	377	5.54%	4,811	1.59
India	377	5.54%	2,961	1.11
World	6,810	100.00%	24,301	1.12

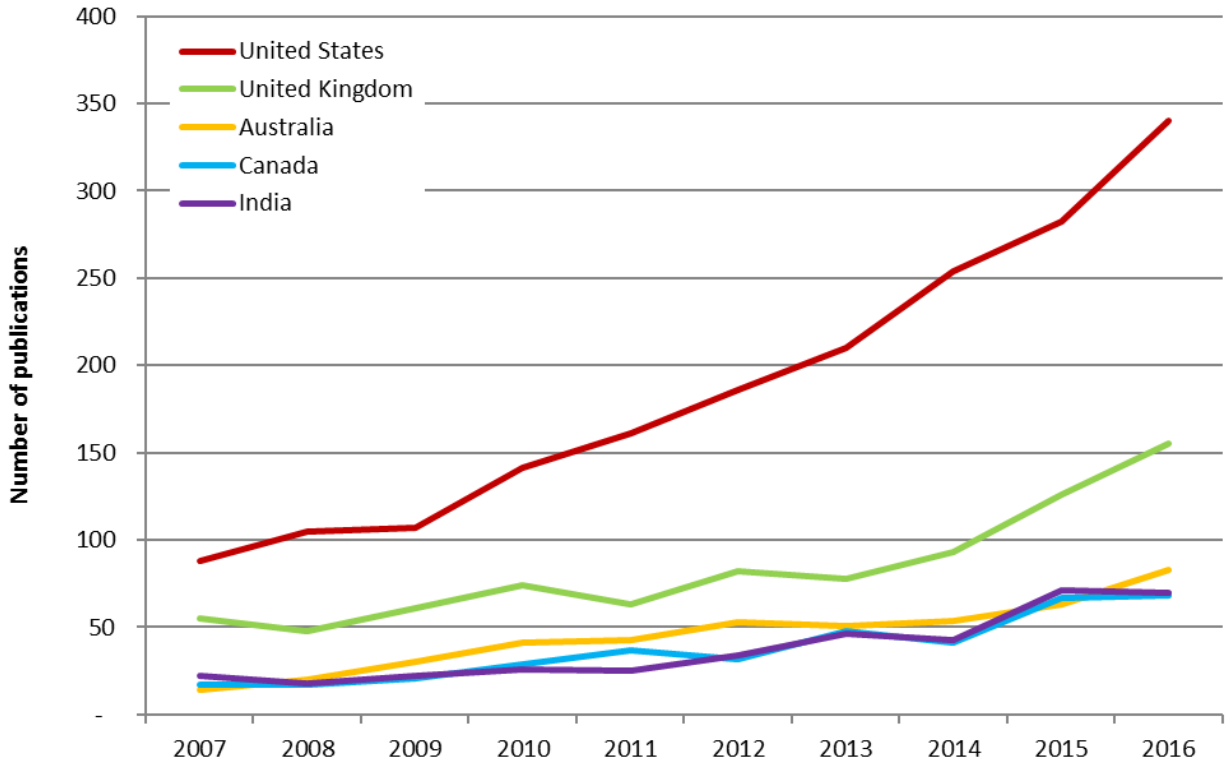


Figure 5.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG5 research. (Source: Scopus)*

5.3.2 Top 20 institutes conducting SDG5 research

A list of the top 20 research institutes publishing SDG5-related research is shown in Table 5.2. Johns Hopkins University ranks 1st in Publication Count and Citation Count followed by Harvard University, and the World Health Organization. University College London sits in the 1st place based on FWCI with a value of 5.18 – nearly 5 times higher than the world average of 1.12. University of California at Berkeley also has a very high FWCI at 3.96. The trends in publication output from 2007-2016 are shown in Figure 5.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Johns Hopkins University (United States)	88	1,737	2.69
2	Harvard University (United States)	87	1,694	3.58
3	World Health Organization (Switzerland)	84	1,386	3.76
4	London School of Hygiene and Tropical Medicine (United Kingdom)	68	1,544	3.44
5	University of Queensland (Australia)	59	864	2.31
6	University of British Columbia (Canada)	59	706	1.85
7	University of Toronto (Canada)	59	737	2.56
8	Columbia University (United States)	56	1,380	2.73
9	University of Washington (United States)	52	1,164	3.48
10	Wageningen University & Research (Netherlands)	48	1,068	2.80
11	United Nations (United States)	46	579	2.06
12	University of North Carolina (United States)	45	758	1.46
13	University of the Witwatersrand (South Africa)	44	640	1.64
14	University of California at Berkeley (United States)	40	954	3.96
15	University of KwaZulu-Natal (South Africa)	39	250	1.35
16	University of Melbourne (Australia)	39	1,154	3.19
17	Makerere University (Uganda)	38	668	2.05
18	University of California at San Francisco (United States)	38	1,108	3.64
19	University College London (United Kingdom)	35	1,632	5.18
20	University of Stellenbosch (South Africa)	34	291	1.15

Table 5.2— *Top 20 research Institutes ranked based on SDG5 publication output and FWCI from 2007-2016. (Source: Scopus)*

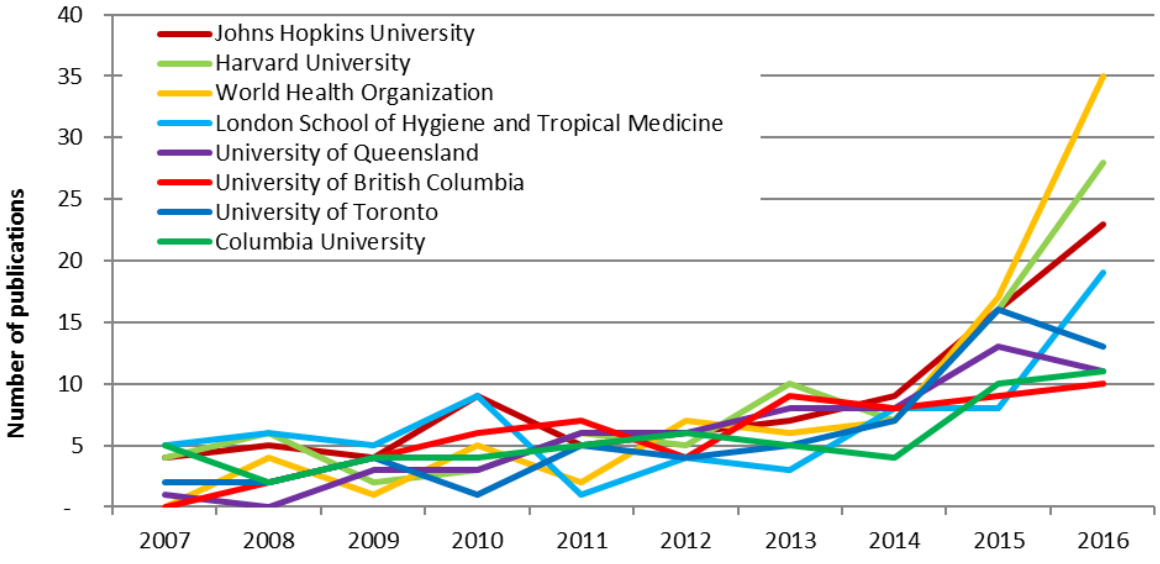


Figure 5.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG5. (Source: Scopus)*

5.3.3 Top 20 researchers conducting SDG5 research

A list of the top 20 researchers publishing in the SDG5 field based on publication output from 2007-2016 is shown in Table 5.3. Bhutta Z. ranks 1st in Publication Count followed by Temmerman M., Godwin A. and Singh R.
Bhutta Z., Lawn J., and Temmerman M. are the top 3 researchers in terms of h-index with an h-index of 87, 65, and 48, respectively.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Bhutta Z.	Hospital for Sick Children University of Toronto (Canada)	17	401	9.95	87
2	Temmerman M.	Aga Khan Hospital Nairobi (Kenya)	10	192	6.60	48
3	Godwin A.	Purdue University (United States)	10	80	5.85	6
4	Singh R.	ICAR-Directorate of Coldwater Fisheries Research (India)	10	56	0.75	10
5	Potvin G.	Florida International University (United States)	9	77	6.27	7
6	Lawn J.	London School of Hygiene & Tropical Medicine (United Kingdom)	9	164	5.81	65
7	Chou D.	Organisation Mondiale de la Sante (Switzerland)	8	197	12.02	17
8	Say L.	Organisation Mondiale de la Sante (Switzerland)	8	183	11.40	37
9	Hazari Z.	Florida International University (United States)	7	76	7.96	10
10	Huisingh D.	University of Tennessee, Knoxville (United States)	6	253	18.50	26
11	Smith A.	University of Sussex (United Kingdom)	6	383	8.10	31
12	Bynum Boley B.	The University of Georgia (United States)	6	85	3.20	8
13	Kuruvilla S.	Organisation Mondiale de la Sante (Switzerland)	6	34	2.67	11
14	Filippi V.	London School of Hygiene & Tropical Medicine (United Kingdom)	6	48	2.60	27
15	Matthews Z.	University of Southampton (United Kingdom)	6	30	2.18	21
16	Witter S.	Queen Margaret University (United Kingdom)	6	82	2.09	21
17	Bukusi E.	Kenya Medical Research Institute (Kenya)	6	48	1.51	31
18	Reed M.	University of Saskatchewan (Canada)	6	36	0.93	14
19	Hill P.	University of Queensland (Australia)	6	20	0.88	15
20	Hoffman L.	Universiteit Stellenbosch (South Africa)	6	61	0.53	25

Table 5.3— *Top 20 researchers publishing SDG5 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG5 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

5.3.4 **Top 10 journals publishing SDG5 research**

A list of the top 10 journals publishing SDG5-related research from 2007-2016 is shown in Table 5.4. *PloS ONE* published the most SDG5 publications (68) followed by *BMC Public Health* (63) and *Sustainability* (49). *The Lancet* ranks 1st in FWCI followed by *BMC Health Services Research* and *BMC Public Health* in the 2nd and 3rd place, respectively. As for CiteScore, *The Lancet* sits in the 1st place (CiteScore of 7.08) followed by *PLoS ONE* (CiteScore of 4.29), and *Journal of Cleaner Production* (CiteScore of 3.70).

Rank	Journal	Publication count	FWCI	CiteScore
1	PLoS ONE	68	1.07	4.29
2	BMC Public Health	63	1.12	2.62
3	Sustainability	49	0.85	0.92
4	Journal of Cleaner Production	45	5.55	3.70
5	ASEE Annual Conference and Exposition, Conference Proceedings	34	0.81	0.00
6	BMC Health Services Research	31	1.38	2.29
7	Lancet, The	29	15.79	7.08
8	Reproductive Health Matters	28	0.69	1.66
9	Mediterranean Journal of Social Sciences	28	0.17	0.00
10	WIT Transactions on Ecology and the Environment	26	0.02	0.08

Table 5.4— *Top 10 journals based on SDG5 publication output from 2007-2016. FWCI is mean FWCI for any SDG5 publications in the journal during the period; CiteScore is based on data for the journal as a whole. (Source: Scopus)*

5.4 Research efforts focused on SDG5

5.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 5.3, the United States is by far the leader in terms of research output related to SDG 5. The United Kingdom follows behind the United States with less than half the publication count of the United States. Among comparators, Colombia has the lowest output in this field, just below Mexico. However, as shown in Table 5.5, Colombia has the greatest Compound Annual Growth Rate (CAGR) of 30.50% in this field of research. Australia also see marked increases in publication output with a CAGR above 20%.

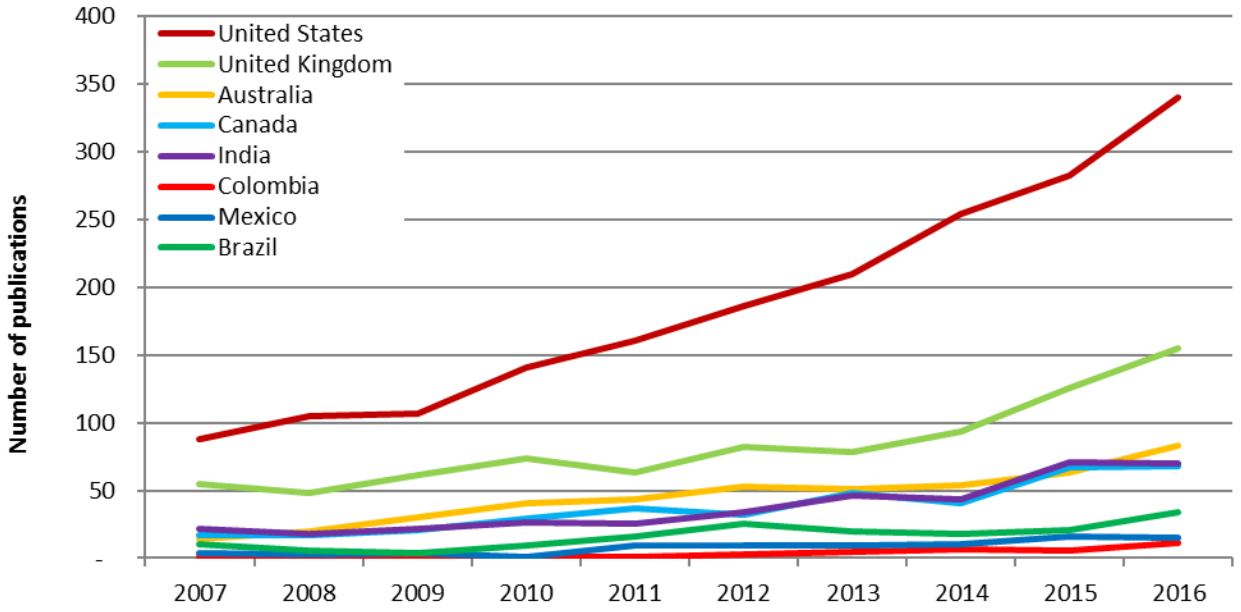


Figure 5.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	1,874	16.20%
United Kingdom	835	12.20%
Australia	452	21.90%
Canada	377	16.70%
India	377	13.70%
Colombia	37	30.50%
Mexico	80	15.80%
Brazil	163	14.60%
World	6,810	13.30%

Table 5.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

5.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG5 related research from 2006-2017 is 1.12.

Comparing the FWCI of publications from each of the eight countries included in this chapter reveals some differences and similarities (Table 5.6). Mexico achieves the highest FWCI among comparator countries, likely resulting from a small number of outlier publications that affect the mean. While the United States of America leads in publication count, its FWCI is 1.59.

Country	FWCI
United States	1.59
United Kingdom	1.90
Australia	1.48
Canada	1.59
India	1.11
Colombia	2.11
Mexico	3.16
Brazil	1.30
World	1.12

Table 5.6— *FWCI per Comparator, 2007-2016. (Source: Scopus)*

5.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 5.4 and Table 5.7, the United States leads in terms of publications that are among the top 10% most cited. The United Kingdom, Australia, and Canada follow in that order. Colombia has a very small number of publications among the top 10% most cited during this time period.

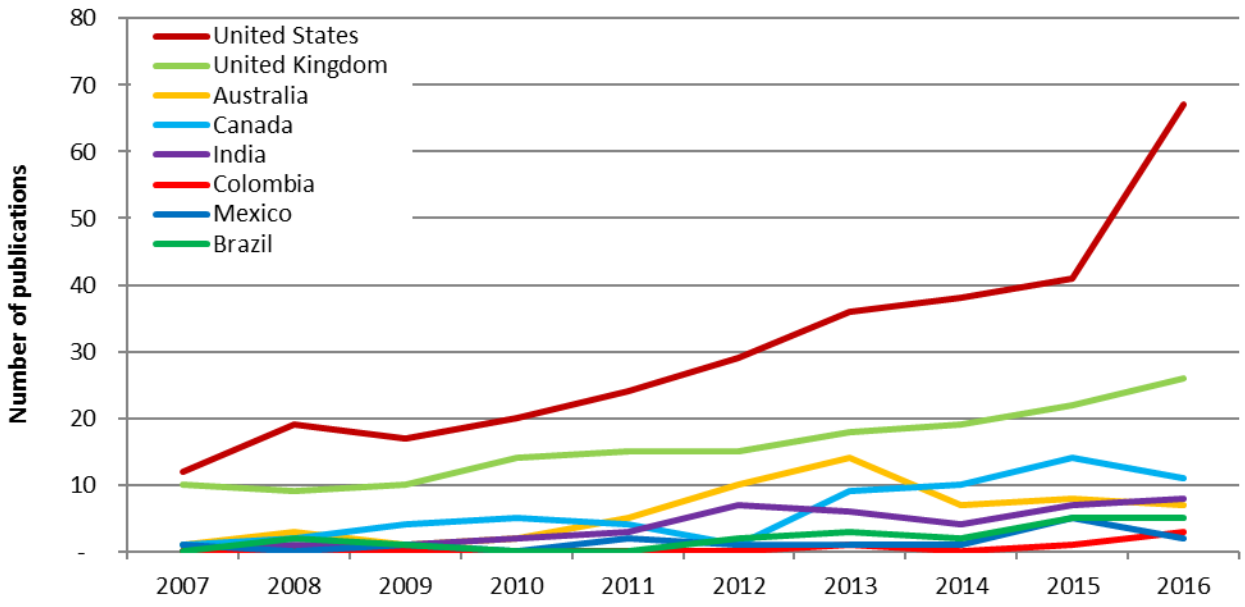


Figure 5.4— *Top 10% most cited publications on SDG5 from 2007-2016 per country. CAGR shown at top of each bar. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
United States	303	21.06%
United Kingdom	158	11.20%
Australia	58	24.14%
Canada	61	30.53%
India	39	-
Colombia	5	-
Mexico	14	8.01%
Brazil	20	-
World	737	15.67%

Table 5.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG5 publications from 2007-2016. (Source: Scopus)*

5.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 5.8 provides the count of SDG5 publications from each country that have been cited in patents and the number of patents that have cited these publications. The findings show that patent citation count is related to publication count in that the leaders in publication output have the highest patent citation count. The United States leads with 6 patent cited publications and 13 patents citing publications followed by the United Kingdom and India. Most countries, including Colombia, have no patent citations.

Country	Patent Cited Publications	Patents Citing Publications
United States	6	13
United Kingdom	3	3
Australia	-	-
Canada	-	-
India	1	1
Colombia	-	-
Mexico	-	-
Brazil	-	-
World	11	19

Table 5.8— *Number of publications cited in USPTO, WIPO, or EPO patents and number of USPTO, WIPO, or EPO patents citing publications on SDG5 from 2007 to 2016. (Source: Scopus and LexisNexis)*

5.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG5. To identify patents relevant to SDG5, we retrieved all the patents citing any SDG5-related publication. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO. From 2006 to 2016, the United States applied for 1 patent and had 10 granted in this field. Other than the United States, Canada and India, other countries had no patents in this field. Note that India and Australia may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	1	10	11	57.89%
United Kingdom	-	-	-	0.00%
Australia	-	-	-	0.00%
Canada	2	-	2	10.53%
India	1	-	1	5.26%
Colombia	-	-	-	0.00%
Mexico	-	-	-	0.00%
Brazil	-	-	-	0.00%
World	8	11	19	

Table 5.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

5.4.6 **Research Focus**

Within the topic of SDG5-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG5-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG5 research is shown in Figure 5.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG5 research from Colombia, terms that stand out as unique to Colombia are 'Building', 'Food Supply', 'Iron', 'Force', 'Water', 'Agroecology', 'Environment', 'Artisanal mining', and 'Mining'. Among the top 50 key phrases the terms 'Conservation of Natural Resources, 'Health', and 'Maternal Mortality'. were common among the countries analyzed. Figure 5.5 provides a visualization of the top 50 key phrases for SDG5 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

Colombia

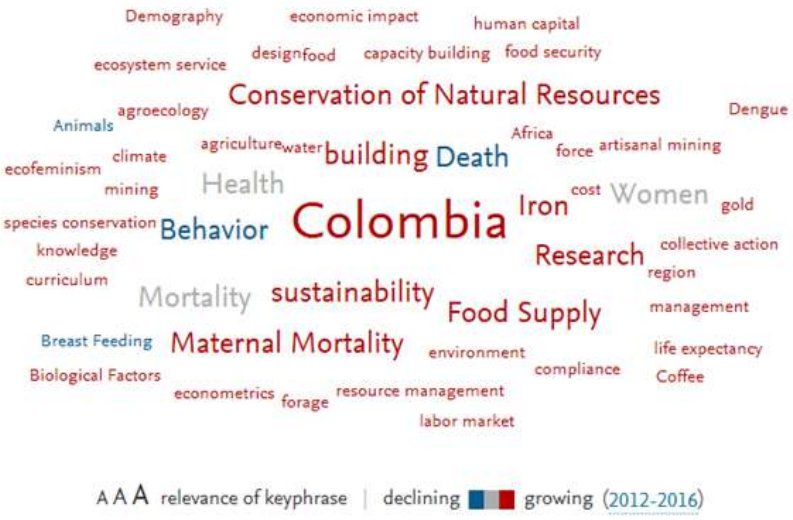


Figure 5.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Mexico

Brazil

United States

United Kingdom

Australia

Canada

India

Distributed power generation
Marketing
womens health
community forestry
village
Women's Health
Self-Help Groups
Reproductive Health
Maternal Mortality
Developing countries
IndustryBiodiversity
Health care Income
Rural areas
Health Goals
Agriculture
Child
Residence Characteristics
HIV
management
gender
Economics
Asia
India
Women
Food
Public policy
sustainability
microfinance
Sustainable development
Maternal Welfare
Internet
watershed
Technology
Communication
Child Welfare
Research
education
Malnutrition
empowerment
self help
Maternal Health Services
household income
Patient rehabilitation
Conservation of Natural Resources
A A A relevance of keyphrase | declining growing (2012-2016)

5.5 The reach of Colombia's SDG5 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

5.5.1 Downloads

As shown in the Figure 5.6, the mean count of downloads per ScienceDirect publication fluctuates considerable across the period for all countries. It should be noted that for all countries except the United States and United Kingdom, the results shown are based on very small counts of SD articles (less than 100 publications) and should be interpreted with caution.

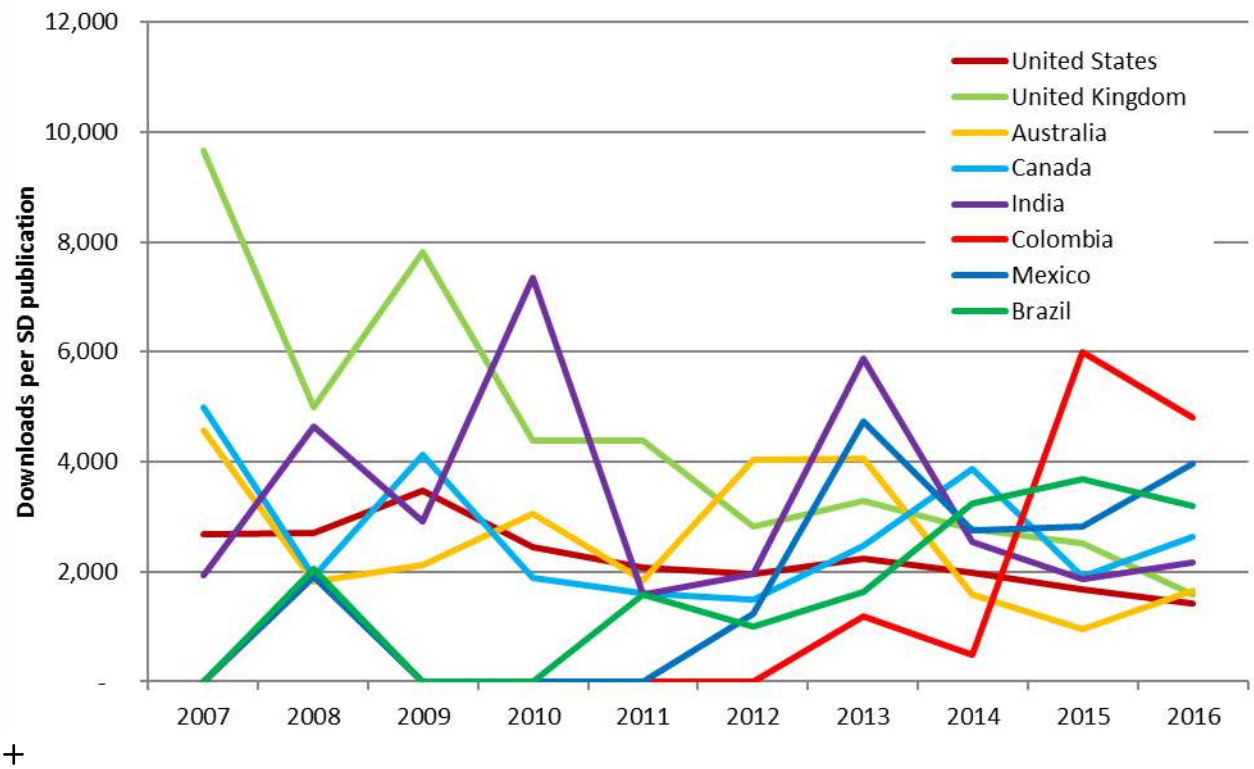


Figure 5.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

5.5.2 **Field Weighted Download Impact (FWDI)**

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. Interestingly, Colombia has the highest mean FWDI for the period of 2007-2016 (Figure 5.7). However, given the very low count of SD publications from all countries analyzed except the United States and United Kingdom (i.e. less than 100 SD publications for the full period), interpretation of this metric should be done with caution.

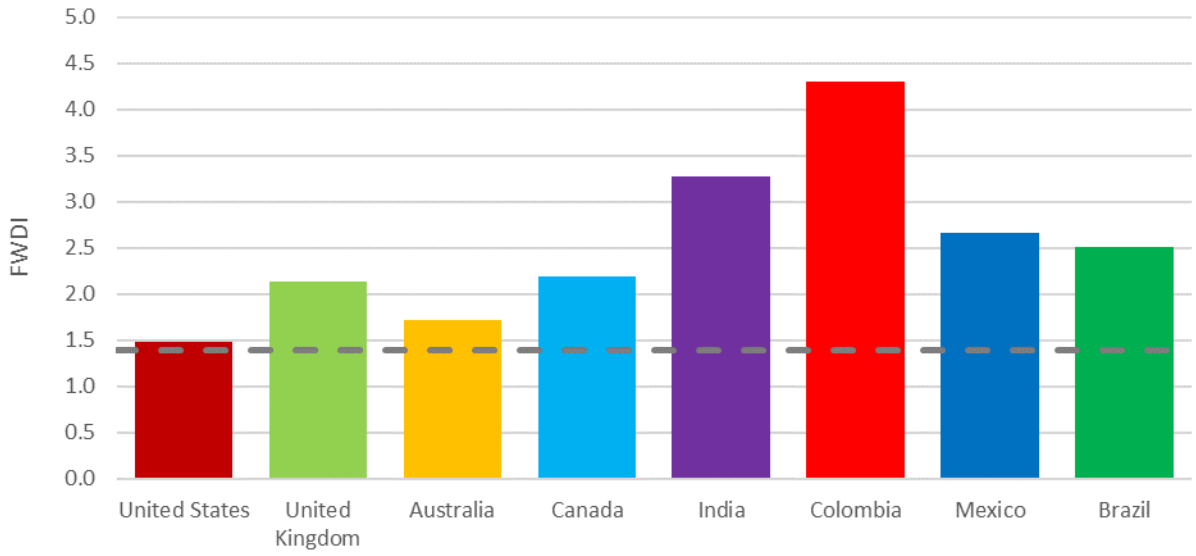


Figure 5.7— *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. Grey dotted line indicates average for all SDG5 research. (Source: ScienceDirect)*

5.6 SDG5 collaboration network

5.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG5-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 5.10-5.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG5 publications with. Among academic partner institutes, Colombia has published the most SDG5 papers in collaboration with University of the Witwatersrand (3 publications from 2007-2016) based on Table 5.10. The other top 20 institutes have each published 2 collaborative publications. The FWCI of those collaborative publications ranges from 20.25 to 6.58, all much higher than the world average.

Country	Institution (Country)	Publication Count	FWCI
Colombia	University of the Witwatersrand (South Africa)	3	6.58
	University of Melbourne (Australia)	2	20.25
	University of Oslo (Norway)	2	20.25
	University of Sydney (Australia)	2	20.25
	Aga Khan University (Pakistan)	2	20.25
	University of Tromso (Norway)	2	20.25
	Indian Council of Medical Research (India)	2	20.25
	Fundacao Oswaldo Cruz (Brazil)	2	15.18
	Universidad de Chile (Chile)	2	12.19
	World Health Organization (Switzerland)	2	11.63
	Universidade de Brasilia (Brazil)	2	11.63
	Harvard University (United States)	2	11.63
	Wageningen University & Research (Netherlands)	2	9.56
	National Institutes of Health (United States)	2	9.52
	London School of Hygiene and Tropical Medicine (United Kingdom)	2	9.52
	Instituto Nacional de Salud Publica (Mexico)	2	9.52
	Queen Mary University of London (United Kingdom)	2	9.52
	Universite de Montreal (Canada)	2	9.15
	Seoul National University (South Korea)	2	9.15
	Johns Hopkins University (United States)	2	9.04

Table 5.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	Wageningen University & Research (Netherlands)	5	8.03
	World Health Organization (Switzerland)	4	9.41
	University of Washington (United States)	4	9.24
	University of Aberdeen (United Kingdom)	3	12.96
	University of Toronto (Canada)	3	11.66
	University of the Witwatersrand (South Africa)	3	8.11
	London School of Hygiene and Tropical Medicine (United Kingdom)	3	8.08
	Harvard University (United States)	3	7.63
	Utrecht University (Netherlands)	3	7.09
	University of Bergen (Norway)	2	14.79
	University of California at San Francisco (United States)	2	14.79
	University of Oxford (United Kingdom)	2	14.79
	Columbia University (United States)	2	14.79
	University of Pennsylvania (United States)	2	11.05
	University of Auckland (New Zealand)	2	11.05
	United Nations (United States)	2	10.96
	South African Medical Research Council (South Africa)	2	10.96
	University of Arizona (United States)	2	10.19
	Queen Mary University of London (United Kingdom)	2	9.52
	National Institutes of Health (United States)	2	9.52

+

Table 5.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	World Health Organization (Switzerland)	10	5.13
	London School of Hygiene and Tropical Medicine (United Kingdom)	7	5.29
	Harvard University (United States)	6	10.05
	Johns Hopkins University (United States)	6	5.26
	Aga Khan University (Pakistan)	5	10.70
	University College London (United Kingdom)	5	8.95
	University of Toronto (Canada)	4	7.47
	University of Oslo (Norway)	3	21.37
	University of Sydney (Australia)	3	14.90
	Institute of Tropical Medicine Antwerp (Belgium)	3	9.05
	Universidad Peruana Cayetano Heredia (Peru)	3	8.88
	University of KwaZulu-Natal (South Africa)	3	7.75
	University of Zurich (Switzerland)	3	7.07
	James Cook University Queensland (Australia)	3	6.46
	University of the Witwatersrand (South Africa)	3	5.92
	American University of Beirut (Lebanon)	3	5.92
	Prince of Songkla University (Thailand)	2	23.70
	University of Melbourne (Australia)	2	20.25
	Indian Council of Medical Research (India)	2	20.25
	University of Tromso (Norway)	2	20.25

Table 5.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	World Health Organization (Switzerland)	47	5.18
	London School of Hygiene and Tropical Medicine (United Kingdom)	23	5.69
	University of Toronto (Canada)	18	3.89
	Makerere University (Uganda)	14	3.57
	South African Medical Research Council (South Africa)	14	3.40
	Aga Khan University (Pakistan)	13	5.39
	University of British Columbia (Canada)	13	3.51
	University of Queensland (Australia)	12	3.51
	Wageningen University & Research (Netherlands)	11	4.99
	University of the Witwatersrand (South Africa)	11	3.09
	University College London (United Kingdom)	10	10.85
	University of Cambridge (United Kingdom)	10	4.03
	University of Oslo (Norway)	9	13.23
	University of Oxford (United Kingdom)	9	4.58
	University of Stellenbosch (South Africa)	9	2.67
	University of Cape Town (South Africa)	9	2.64
	Save the Children (United Kingdom)	8	5.75
	Imperial College London (United Kingdom)	8	5.61
	Universidad Peruana Cayetano Heredia (Peru)	8	5.40
	Chinese Center for Disease Control and Prevention (China)	8	3.91

+

Table 5.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	World Health Organization (Switzerland)	26	6.67
	Harvard University (United States)	18	8.45
	Johns Hopkins University (United States)	15	5.87
	University of the Witwatersrand (South Africa)	14	3.07
	Columbia University (United States)	11	8.87
	University of Washington (United States)	10	11.50
	Makerere University (Uganda)	10	2.81
	University of Toronto (Canada)	9	6.88
	United Nations (United States)	9	4.55
	Wageningen University & Research (Netherlands)	8	7.57
	Aga Khan University (Pakistan)	8	5.31
	University of KwaZulu-Natal (South Africa)	8	3.23
	University of Queensland (Australia)	7	6.10
	University of Cape Town (South Africa)	7	4.46
	UNICEF (United States)	6	7.64
	Institute of Tropical Medicine Antwerp (Belgium)	6	5.56
	Ghent University (Belgium)	6	4.87
	Utrecht University (Netherlands)	6	4.81
	Universitat Autonoma de Barcelona (Spain)	6	2.55
	University of Amsterdam (Netherlands)	6	1.73

+

Table 5.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Australia	World Health Organization (Switzerland)	10	8.59
	Harvard University (United States)	8	8.79
	University of Toronto (Canada)	7	4.12
	University of British Columbia (Canada)	7	3.25
	University of the Witwatersrand (South Africa)	7	3.03
	University of Washington (United States)	5	12.93
	Aga Khan University (Pakistan)	5	10.34
	Wageningen University & Research (Netherlands)	5	8.31
	University of Oslo (Norway)	4	22.52
	Johns Hopkins University (United States)	4	5.72
	University of Oxford (United Kingdom)	4	5.54
	University of Cape Town (South Africa)	4	5.42
	University College London (United Kingdom)	4	5.28
	University of Auckland (New Zealand)	4	4.94
	University of Calgary (Canada)	4	4.79
	Stanford University (United States)	3	21.83
	University of California at San Francisco (United States)	3	21.78
	University of Otago (New Zealand)	3	9.01
	Universidad de Chile (Chile)	3	8.03
	Center for International Forestry Research, West Java (Indonesia)	3	7.18

Table 5.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Australia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Canada	Aga Khan University (Pakistan)	14	6.14
	Harvard University (United States)	10	9.35
	World Health Organization (Switzerland)	9	6.32
	London School of Hygiene and Tropical Medicine (United Kingdom)	8	9.43
	Johns Hopkins University (United States)	8	9.35
	University College London (United Kingdom)	6	12.77
	University of Washington (United States)	6	10.38
	United Nations (United States)	6	5.14
	University of KwaZulu-Natal (South Africa)	6	4.28
	Institute of Tropical Medicine Antwerp (Belgium)	5	5.97
	University of Cape Town (South Africa)	5	5.27
	Yale University (United States)	5	4.00
	University of Stellenbosch (South Africa)	5	3.42
	University of Melbourne (Australia)	4	10.34
	World Bank (United States)	4	10.11
	Stanford University (United States)	4	6.38
	University of Queensland (Australia)	4	6.19
	University of Auckland (New Zealand)	4	5.87
	Wageningen University & Research (Netherlands)	4	5.81
	Ghent University (Belgium)	4	5.76

+

Table 5.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Canada. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
India	World Health Organization (Switzerland)	10	8.37
	London School of Hygiene and Tropical Medicine (United Kingdom)	9	4.42
	Columbia University (United States)	8	9.23
	National Institutes of Health (United States)	8	5.02
	Harvard University (United States)	7	13.65
	University College London (United Kingdom)	7	7.48
	Aga Khan University (Pakistan)	7	6.69
	Johns Hopkins University (United States)	7	5.57
	Karolinska Institutet (Sweden)	6	3.40
	University of Oslo (Norway)	5	22.21
	University of California at San Francisco (United States)	5	13.71
	University of the Witwatersrand (South Africa)	5	5.24
	Research Triangle Institute International (United States)	5	1.03
	University of Washington (United States)	4	16.01
	Bill and Melinda Gates Foundation (United States)	4	14.11
	South African Medical Research Council (South Africa)	4	7.26
	United Nations (United States)	4	5.70
	King's College London (United Kingdom)	4	5.52
	University of Alabama at Birmingham (United States)	4	5.41
	University of North Carolina (United States)	4	1.58

+

Table 5.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for India. (Source: Scopus)*

5.6.2 **Collaboration impact analysis**

To visualize the citation impact of collaborations, the ratio of FWCI from SDG5 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG5 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG5 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. As shown in Figure 5.8, University of Melbourne sits far at the upper top right, indicating that they've developed a highly mutually beneficial collaboration with Colombia in terms of citation impact. Other institutes in this quadrant include Aga Khan University and the University of Sydney. The Indian Council of Medical Research sits on the horizontal line indicating that the collaboration helps raise Colombia's FWCI, but not its own.

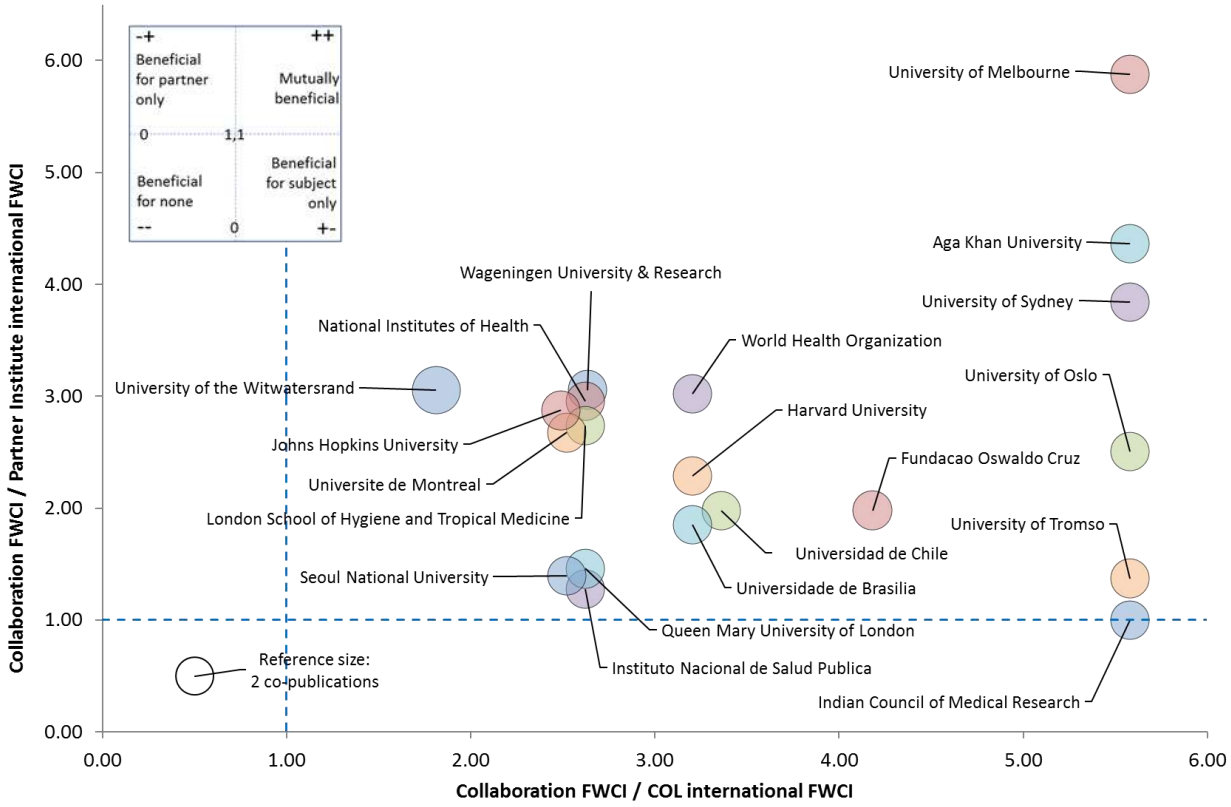


Figure 5.8— *Collaboration quadrant of Colombia's Top 20 collaborations in SDG5-related research with other institutions. Collaboration FWCI refers to the FWCI of all SDG5-related research co-authored by Colombia and the partner institute during the period 2007-2016. Bubble size corresponds to number of co-authored publications (reference bubble depicted at top left of chart). Impact of collaboration between partners can be interpreted based on quadrant position as described in legend on top left. (Source: Scopus).*

5.6.3 **Collaboration chart**

Figure 5.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG5. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 5.9 shows where there may be potential to improve output and impact through partnership. Among Colombia's top 20 partners, Johns Hopkins University, Harvard University, and the World Health Organization produce the highest number of SDG5 publications with 88, 87, and 84 publications respectively. Among Colombia's top 20 partners, University of Oslo and University of Tromso have the highest FWCI for SDG5 research. Colombia may want to leverage its existing relationships with these institutes to increase its publication output and impact in SDG5 research.

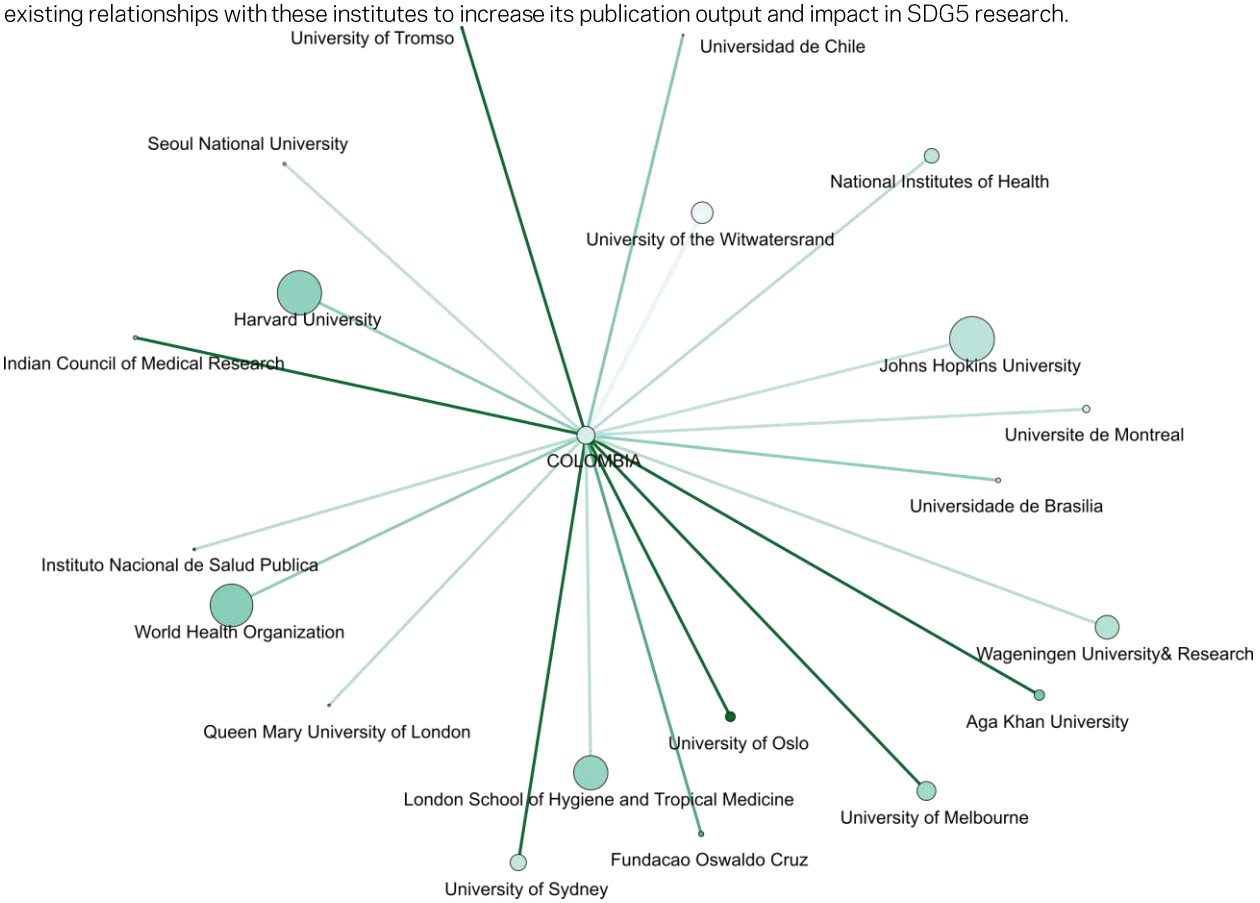


Figure 5.9— *Chart showing Colombia's top 20 collaborators on SDG5 from 2007-2016. Circle (node) size is proportional to the number of SDG5 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (7.25) and lightest shade of green indicating the lowest FWCI (1.64). (Source: Scopus).*

Chapter 6
Clean Water and Sanitation

In this Chapter, we assess research related to SDG6, which aims to ensure access to water and sanitation for all. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

6.1 **Key Findings**

Goal 6: Ensure access to water and sanitation for all

WORLD RESEARCH OUTPUT

58,404

Number of SDG6 publications, 2007-2016.

SDG6 PATENTS

1,010

Number of SDG6 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

212

Colombia's SDG6 publications, 2007-2016.

COLOMBIA RESEARCH OUTPUT CAGR

27%

Compound annual growth rate for Colombia's 2007-2016 SDG6 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

27

Colombia's SDG6 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

1.04

Average field-weighted citation impact for Colombia's SDG6 publications, 2007-2016.

6.2 SDG6 – Ensure access to water and sanitation for all

According to the United Nations,

> *"Clean, accessible water for all is an essential part of the world we want to live in. There is sufficient fresh water on the planet to achieve this. But due to bad economics or poor infrastructure, every year millions of people, most of them children, die from diseases associated with inadequate water supply, sanitation and hygiene.*
> *Water scarcity, poor water quality and inadequate sanitation negatively impact food security, livelihood choices and educational opportunities for poor families across the world. Drought afflicts some of the world's poorest countries, worsening hunger and malnutrition.*
> *By 2050, at least one in four people is likely to live in a country affected by chronic or recurring shortages of fresh water."*[11]

The targets for SDG6, according to the United Nations are:

- *"By 2030, achieve universal and equitable access to safe and affordable drinking water for all.*
- *By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.*
- *By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.*
- *By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.*
- *By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.*
- *By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.*
- *By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies.*
- *Support and strengthen the participation of local communities in improving water and sanitation management."*[11]

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG6 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

[11] http://www.un.org/sustainabledevelopment/water-and-sanitation/

6.3 SDG6: Leaders in the field

6.3.1 Top 5 countries conducting SDG6 research

The top 5 countries publishing on SDG 6 based on cumulative publication output from 2007-2016 is indicated by Table 6.1 and Figure 6.1. The United States ranks 1st in Publication Count, Percentage of Global Output, and Citation Count. China follows with approximately 2,000 fewer publications while the United Kingdom, India, and Australia publish 3,200-4,000. The United Kingdom ranks 1st according to FWCI with an FWCI of 1.69, followed by Australia and the United States, all of which had an FWCI higher than the world average.

Table 6.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	12,364	21.17%	194,463	1.44
China	10,545	18.06%	83,499	0.93
United Kingdom	4,087	7.00%	81,328	1.73
India	3,571	6.11%	34,838	0.91
Australia	3,200	5.48%	59,126	1.69
World	58,404	100.00%	263,899	1.10

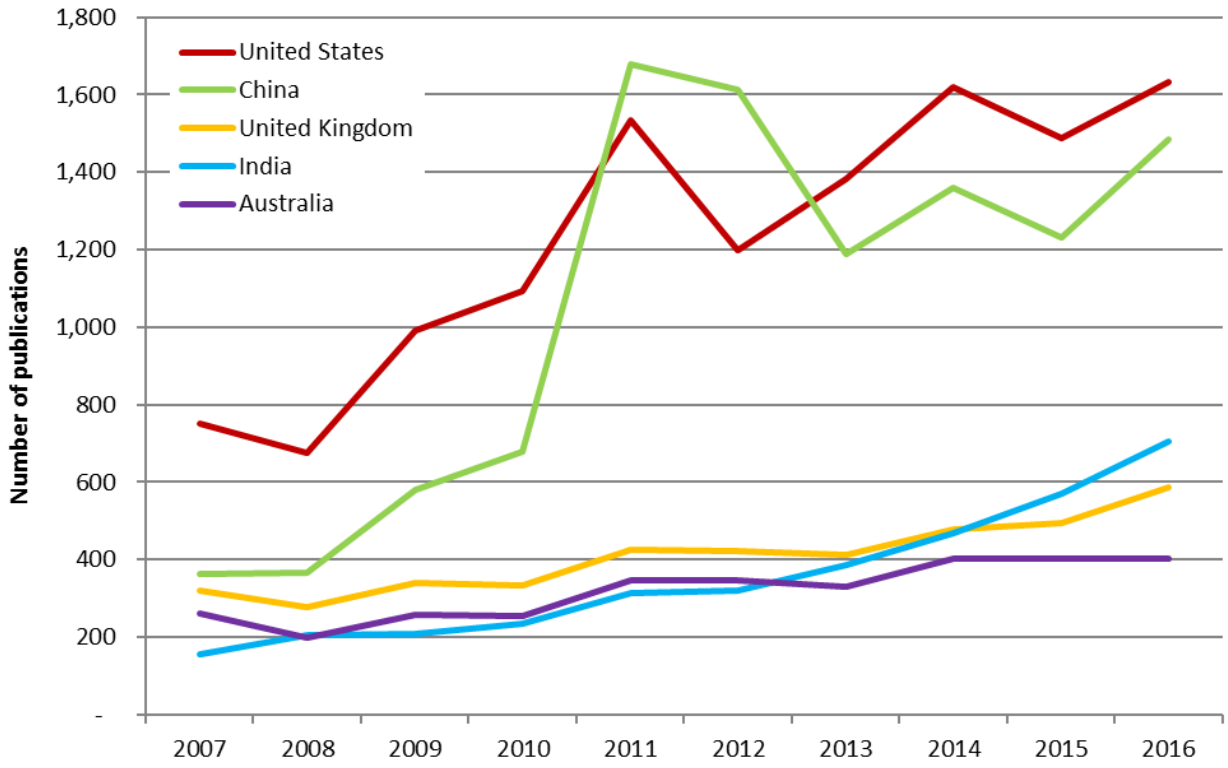


Figure 6.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG6 research (Source: Scopus)*

6.3.2 Top 20 institutes conducting SDG6 research

A list of the top 20 research institutes publishing SDG6-related research is shown in Table 6.2. The Chinese Academy of Sciences ranks 1st in Publication Count and Citation Count followed by the U.S. Department of Agriculture and Wageningen University & Research. Arizona State University sits in 1st place according to FWCI with an FWCI of 2.84. Wageningen University & Research also have a high FWCI with an FWCI of 2.58. All other top 20 Institutes' FWCI values are above the world average, except for Hohai University and Chang'an University in China. The trends in publication output from 2007-2016 are shown in Figure 6.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Chinese Academy of Sciences (China)	1,492	19,491	1.36
2	U.S. Department of Agriculture (United States)	555	13,954	1.95
3	Wageningen University & Research (Netherlands)	537	16,496	2.65
4	Ministry of Education China (China)	501	5,142	1.25
5	CSIRO (Australia)	426	12,907	2.15
6	CNRS (France)	414	8,492	1.89
7	Beijing Normal University (China)	390	3,913	1.25
8	INRA Institut National de La Recherche Agronomique (France)	347	7,735	2.20
9	CSIC (Spain)	313	7,550	1.87
10	Tsinghua University (China)	299	4,362	1.61
11	Delft University of Technology (Netherlands)	297	6,079	1.85
12	Texas A and M University (United States)	289	4,143	1.45
13	China Agricultural University (China)	286	3,797	1.28
14	Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences (China)	284	3,092	1.15
15	Arizona State University (United States)	273	12,649	2.84
16	Chang'an University (China)	271	177	0.38
17	Hohai University (China)	271	1,297	0.72
18	Ghent University (Belgium)	256	6,757	1.88
19	University of Queensland (Australia)	253	8,158	2.53
20	Universidade de Sao Paulo (Brazil)	244	2,378	1.07

Table 6.2— *Top 20 research Institutes ranked based on SDG6 publication output and FWCI from 2007-2016. (Source: Scopus)*

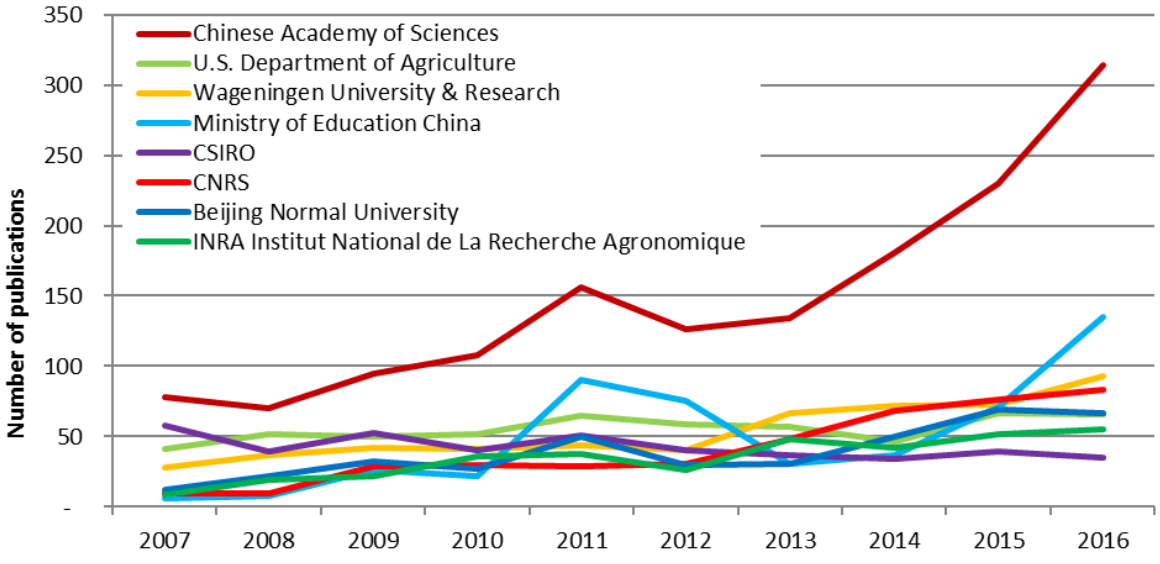


Figure 6.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG6. (Source: Scopus)*

6.3.3 Top 20 researchers conducting SDG6 research

A list of the top 20 researchers publishing in the SDG6 field based on publication output from 2007-2016 is shown in Table 6.3. Scholz M. ranks 1st in Publication Count followed by Lal R. and Brown R.
Chung T., Lal R., and Dinçer I. are the top 3 researchers in terms of h-index with an h-index of 84, 76, and 73, respectively.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Scholz M.	University of Salford (United Kingdom)	53	615	0.92	26
2	Lal R.	Ohio State University (United States)	51	1,251	1.91	76
3	Brown R.	Monash University (Australia)	49	1,458	2.25	24
4	Wang W.	Chang'an University (China)	44	26	0.36	10
5	Dinçer I.	University of Ontario Institute of Technology (Canada)	42	1,019	2.93	73
6	YANG Z.	Beijing Normal University (China)	42	702	1.38	50
7	Huang G.	Beijing Normal University (China)	38	670	1.86	50
8	Li Y.	Beijing Normal University (China)	33	611	2.05	33
9	Bhattacharya P.	University of Southern Queensland (Australia)	32	354	1.04	33
10	Butler D.	University of Exeter (United Kingdom)	31	654	4.14	31
11	Hoekstra A.	University of Twente (Netherlands)	30	2,143	8.74	41
12	Chung T.	National University of Singapore (Singapore)	30	1,427	4.25	84
13	Madani K.	Imperial College London (United Kingdom)	30	341	3.74	21
14	Mihelcic J.	University of South Florida Tampa (United States)	30	795	1.48	26
15	Webber M.	University of Texas at Austin (United States)	30	247	1.01	29
16	Shao H.	Jiangsu Academy of Agricultural Sciences (China)	30	625	0.77	34
17	Chen B.	Beijing Normal University (China)	29	804	2.19	46
18	Zhang F.	China Agricultural University (China)	28	1,068	3.29	72
19	Gabarrell X.	Institut de Ciencia i Tecnologia Ambientals (ICTA)-UAB (Spain)	27	575	1.91	26
20	Xia J.	Hong Kong University of Science and Technology (China)	27	436	1.61	44

Table 6.3— *Top 20 researchers publishing SDG6 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG6 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

6.3.4 **Top 10 journals publishing SDG6 research**

A list of the top 10 journals publishing SDG6-related research from 2007-2016 is shown in Table 6.4. *Advanced Materials Research* published the most SDG 6 publications of 1501 followed by *Journal of Cleaner Production*, *ISWREP 2011 – Proceedings of 2011 International Symposium on Water Resource and Environmental Protection*, and other journals with more than three hundred publications. *Journal of Cleaner Production* ranks 1st in FWCI followed by *Journal of Environmental Management*, *Sustainability* and *Acta Horticulturae*. As for CiteScore, *Journal of Environmental Management* sits in the 1st place with a CiteScore of 3.75 followed by *Journal of Cleaner Production* with a CiteScore of 3.70.

Rank	Journal	Publication count	FWCI	CiteScore
1	Advanced Materials Research	1,501	0.44	0.17
2	Journal of Cleaner Production	639	2.69	3.70
3	ISWREP 2011 - Proceedings of 2011 International Symposium on Water Resource and Environmental Protection	614	0.46	0.00
4	World Environmental and Water Resources Congress 2011: Bearing Knowledge for Sustainability - Proceedings of the 2011 World Environmental and Water Resources Congress	505	0.45	0.00
5	Applied Mechanics and Materials	458	0.43	0.11
6	Acta Ecologica Sinica	443	0.23	0.55
7	WIT Transactions on Ecology and the Environment	436	0.08	0.08
8	Sustainability	433	1.06	0.92
9	Acta Horticulturae	402	1.02	0.20
10	Journal of Environmental Management	375	1.57	3.75

Table 6.4— *Top 10 journals based on SDG6 publication output from 2007-2016. FWCI is mean FWCI for any SDG6 publications in the journal during the period; CiteScore is based on data for the journal as a whole. (Source: Scopus)*

6.4 Research efforts focused on SDG6

6.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 6.3, the United States is by far the leader in terms of research output related to SDG 6 followed closely by China. The United Kingdom follows, along with India, and Australia. Among comparators, Colombia has the lowest output in this field, just below Mexico. However, as shown in Table 6.5, Colombia has the greatest a Compound Annual Growth Rate (CAGR) at 26.80% in this field of research. India, China, Brazil, and Mexico also see marked increases in publication output with a CAGR above 10%.

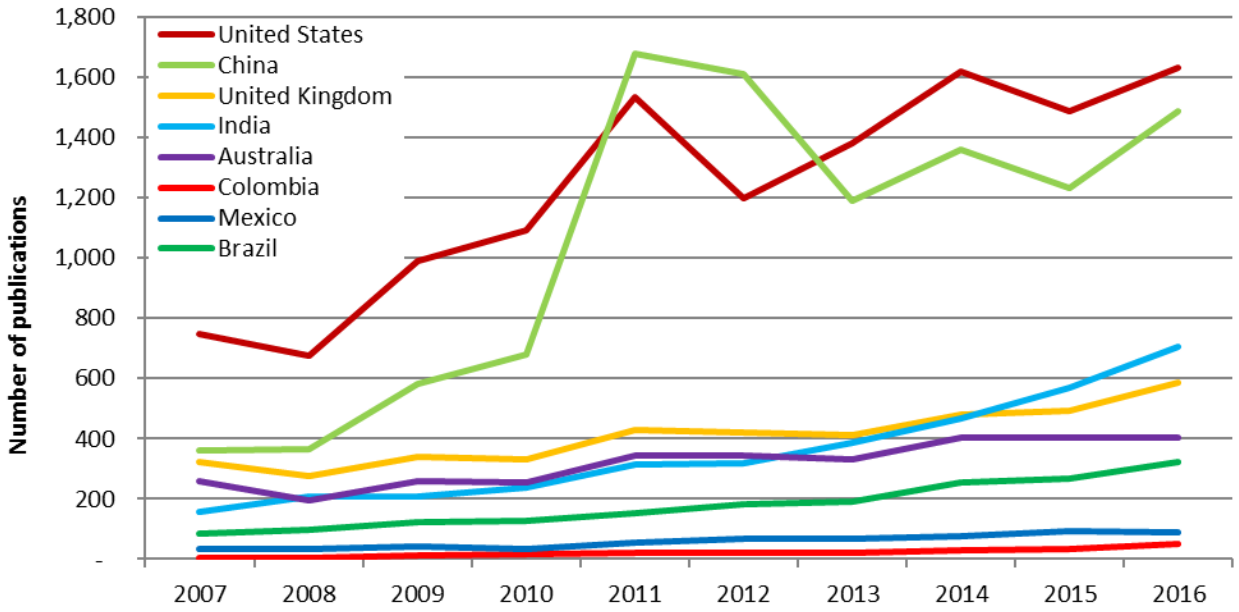


Figure 6.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	12,364	9.00%
China	10,545	17.00%
United Kingdom	4,087	6.90%
India	3,571	18.20%
Australia	3,200	5.00%
Colombia	212	26.80%
Mexico	595	11.70%
Brazil	1,806	15.90%
World	58,404	6.90%

Table 6.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

6.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG6 related research from 2006-2017 is 1.10.

Country	FWCI
United States	1.44
China	0.93
United Kingdom	1.73
India	0.91
Australia	1.69
Colombia	1.04
Mexico	1.04
Brazil	0.97
World	1.10

Comparing the FWCI of publications from each of the eight countries included in this chapter reveals some differences and similarities (Table 6.6). Most notably, the United Kingdom achieves the highest FWCI among comparator countries, followed by. Australia and the United States.

Table 6.6— *FWCI for SDG6 research from 2007-2016 per country and world. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

6.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 6.4 and Table 6.7, the United States leads in terms of publications that are among the top 10% most cited. China, the United Kingdom, Australia, and India follow in that order. Colombia has a very small number of publications among the top 10% most cited during this time period. According to Table 6.7, China, Colombia and India are the top 3 countries in CAGR, with China's growth above 30% per year, and Colombia's and India's approaching 20%.

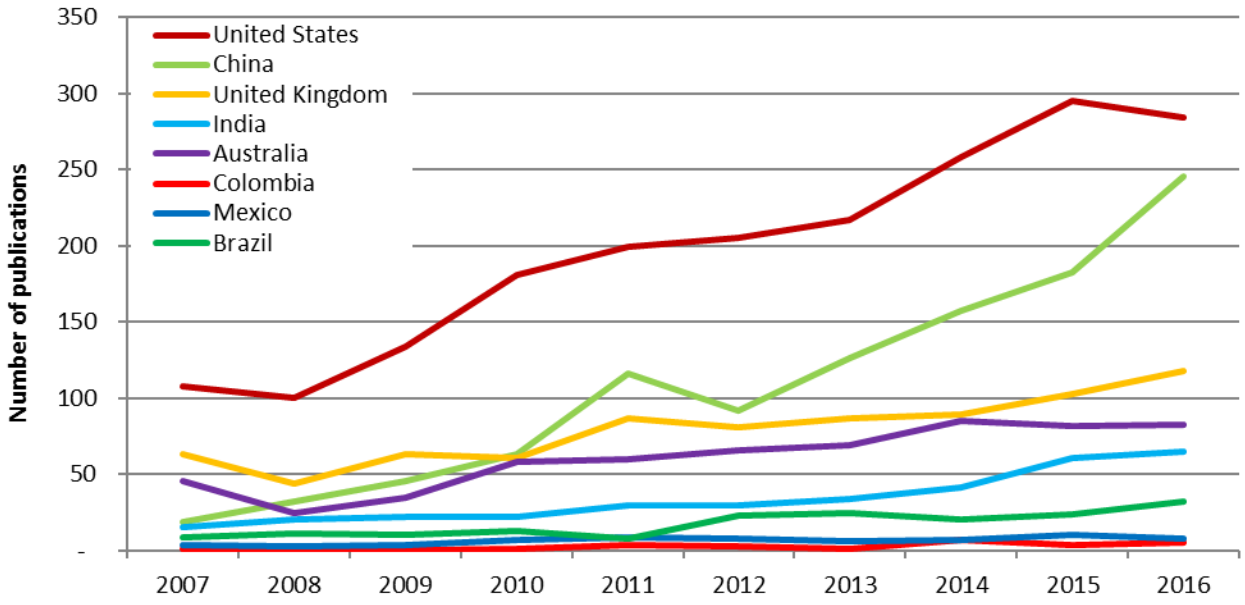


Figure 6.4— *Top 10% most cited publications on SDG6 from 2007-2016 per country. CAGR shown at top of each bar. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
United States	1,981	11.34%
China	1,080	32.92%
United Kingdom	796	7.22%
India	340	17.69%
Australia	609	6.78%
Colombia	27	19.58%
Mexico	66	8.01%
Brazil	175	15.14%
World	6,957	13.51%

Table 6.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG6 publications from 2007-2016. (Source: Scopus)*

6.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 6.8 provides the count of SDG6 publications from each country that have been cited in patents and the number of patents that have cited these publications. The findings show that patent citation count is related to publication count in that the leaders in publication output have the highest patent citation count. The United States leads with 166 patent cited publications cited in 429 patents. China and the United Kingdom follow with approximately one third the number of publications cited by one quarter the number of patents. Colombia has only 2 patent cited publications and 2 patents citing publications.

Country	Patent Cited Publications	Patents Citing Publications
United States	166	429
China	52	106
United Kingdom	48	92
India	27	49
Australia	32	62
Colombia	2	2
Mexico	5	12
Brazil	9	12
World	512	1,251

Table 6.8— *Number of publications cited in USPTO, WIPO, or EPO patents and number of USPTO, WIPO, or EPO patents citing publications on SDG6 from 2007 to 2016. (Source: Scopus and LexisNexis)*

6.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG6. To identify patents relevant to SDG6, we retrieved all the patents citing any SDG6-related publication. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO. From 2006 to 2016, the United States applied for the most patents (138) and had 416 granted in this field. Next in terms of patents are the United Kingdom, Australia, India, and China. Colombia and Mexico have 2 patent applications each, while Brazil has one patent application and one granted patent. Note that China may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	138	416	554	54.85%
China	9	5	14	1.39%
United Kingdom	27	14	41	4.06%
India	22	8	30	2.97%
Australia	12	18	30	2.97%
Colombia	2	-	2	0.20%
Mexico	2	-	2	0.20%
Brazil	1	1	2	0.20%
World	479	531	1,010	

Table 6.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

6.4.6 **Research Focus**

Within the topic of SDG6-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG6-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG6 research is shown in Figure 6.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG6 research from Colombia, terms that stand out as unique to Colombia are 'Tanks (Containers)', 'Environmental Impact Assessments', 'Engineering', 'Construction, and 'Electricity'. Among the top 50 key phrases the terms 'Water Management', 'Pollution Control'; and 'Water', 'Water Conservation', and 'Water Supply' were common among the countries analyzed. Figure 6.5 provides a visualization of the top 50 key phrases for SDG6 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

Colombia

Mexico

Figure 6.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Brazil

United States

China

United Kingdom

India

Australia

6.5 The reach of Colombia's SDG6 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

6.5.1 Downloads

As shown in the Figure 6.6, the mean count of downloads per ScienceDirect publication fluctuates considerably from 2007-2011 and then converges to a similar trend for all countries. The fluctuations likely stem from the fact that most data points were based on less than 100 SD publications per year from 2007-2011. It should be noted that for Colombia, the results shown are based on very small counts of SD articles (less than 100 publications) and should be interpreted with caution.

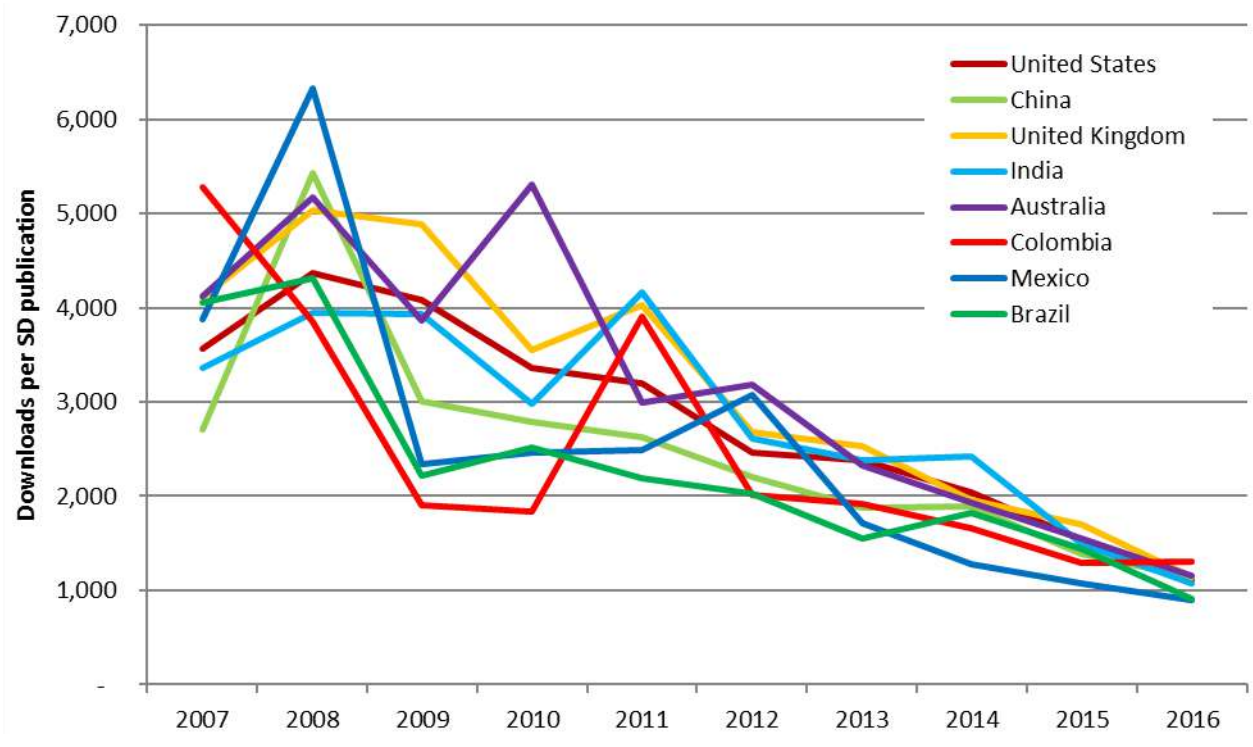


Figure 6.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

6.5.2 **Field Weighted Download Impact (FWDI)**

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. The majority of countries have an FWDI near the world average for SDG6 publications (Figure 6.7). However, given the very low count of SD publications from Colombia (i.e. less than 100 SD publications for the full period) interpretation of this metric should focus on the other countries only.

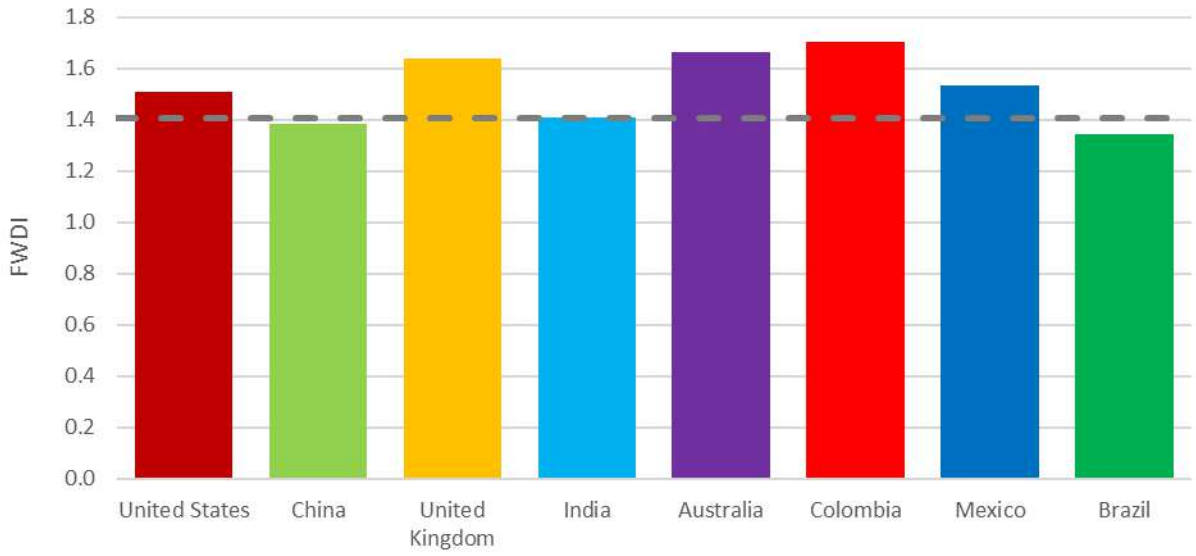


Figure 6.7— *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. (Source: ScienceDirect)*

6.6 SDG6 collaboration network

6.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG6-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 6.10-6.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG6 publications with. Among academic partner institutes, Colombia has published the most SDG6 papers in collaboration with Wageningen University & Research (7 publications from 2007-2016) with a high FWCI of 3.63 (Table 6.10). CSIC, International Crops Research Institute for the Semi-Arid Tropics, and Universitat Autonoma de Barcelona co-authored 6, 5, and 5 collaborative publications with Colombia, respectively. Except for publications co-authored with CSIRO, the average FWCI from collaborations with the top 20 partners exceeds the world average.

Country	Institution (Country)	Publication Count	FWCI
Colombia	Wageningen University & Research (Netherlands)	7	3.63
	CSIC (Spain)	6	2.11
	International Crops Research Institute for the Semi-Arid Tropics (India)	5	3.83
	Universitat Autonoma de Barcelona (Spain)	5	1.91
	IRD (France)	4	3.33
	University of California at Davis (United States)	4	1.71
	IRTA - Institute of Agrifood Research and Technology (Spain)	4	1.66
	World Bank (United States)	3	5.51
	Chinese Academy of Agricultural Sciences (China)	3	2.85
	Imperial College London (United Kingdom)	3	2.42
	Japan International Research Center for Agricultural Sciences (Japan)	3	2.41
	University of Cambridge (United Kingdom)	3	1.91
	Universitat Politecnica de Catalunya (Spain)	3	1.67
	CSIRO (Australia)	3	0.76
	International Livestock Research Institute (Kenya)	2	6.53
	Universite Paris Saclay (France)	2	6.00
	United Nations (United States)	2	5.62
	Stanford University (United States)	2	4.92
	Embrapa - Empresa Brasileira de Pesquisa Agropecuaria (Brazil)	2	3.36
	Universidad de Buenos Aires (Argentina)	2	2.83

Table 6.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	Texas A and M University (United States)	23	1.64
	King Abdulaziz University (Saudi Arabia)	13	1.38
	University of Arizona (United States)	11	0.65
	U.S. Department of Agriculture (United States)	10	0.71
	Wageningen University & Research (Netherlands)	9	5.11
	KU Leuven (Belgium)	8	2.06
	New Mexico State University (United States)	7	3.69
	University of Massachusetts Lowell (United States)	7	1.27
	CSIRO (Australia)	6	5.54
	University of California at San Diego (United States)	6	3.60
	Louisiana State University (United States)	6	2.07
	CSIC (Spain)	5	2.21
	Arizona State University (United States)	5	1.11
	Universidad Nacional de Colombia (Colombia)	5	0.24
	Imperial College London (United Kingdom)	4	5.41
	University of California at Berkeley (United States)	4	3.18
	CNRS (France)	4	2.30
	Technical University of Denmark (Denmark)	4	2.10
	Ghent University (Belgium)	4	1.69
	Mekelle University (Ethiopia)	4	1.69

+

Table 6.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	U.S. Department of Agriculture (United States)	20	2.72
	University of Florida (United States)	18	2.67
	Wageningen University & Research (Netherlands)	14	4.89
	INRA Institut National de La Recherche Agronomique (France)	14	3.39
	CNRS (France)	14	2.68
	CIRAD (France)	11	2.85
	Universidad Nacional Autonoma de Mexico (Mexico)	11	1.94
	University of Illinois at Urbana-Champaign (United States)	9	4.34
	Max Planck Institute for Chemistry (Germany)	9	0.73
	University of Oxford (United Kingdom)	8	2.89
	Universidade Nova de Lisboa (Portugal)	8	2.30
	Universidade de Lisboa (Portugal)	8	1.71
	University of Amsterdam (Netherlands)	8	0.91
	IRD (France)	7	3.61
	Universitat Autonoma de Barcelona (Spain)	7	3.34
	CSIRO (Australia)	7	3.00
	Delft University of Technology (Netherlands)	7	2.10
	University of East Anglia (United Kingdom)	7	1.53
	University of Maryland (United States)	6	3.86
	University of California at Davis (United States)	6	3.55

+

Table 6.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	Chinese Academy of Sciences (China)	200	2.68
	Wageningen University & Research (Netherlands)	68	5.59
	University of British Columbia (Canada)	53	5.64
	Beijing Normal University (China)	51	1.82
	CSIRO (Australia)	47	5.62
	Ministry of Education China (China)	46	2.41
	Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences (China)	45	1.61
	Tsinghua University (China)	43	2.99
	Peking University (China)	43	2.14
	China Agricultural University (China)	41	1.99
	CNRS (France)	40	3.79
	World Health Organization (Switzerland)	39	2.87
	Imperial College London (United Kingdom)	38	3.17
	University of Cambridge (United Kingdom)	37	6.74
	University of Oxford (United Kingdom)	35	4.66
	University of Queensland (Australia)	34	8.00
	East China Normal University (China)	34	1.06
	Stockholm University (Sweden)	33	9.08
	McGill University (Canada)	33	9.05
	International Institute for Applied Systems Analysis, Laxenburg (Austria)	32	4.69

Table 6.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
China	U.S. Department of Agriculture (United States)	59	2.06
	CSIRO (Australia)	46	2.73
	Colorado State University (United States)	45	0.81
	University of Regina (Canada)	40	2.10
	Wageningen University & Research (Netherlands)	38	2.43
	Hong Kong Polytechnic University (Hong Kong)	36	1.23
	Texas A and M University (United States)	35	1.66
	Georgia Institute of Technology (United States)	33	4.49
	University of Hong Kong (Hong Kong)	32	1.27
	Arizona State University (United States)	27	2.04
	Chinese University of Hong Kong (Hong Kong)	26	1.50
	City University of Hong Kong (Hong Kong)	25	2.00
	National Institute for Environmental Studies of Japan (Japan)	24	2.61
	International Institute for Applied Systems Analysis, Laxenburg (Austria)	23	4.16
	Delft University of Technology (Netherlands)	23	3.12
	National University of Singapore (Singapore)	23	2.25
	Nanyang Technological University (Singapore)	23	2.12
	University of Maryland (United States)	21	4.64
	UTS University of Technology Sydney (Australia)	21	2.55
	University of Nebraska (United States)	21	1.37

+

Table 6.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for China. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	Wageningen University & Research (Netherlands)	74	4.01
	INRA Institut National de La Recherche Agronomique (France)	42	4.44
	Chinese Academy of Sciences (China)	38	3.14
	CSIC (Spain)	37	1.84
	CNRS (France)	28	3.99
	European Commission Joint Research Centre Institute (Belgium)	27	6.15
	Aarhus University (Denmark)	27	3.15
	University of Copenhagen (Denmark)	25	3.23
	CSIRO (Australia)	24	5.34
	Ghent University (Belgium)	24	3.14
	University of Bologna (Italy)	21	3.48
	University of Maryland (United States)	20	5.61
	James Cook University Queensland (Australia)	20	4.48
	World Health Organization (Switzerland)	20	4.31
	KU Leuven (Belgium)	20	2.02
	University of British Columbia (Canada)	19	9.14
	University of Washington (United States)	19	7.18
	Stockholm University (Sweden)	19	5.43
	Stockholm Environment Institute (Sweden)	19	2.64
	United Nations (United States)	19	2.27

Table 6.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
India	International Rice Research Institute (Philippines)	21	2.74
	Wageningen University & Research (Netherlands)	20	3.74
	The Ohio State University (United States)	20	1.17
	International Water Management Institute (Sri Lanka)	14	2.47
	CNRS (France)	13	3.01
	Royal Institute of Technology (Sweden)	13	0.99
	University of Queensland (Australia)	12	11.22
	BRGM (France)	12	1.09
	UNESCO-IHE Institute for Water Education (Netherlands)	11	3.25
	CSIRO (Australia)	10	4.17
	United Nations (United States)	9	3.75
	International Centre for Genetic Engineering and Biotechnology (Italy)	9	1.92
	University of South Australia (Australia)	9	1.67
	UNICEF (United States)	9	1.38
	Australian National University (Australia)	9	1.12
	Edith Cowan University (Australia)	9	1.11
	Delft University of Technology (Netherlands)	8	3.74
	International Food Policy Research Institute (United States)	8	3.72
	U.S. Department of Agriculture (United States)	8	1.80
	University of Edinburgh (United Kingdom)	8	1.02

+

Table 6.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for India. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Australia	Chinese Academy of Sciences (China)	67	2.40
	Wageningen University & Research (Netherlands)	39	6.05
	University of British Columbia (Canada)	19	8.18
	U.S. Department of Agriculture (United States)	19	4.48
	Royal Institute of Technology (Sweden)	18	3.63
	Imperial College London (United Kingdom)	18	2.82
	International Water Management Institute (Sri Lanka)	16	5.15
	INRA Institut National de La Recherche Agronomique (France)	15	4.98
	Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences (China)	15	2.89
	Stanford University (United States)	14	5.84
	University of Exeter (United Kingdom)	14	5.27
	Shandong University (China)	14	2.89
	University of Cambridge (United Kingdom)	13	9.94
	University of Auckland (New Zealand)	13	6.57
	CSIC (Spain)	13	3.19
	China Agricultural University (China)	13	2.24
	Wuhan University (China)	12	3.37
	Delft University of Technology (Netherlands)	12	3.28
	Lanzhou University (China)	12	2.20
	International Rice Research Institute (Philippines)	12	1.92

Table 6.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Australia. (Source: Scopus)*

6.6.2 **Collaboration impact analysis**

To visualize the citation impact of collaborations, the ratio of FWCI from SDG6 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG6 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG6 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. As shown in Figure 6.8, the United Nations sits at the upper top right indicating that they've developed a highly mutually beneficial collaboration with Colombia in terms of citation impact. Other institutes, such as Universite Paris Saclay, are also in the same quadrant. Several collaborations such as those with the University of Cambridge, only provide a citation advantage for Colombia but not the partner. CSIRO is in the bottom left quadrant indicating that the collaboration between CSIRO and Colombia does not yield any citation advantage to either partner.

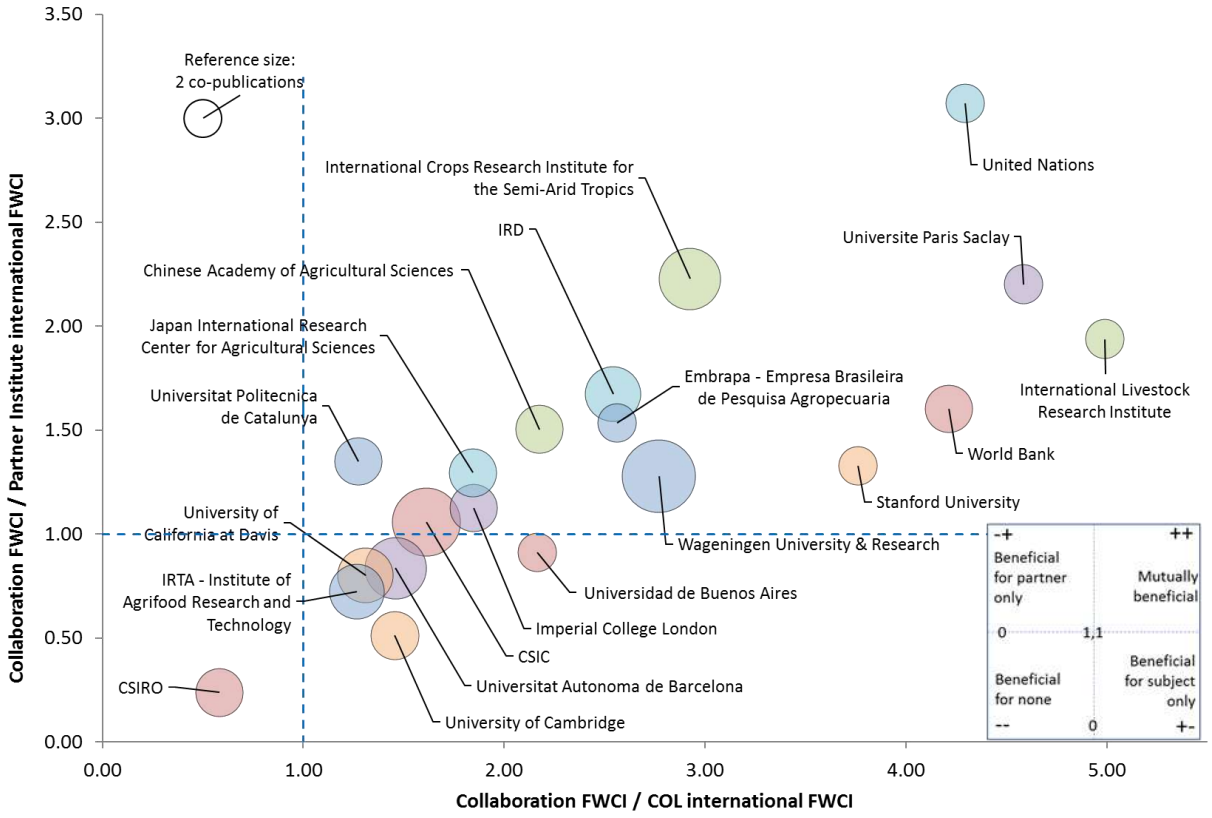


Figure 6.8— *Collaboration quadrant of Colombia's Top 20 collaborations in SDG6-related research with other institutions. Collaboration FWCI refers to the FWCI of all SDG6-related research co-authored by Colombia and the partner institute during the period 2007-2016. Bubble size corresponds to number of co-authored publications (reference bubble depicted at top left of chart). Impact of collaboration between partners can be interpreted based on quadrant position as described in legend on right. (Source: Scopus).*

6.6.3 **Collaboration chart**

Figure 6.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG6. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 6.9 shows where there may be potential to improve output and impact through partnership. Currently, Colombia produces the most co-authored papers with Wageningen University & Research, which produces the highest number of publications (among Colombia's top 20 partners), with 537 SDG6 publications. CSIRO is Colombia's second most prolific partner in this field, with 426 publications, only 3 of which were co-authored with Colombia. Among Colombia's top 20 partners, International Livestock Research Institute and Stanford University have the highest FWCI for SDG6 research. Colombia may want to leverage its existing relationships with these institutes to increase its publication output and impact in SDG6 research.

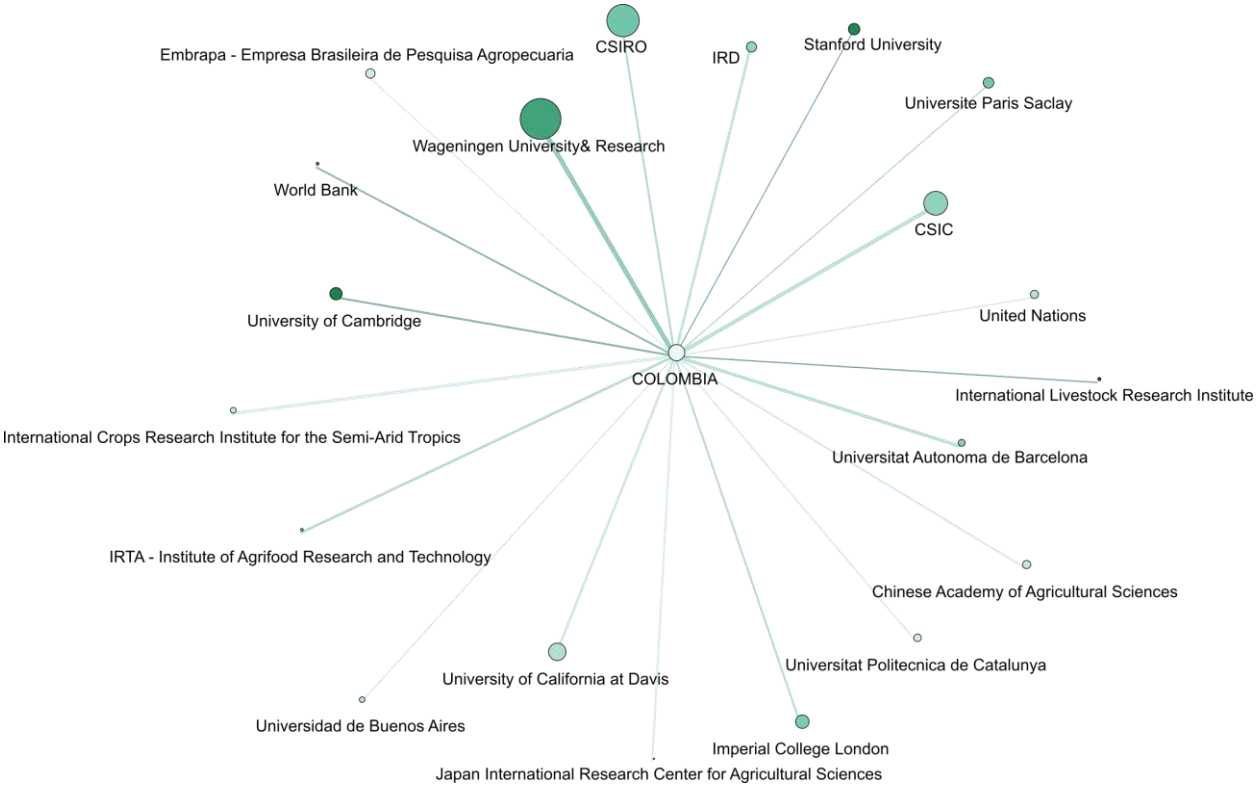


Figure 6.9— Chart showing Colombia's top 20 collaborators on SDG6 from 2007-2016. Circle (node) size is proportional to the number of SDG6 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (3.44) and lightest shade of green indicating the lowest FWCI (1.25). (Source: Scopus).

Chapter 7
Affordable and Clean Energy

In this Chapter, we assess research related to SDG7, which aims to ensure access to affordable, reliable, sustainable and modern energy for all. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

7.1 Key Findings

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all

WORLD RESEARCH OUTPUT

45,687

Number of SDG7 publications, 2007-2016.

SDG7 PATENTS

1,785

Number of SDG7 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

191

Colombia's SDG7 publications, 2007-2016.

COLOMBIA RESEARCH OUTPUT CAGR

30%

Compound annual growth rate for Colombia's 2007-2016 SDG7 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

24

Colombia's SDG7 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

1.06

Average field-weighted citation impact for Colombia's SDG7 publications, 2007-2016.

7.2 SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

According to the United Nations,

> *"Energy is central to nearly every major challenge and opportunity the world faces today. Be it for jobs, security, climate change, food production or increasing incomes, access to energy for all is essential. Sustainable energy is opportunity – it transforms lives, economies and the planet."*[12]

The targets for SDG7, according to the United Nations are:

- *By 2030, ensure universal access to affordable, reliable and modern energy services.*
- *By 2030, increase substantially the share of renewable energy in the global energy mix.*
- *By 2030, double the global rate of improvement in energy efficiency.*
- *By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.*
- *By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support."*[12]

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG7 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

[12] http://www.un.org/sustainabledevelopment/energy/

7.3 SDG7: Leaders in the field

7.3.1 Top 5 countries conducting SDG7 research

The top 5 countries publishing on SDG 7 based on cumulative publication output from 2007-2016 is indicated by Table 7.1 and Figure 7.1. The United States ranks 1st in Publication Count, Percentage of Global Output, and Citation Count, followed by China, then United Kingdom, Germany, and Italy. The United Kingdom ranks 1st in FWCI with 1.93, which is higher than the world average. All other countries' FWCI exceed the average as well.

Table 7.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	10,167	22.30%	175,387	1.68
China	5,660	12.42%	69,723	1.34
United Kingdom	3,083	6.76%	61,683	1.93
Germany	2,925	6.42%	48,411	1.81
Italy	2,871	6.30%	37,715	1.80
World	45,587	100.00%	284,180	1.40

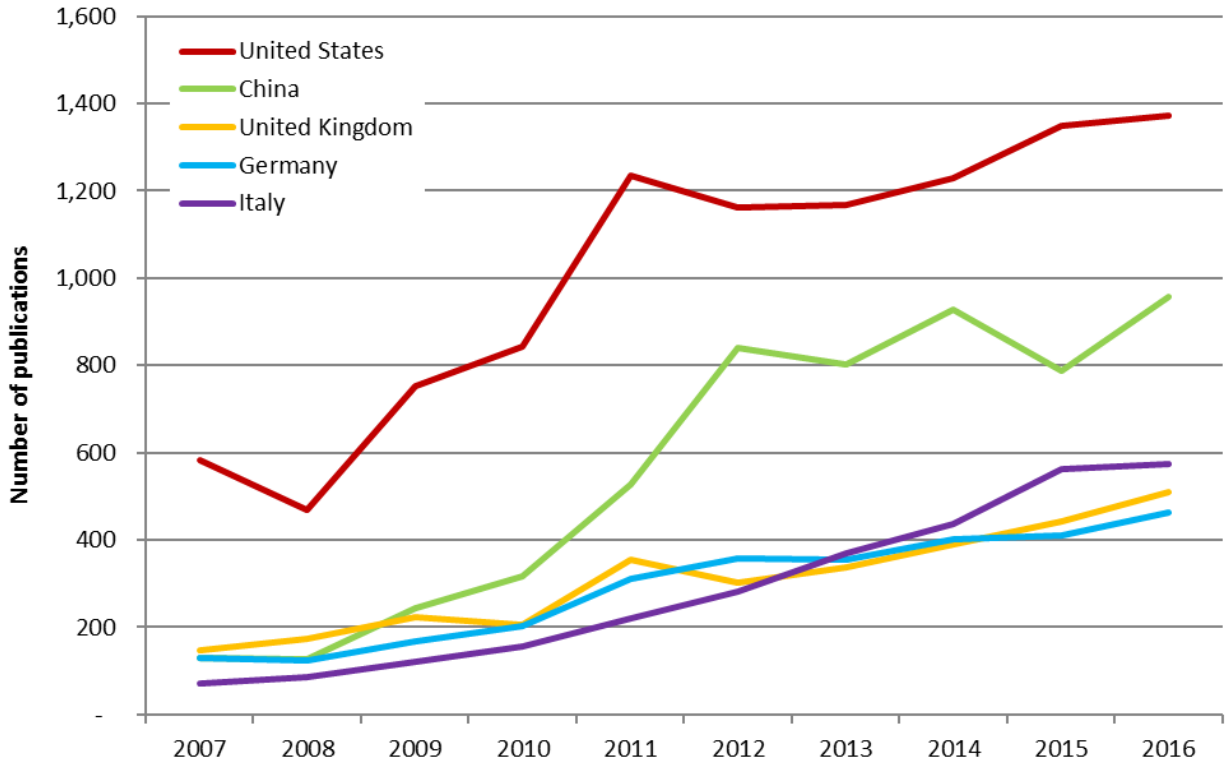


Figure 7.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG7 research. (Source: Scopus)*

7.3.2 Top 20 institutes conducting SDG7 research

A list of the top 20 research institutes publishing SDG7-related research is shown in Table 7.2. The Chinese Academy of Sciences ranks 1st in Publication Count and Citation Count followed by the U. S. Department of Agriculture and Wageningen University & Research. The University of California at Berkeley sits in 1st place with an FWCI at 3.13, much higher than the world average. CNRS also has a high FWCI for SDG7 research at 2.80. Except for North China Electric Power University, the FWCI of all other top 20 institutes is also above the global average. The trends in publication output from 2007-2016 are shown in Figure 7.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Chinese Academy of Sciences (China)	667	13,742	1.92
2	U.S. Department of Agriculture (United States)	379	8,938	1.74
3	Wageningen University & Research (Netherlands)	325	9,459	2.57
4	Tsinghua University (China)	312	5,910	1.72
5	CNRS (France)	305	8,139	2.80
6	Delft University of Technology (Netherlands)	274	5,718	2.21
7	Technical University of Denmark (Denmark)	266	7,969	2.64
8	University of California at Berkeley (United States)	249	7,542	3.13
9	Politecnico di Milano (Italy)	238	2,516	2.22
10	Ministry of Education China (China)	234	3,720	1.88
11	Universiti Teknologi Malaysia (Malaysia)	225	2,872	1.92
12	Universidade de Sao Paulo (Brazil)	224	2,793	1.42
13	Royal Institute of Technology (Sweden)	223	2,485	1.65
14	ETH Zurich (Switzerland)	220	5,588	2.58
15	North China Electric Power University (China)	208	1,639	0.92
16	Georgia Institute of Technology (United States)	206	4,876	2.59
17	Texas A and M University (United States)	206	3,621	1.74
18	CSIRO (Australia)	198	5,597	2.33
19	INRA Institut National de La Recherche Agronomique (France)	194	5,804	2.33
20	CNR (Italy)	192	2,658	1.60

Table 7.2— *Top 20 research Institutes ranked based on SDG7 publication output and FWCI from 2007-2016. (Source: Scopus)*

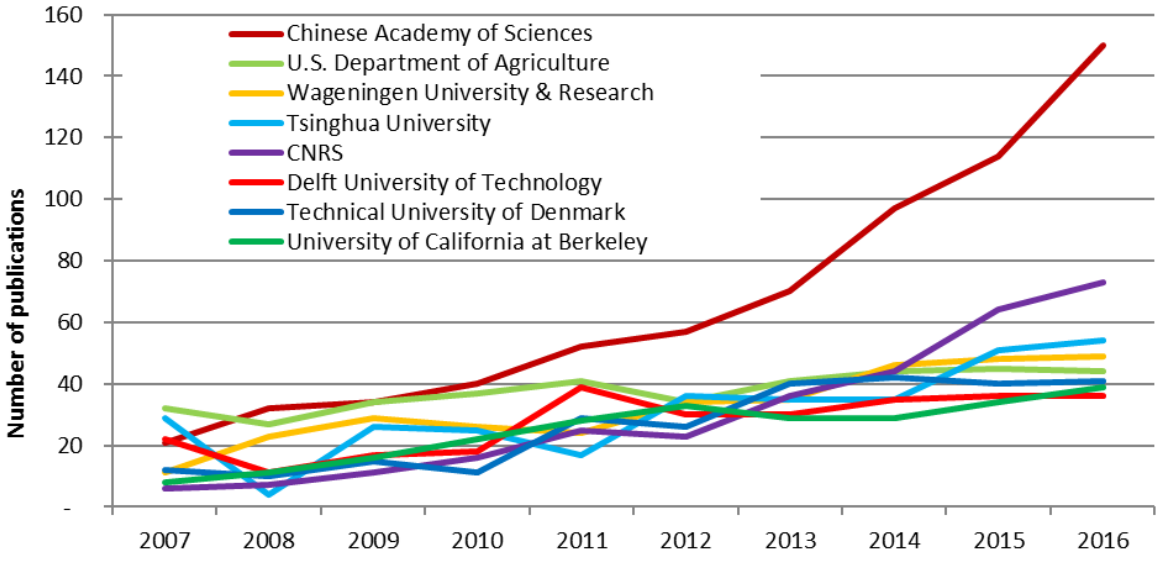


Figure 7.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG7. (Source: Scopus)*

7.3.3 Top 20 researchers conducting SDG7 research

A list of the top 20 researchers publishing in the SDG7 field based on publication output from 2007-2016 is shown in Table 7.3. Dinçer I. ranks 1st in Publication Count followed by Faaij A. and Hepbaşli A.
Dinçer I., Faaij A., and Centi G. are the top 3 researchers in terms of h-index with an h-index of 73, 61, and 54, respectively.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Dinçer I.	University of Ontario Institute of Technology (Canada)	68	2,102	3.65	73
2	Faaij A.	University of Groningen (Netherlands)	45	2,215	4.01	61
3	Hepbaşli A.	Yasar Universitesi (Turkey)	43	1,657	2.29	48
4	Azapagic A.	University of Manchester (United Kingdom)	42	799	2.58	32
5	Rosen M.	University of Ontario Institute of Technology (Canada)	38	783	2.32	53
6	Webber M.	University of Texas at Austin (United States)	37	271	1.20	29
7	Lee K.	Universiti Sains Malaysia (Malaysia)	32	1,930	2.10	49
8	Dewulf J.	Universiteit Gent (Belgium)	31	877	2.28	45
9	Küçükvar M.	Istanbul Sehir Universitesi (Turkey)	30	582	3.35	19
10	Centi G.	Universita degli Studi di Messina (Italy)	30	1,310	3.29	54
11	Bakshi B.	Ohio State University (United States)	30	580	1.04	30
12	Rieradevall J.	Institut de Ciencia i Tecnologia Ambientals (ICTA)-UAB (Spain)	29	549	1.86	29
13	Ulgiati S.	Universita degli Studi di Napoli Parthenope (Italy)	29	694	1.85	38
14	Gabarrell X.	Institut de Ciencia i Tecnologia Ambientals (ICTA)-UAB (Spain)	29	507	1.78	26
15	Gheewala S.	King Mongkuts University of Technology Thonburi (Thailand)	29	615	1.51	33
16	Kaygusuz K.	Karadeniz Teknik Universitesi (Turkey)	29	730	1.31	38
17	Ng D.	The University of Nottingham Malaysia Campus (Malaysia)	28	468	4.04	29
18	Tatari O.	University of Central Florida (United States)	28	588	3.55	21
19	Venkata Mohan S.	Indian Institute of Chemical Technology (India)	28	1,190	2.69	47
20	Narodoslawsky M.	Technische Universitat Graz (Austria)	28	390	1.65	18

Table 7.3— *Top 20 researchers publishing SDG7 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG7 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

7.3.4 **Top 10 journals publishing SDG7 research**

A list of the top 10 journals publishing SDG7-related research from 2007-2016 is shown in Table 7.4. *Renewable and Sustainable Energy Reviews* published the most SDG7 publications of 1242 followed by *Advanced Materials Research* and *Journal of Cleaner Production.* All top 10 journals published more than 300 SDG7 publications over the period. *Applied Energy* ranks 1st according to FWCI, followed by *Journal of Cleaner Production* and *Biomass and Bioenergy* in the 2nd and 3rd place, respectively. As for CiteScore, *Renewable and Sustainable Energy Reviews* sits in the 1st place with a CiteScore of 7.66 followed by *Applied Energy* with a CiteScore of 5.87.

Rank	Journal	Publication count	FWCI	CiteScore
1	Renewable and Sustainable Energy Reviews	1,242	1.23	7.66
2	Advanced Materials Research	1,203	0.52	0.17
3	Journal of Cleaner Production	708	3.18	3.70
4	Energy Policy	658	1.72	3.52
5	Energy Procedia	649	1.30	2.05
6	Energy	478	1.95	4.29
7	Applied Energy	434	3.35	5.87
8	Sustainability	366	1.17	0.92
9	Biomass and Bioenergy	352	2.22	4.53
10	Renewable Energy	344	1.24	4.08

Table 7.4— *Top 10 journals based on SDG7 publication output from 2007-2016. FWCI is mean FWCI for any SDG7 publications in the journal during the period; CiteScore is based on data for the journal as a whole. (Source: Scopus)*

7.4 Research efforts focused on SDG7

7.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 7.3, the United States is by far the leader in terms of research output related to SDG 7. China follows, along with the United Kingdom, Germany and Italy. Among comparators, Colombia has the lowest output in this field, just below Mexico. However, as shown in Table 7.5, Colombia has the greatest a Compound Annual Growth Rate (CAGR) of 30.20% in this field of research. Italy, China, Mexico and Brazil also see marked increases in publication output with a CAGR above 20%.

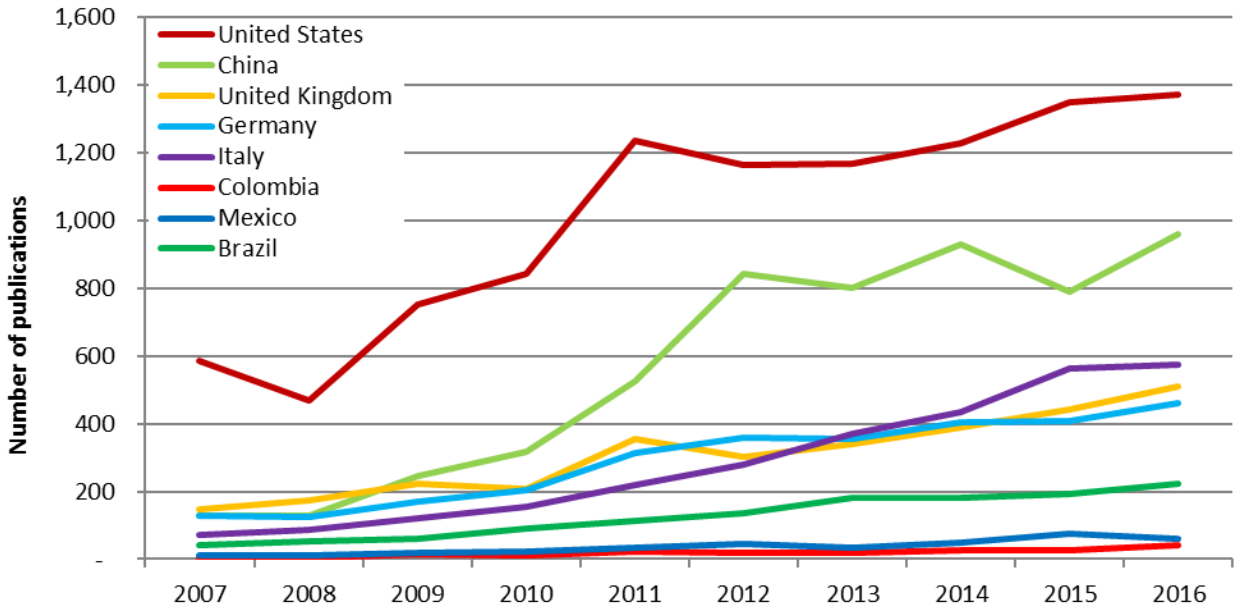


Figure 7.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	10,167	10.00%
China	5,660	25.00%
United Kingdom	3,083	14.80%
Germany	2,925	15.10%
Italy	2,871	26.10%
Colombia	191	30.20%
Mexico	361	22.30%
Brazil	1,268	20.30%
World	45,587	10.20%

Table 7.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

7.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG7 related research from 2006-2017 is 1.40.

Comparing the FWCI of publications from each of the eight countries included in this chapter reveals some differences and similarities (Table 7.6). Most notably, the United Kingdom achieves the highest FWCI among comparator countries. Germany, Italy, and the United States follow with an FWCI approximately 70-80% higher than the world average.

Country	FWCI
United States	1.68
China	1.34
United Kingdom	1.93
Germany	1.81
Italy	1.80
Colombia	1.06
Mexico	1.19
Brazil	1.12
World	1.40

Table 7.6— *FWCI for SDG7 research from 2007-2016 per country and world. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

7.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 7.4 and Table 7.7, the United States leads in terms of publications that are among the top 10% most cited. China, the United Kingdom, Germany and Italy follow in that order. Colombia had a very small number of publications among the top 10% most cited during this time period. According to Table 7.7, China leads in CAGR by a wide margin at nearly 46% per annum., followed by Italy at over 30%. SDG7 is a field with strong growth in top cited scholarly output globally and for all comparators except Mexico.

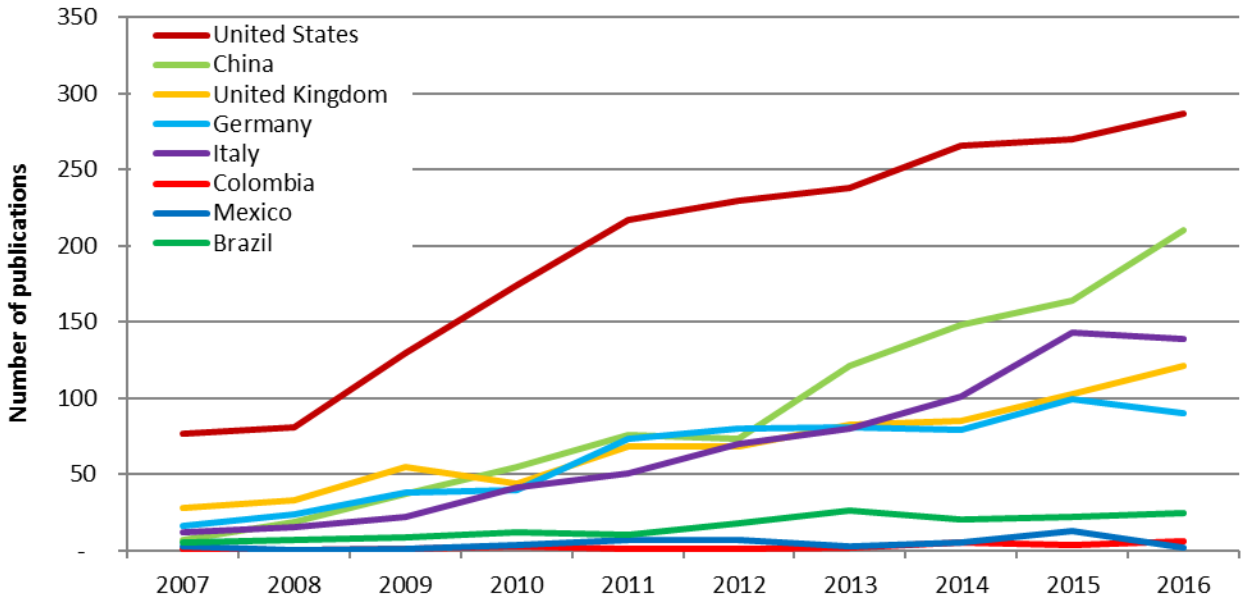


Figure 7.4— *Top 10% most cited publications on SDG7 from 2007-2016 per country. CAGR shown at top of each bar. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
United States	1,970	15.74%
China	910	45.92%
United Kingdom	688	17.66%
Germany	620	21.16%
Italy	674	31.28%
Colombia	24	22.03%
Mexico	45	-4.41%
Brazil	154	19.58%
World	7,342	19.51%

Table 7.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG7 publications from 2007-2016. (Source: Scopus)*

7.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 7.8 provides the count of SDG7 publications from each country that have been cited in patents and the number of patents that have cited these publications. The findings show that patent citation count is related to publication count in that the leaders in publication output have the highest patent citation count. The United States leads with 257 publications cited in 1,101 patents. China, the United Kingdom, Germany, and Italy follow in this order. Colombia has one patent cited publication and one patent citing publication.

Country	Patent Cited Publications	Patents Citing Publications
United States	257	1,101
China	71	245
United Kingdom	48	122
Germany	51	134
Italy	21	45
Colombia	1	1
Mexico	3	7
Brazil	10	16
World	688	2,453

Table 7.8— *Number of publications cited in USPTO, WIPO, or EPO patents and number of USPTO, WIPO, or EPO patents citing publications on SDG7 from 2007 to 2016. (Source: Scopus and LexisNexis)*

7.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG7. To identify patents relevant to SDG7, we retrieved all the patents citing any SDG7-related publication. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO From 2006 to 2016, the United States leads with 349 patent applications and 763 patents granted in this field followed by Germany, China, and the United Kingdom. Colombia has 2 granted patents, Brazil has 3 patent applications. Mexico has 2 patent applications and 1 granted patent in this field. Note that China may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	349	763	1,112	62.30%
China	38	17	55	3.08%
United Kingdom	34	14	48	2.69%
Germany	75	20	95	5.32%
Italy	19	4	23	1.29%
Colombia	-	2	2	0.11%
Mexico	2	1	3	0.17%
Brazil	3	-	3	0.17%
World	829	956	1,785	

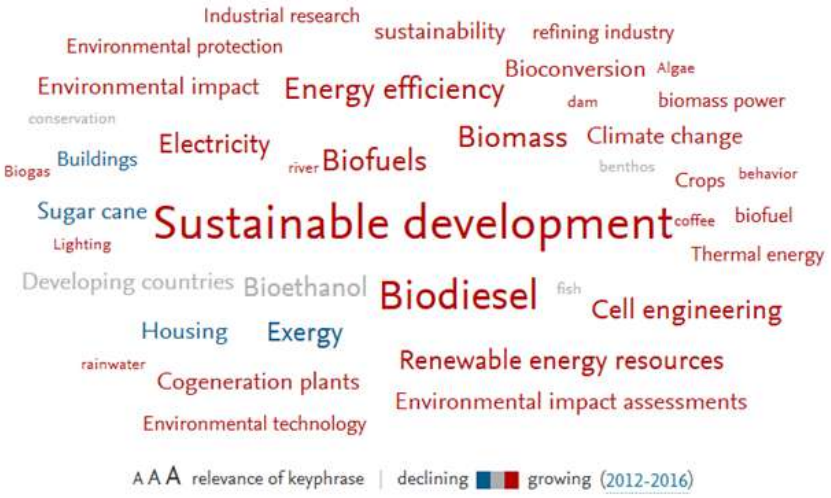
Table 7.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

7.4.6 **Research Focus**

Within the topic of SDG7-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG7-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG7 research is shown in Figure 7.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG7 research from Colombia, the term that stands out as unique to Colombia is 'Crops'. Among the top 50 key phrases the terms 'Biofuels', 'Biomass'; 'Electricity', 'Renewable Energy Resources', 'Greenhouse Gases', 'Environmental Impact', 'Energy Policy', and 'Biogas' were common among the countries analyzed. The terms 'Biodiesel', 'Bioethanol', and 'Bioconversion' stand out as unique to the Latin American countries. Figure 7.5 provides a visualization of the top 50 key phrases for SDG7 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

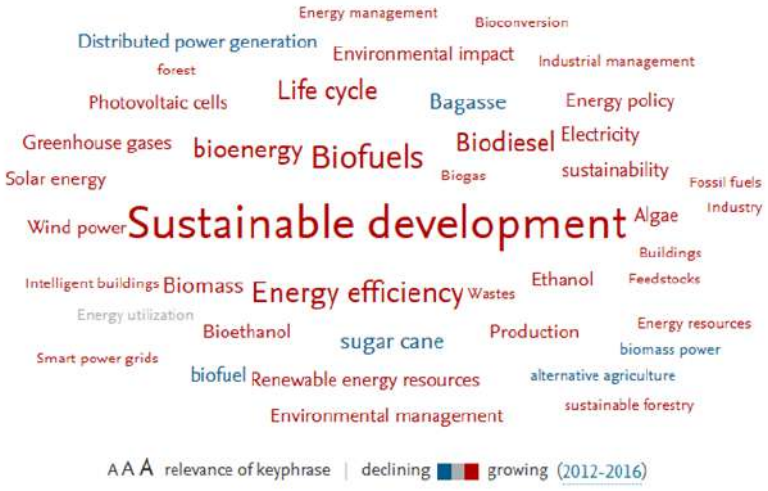
Colombia



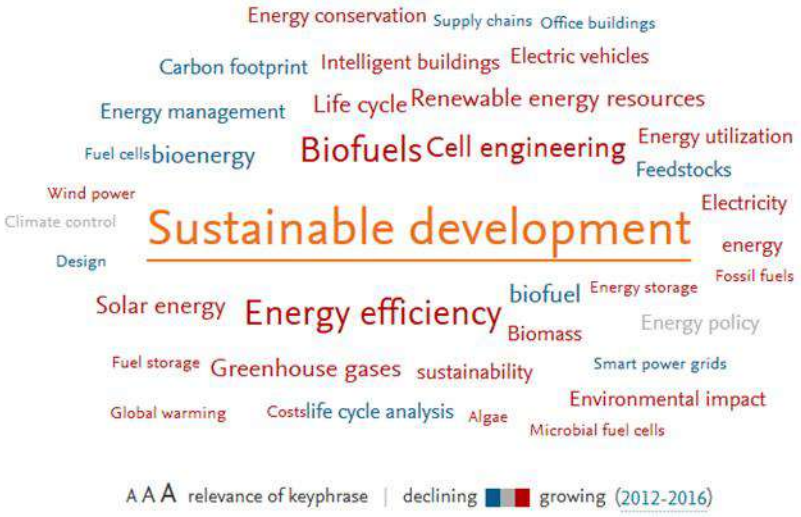
Mexico

Figure 7.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Brazil

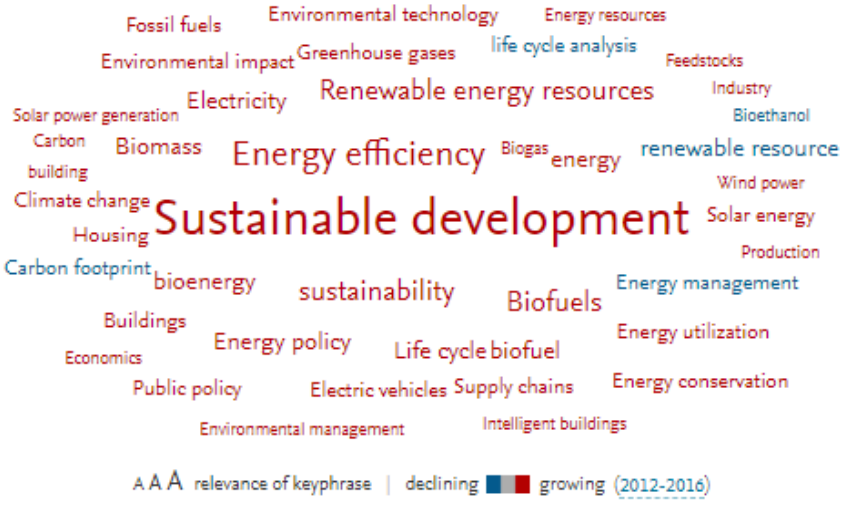


United States



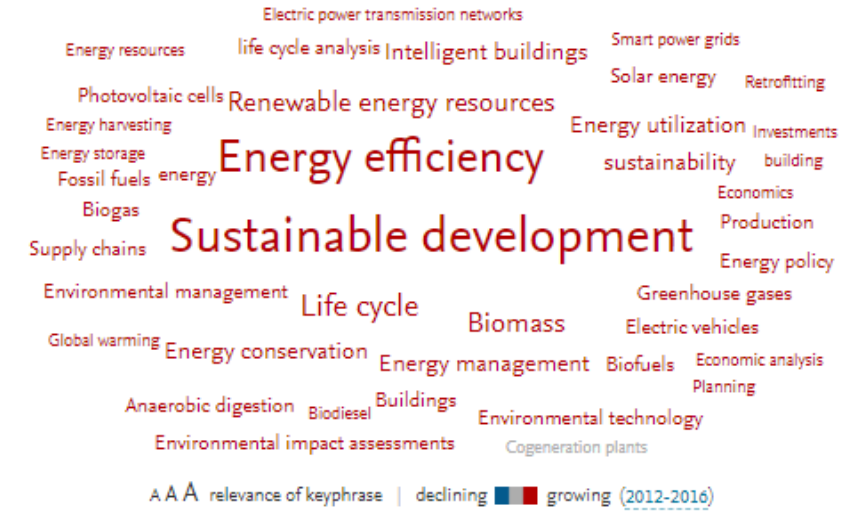
China

United Kingdom



Germany

Italy



7.5 The reach of Colombia's SDG7 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

7.5.1 Downloads

As shown in the Figure 7.6, the mean count of downloads per ScienceDirect publication is similar across all countries. For Colombia, there is a prominent peak in 2009. This peak is the result of three SD articles in 2009 from Colombia that were downloaded approximately 60,000 times, resulting in a high 'mean' value. It should be noted that for Colombia, the results shown are based on very small counts of SD articles and should be interpreted with caution.

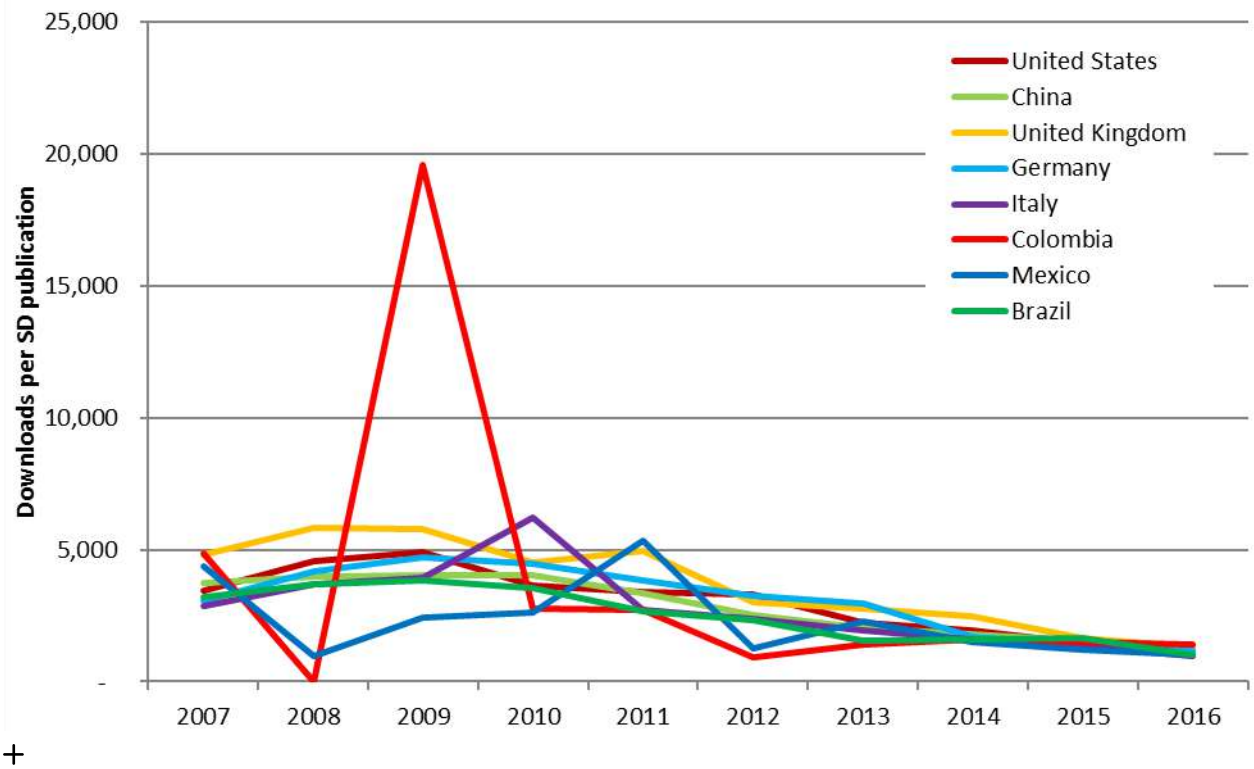


Figure 7.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

7.5.2 **Field Weighted Download Impact (FWDI)**

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. All countries have an FWDI near the world average for SDG7 (Figure 7.7). However, given the very low count of SD publications from Colombia (i.e. less than 100 SD publications for the full period) interpretation of this metric should focus on the other countries only.

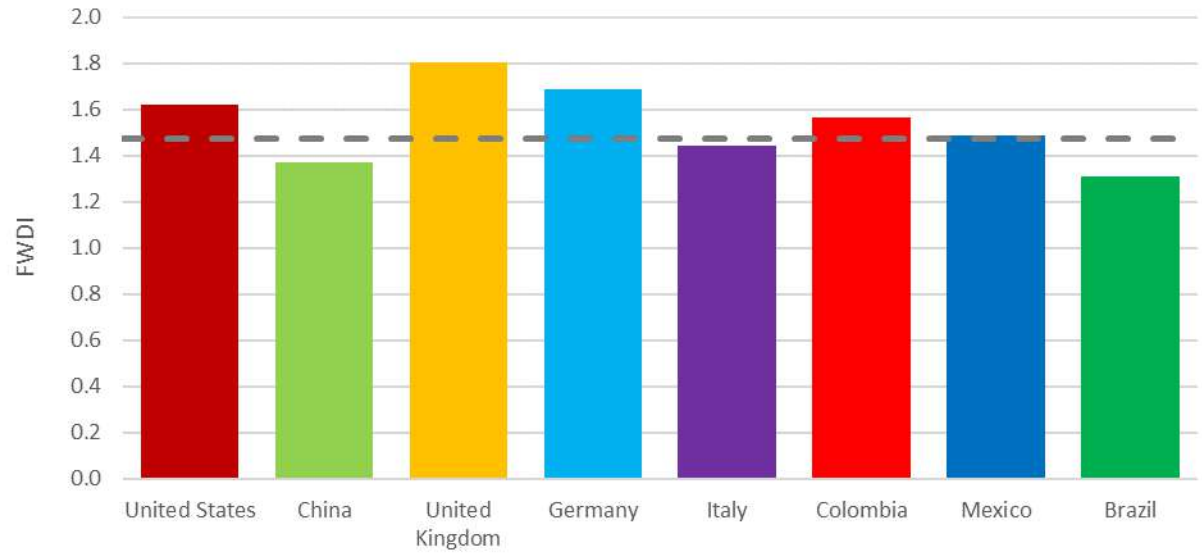


Figure 7.7— *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. Grey dotted line indicates average for all SDG7 research. (Source: ScienceDirect)*

7.6 SDG7 collaboration network

7.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG7-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 7.10-7.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG7 publications with. Among academic partner institutes, Colombia publishes the most SDG7 papers in collaboration with Universitat Rovira i Virgili (5 publications from 2007-2016) with a high FWCI (3.36, see Table 7.10). Universidade de Sao Paulo also produces 5 collaborative publications with Colombia. Imperial College London and the University of Bremen each co-author 4 publications with Colombia. Other institutes each co-author either 3 or 2 collaborative publications with Colombia. The FWCI of those collaborative publications ranges from 5.72 to 0.54, with a quarter of them below the world average.

Country	Institution (Country)	Publication Count	FWCI
Colombia	Universitat Rovira i Virgili (Spain)	5	3.36
	Universidade de Sao Paulo (Brazil)	5	0.54
	Imperial College London (United Kingdom)	4	1.37
	University of Bremen (Germany)	4	0.84
	IRD (France)	3	3.19
	University of California at Davis (United States)	3	2.80
	ETH Zurich (Switzerland)	3	2.52
	University of Florida (United States)	3	0.80
	Royal Institute of Technology (Sweden)	3	0.44
	Yale University (United States)	3	0.28
	International Crops Research Institute for the Semi-Arid Tropics (India)	2	5.72
	World Bank (United States)	2	5.68
	Universitat Politecnica de Catalunya (Spain)	2	5.02
	Texas A and M University (United States)	2	2.91
	PSL Research University (France)	2	1.87
	Ecole Normale Superieure (France)	2	1.87
	Universitat Autonoma de Barcelona (Spain)	2	1.80
	Universite Paris-Est (France)	2	1.62
	UNIVERSIDAD DEL BIO-BIO (Chile)	2	1.37
	Universidad de Alcala (Spain)	2	1.37

Table 7.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	Texas A and M University (United States)	21	1.58
	King Abdulaziz University (Saudi Arabia)	10	2.31
	Michigan Technological University (United States)	8	0.52
	Wageningen University & Research (Netherlands)	6	4.59
	KU Leuven (Belgium)	6	1.85
	Instituto Nacional de Tecnologia Agropecuaria (Argentina)	5	0.64
	CSIC (Spain)	4	2.80
	University of Texas at Austin (United States)	4	1.32
	U.S. Department of Agriculture (United States)	4	1.20
	University of California Office of the President (United States)	3	8.13
	Virginia Polytechnic Institute and State University (United States)	3	3.59
	Universitat Autonoma de Barcelona (Spain)	3	3.41
	University of California at Davis (United States)	3	2.75
	University of Twente (Netherlands)	3	2.45
	University of California at Berkeley (United States)	3	2.22
	Mekelle University (Ethiopia)	3	1.46
	Ghent University (Belgium)	3	1.46
	Yale University (United States)	3	1.31
	Imperial College London (United Kingdom)	3	0.66
	Universidad de Buenos Aires (Argentina)	3	0.62

Table 7.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	CIRAD (France)	16	2.19
	INRA Institut National de La Recherche Agronomique (France)	11	3.82
	Wageningen University & Research (Netherlands)	11	1.65
	U.S. Department of Agriculture (United States)	11	1.37
	Colorado State University (United States)	10	2.67
	University of Illinois at Urbana-Champaign (United States)	10	2.23
	University of Florida (United States)	8	1.61
	Florida State University (United States)	8	1.14
	CNRS (France)	7	3.36
	Universidade Nova de Lisboa (Portugal)	7	2.36
	Ericsson Sweden (Sweden)	7	1.56
	Royal Institute of Technology (Sweden)	7	1.29
	Michigan Technological University (United States)	7	0.51
	University of East Anglia (United Kingdom)	6	4.96
	Universidad Nacional Autonoma de Mexico (Mexico)	6	2.16
	Imperial College London (United Kingdom)	6	0.64
	University of Coimbra (Portugal)	5	3.05
	Universidad Politecnica de Valencia (Spain)	5	3.02
	Chalmers University of Technology (Sweden)	5	2.74
	United Nations (United States)	5	1.94

+

Table 7.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	Chinese Academy of Sciences (China)	112	3.66
	Tsinghua University (China)	42	2.99
	Wageningen University & Research (Netherlands)	35	3.31
	Universidade de Sao Paulo (Brazil)	34	2.12
	Technical University of Denmark (Denmark)	33	5.82
	ETH Zurich (Switzerland)	32	4.31
	CNRS (France)	31	4.82
	CSIRO (Australia)	27	4.91
	Ministry of Education China (China)	26	1.92
	King Abdulaziz University (Saudi Arabia)	25	3.31
	University of Toronto (Canada)	25	0.92
	Imperial College London (United Kingdom)	24	2.67
	Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences (China)	24	0.83
	Ghent University (Belgium)	23	3.95
	University of British Columbia (Canada)	21	7.74
	Politecnico di Milano (Italy)	21	2.38
	Khalifa University of Science and Technology (United Arab Emirates)	21	1.63
	Seoul National University (South Korea)	20	2.36
	Peking University (China)	20	2.07
	Delft University of Technology (Netherlands)	19	6.82

+

Table 7.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
China	Georgia Institute of Technology (United States)	52	5.26
	Hong Kong Polytechnic University (Hong Kong)	38	2.72
	City University of Hong Kong (Hong Kong)	29	1.58
	U.S. Department of Agriculture (United States)	28	1.90
	University of South Australia (Australia)	23	2.33
	Nanyang Technological University (Singapore)	22	3.31
	National University of Singapore (Singapore)	21	3.92
	CSIRO (Australia)	20	2.25
	Colorado State University (United States)	20	0.65
	University of Michigan (United States)	19	2.54
	Texas A and M University (United States)	19	1.68
	National Institute for Environmental Studies of Japan (Japan)	18	3.05
	Royal Institute of Technology (Sweden)	18	2.55
	University of Minnesota (United States)	18	1.14
	University of Adelaide (Australia)	17	2.81
	University of Western Australia (Australia)	17	2.54
	University of Hong Kong (Hong Kong)	17	1.14
	Hong Kong University of Science and Technology (Hong Kong)	17	0.97
	University of Nottingham (United Kingdom)	16	2.92
	Griffith University Queensland (Australia)	15	3.61

+

Table 7.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for China. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	Wageningen University & Research (Netherlands)	34	3.61
	European Commission Joint Research Centre Institute (Belgium)	27	1.66
	CNRS (France)	26	6.35
	Chinese Academy of Sciences (China)	21	2.31
	INRA Institut National de La Recherche Agronomique (France)	19	3.93
	Chalmers University of Technology (Sweden)	16	4.28
	ETH Zurich (Switzerland)	16	3.34
	Technical University of Denmark (Denmark)	16	3.29
	CEA (France)	15	3.29
	CSIC (Spain)	15	2.93
	University of Copenhagen (Denmark)	15	2.86
	CSIRO (Australia)	14	8.51
	Harvard University (United States)	14	3.00
	Utrecht University (Netherlands)	14	2.69
	Ministry of Education China (China)	13	2.60
	Aristotle University of Thessaloniki (Greece)	13	2.02
	CNR (Italy)	12	2.40
	University of Sydney (Australia)	12	2.00
	Universite Paris Saclay (France)	11	7.69
	Lawrence Berkeley National Laboratory (United States)	11	4.57

Table 7.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Germany	ETH Zurich (Switzerland)	38	2.89
	Wageningen University & Research (Netherlands)	36	2.59
	Chinese Academy of Sciences (China)	36	2.23
	European Commission Joint Research Centre Institute (Belgium)	32	2.04
	CNRS (France)	28	4.25
	CEA (France)	26	3.98
	Utrecht University (Netherlands)	22	2.87
	Technical University of Denmark (Denmark)	18	6.93
	Delft University of Technology (Netherlands)	18	3.33
	Politecnico di Milano (Italy)	18	2.24
	International Institute for Applied Systems Analysis, Laxenburg (Austria)	16	3.26
	Vienna University of Technology (Austria)	15	1.45
	Royal Institute of Technology (Sweden)	15	1.28
	University of New South Wales (Australia)	14	9.83
	Swedish University of Agricultural Sciences (Sweden)	14	3.25
	Chalmers University of Technology (Sweden)	14	2.37
	University of Copenhagen (Denmark)	13	4.06
	Universitat Autonoma de Barcelona (Spain)	13	3.19
	Paul Scherrer Institut (Switzerland)	13	1.77
	CNR (Italy)	13	1.74

+

Table 7.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Germany. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Italy	European Commission Joint Research Centre Institute (Belgium)	108	2.27
	Wageningen University & Research (Netherlands)	20	3.20
	European Commission (Belgium)	20	2.04
	ETH Zurich (Switzerland)	18	3.36
	CNRS (France)	18	2.39
	Ghent University (Belgium)	17	3.52
	Beijing Normal University (China)	15	1.64
	INRA Institut National de La Recherche Agronomique (France)	14	3.42
	Imperial College London (United Kingdom)	14	2.91
	Technical University of Denmark (Denmark)	13	2.71
	CEA (France)	13	2.25
	CSIC (Spain)	13	1.98
	Vrije Universiteit (Netherlands)	13	1.29
	University of Copenhagen (Denmark)	12	2.74
	University Politehnica of Bucharest (Romania)	12	2.53
	Royal Institute of Technology (Sweden)	12	1.63
	Leiden University (Netherlands)	11	3.36
	Aristotle University of Thessaloniki (Greece)	11	2.64
	Swedish University of Agricultural Sciences (Sweden)	10	3.88
	Norwegian University of Science and Technology (Norway)	10	1.52

+

Table 7.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Italy. (Source: Scopus)*

7.6.2 **Collaboration impact analysis**

To visualize the citation impact of collaborations, the ratio of FWCI from SDG7 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG7 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG7 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. As shown in Figure 7.8, Universitat Polytecnica de Catalunya sits far at the upper top right indicating that they've developed a highly mutually beneficial collaboration with Colombia. Other institutes such as the World Bank are also in the same quadrant and therefore have mutually beneficial collaborations with Colombia in terms of citation impact. Four research institutes, such as ETH Zurich sits in the lower right quadrant, meaning that they do not reap any citation benefit from the collaboration, while Colombia does. Other academic partners such as Yale University, are in the bottom left quadrant indicating that their collaboration does not yield any citation advantage to either Colombia or the partner.

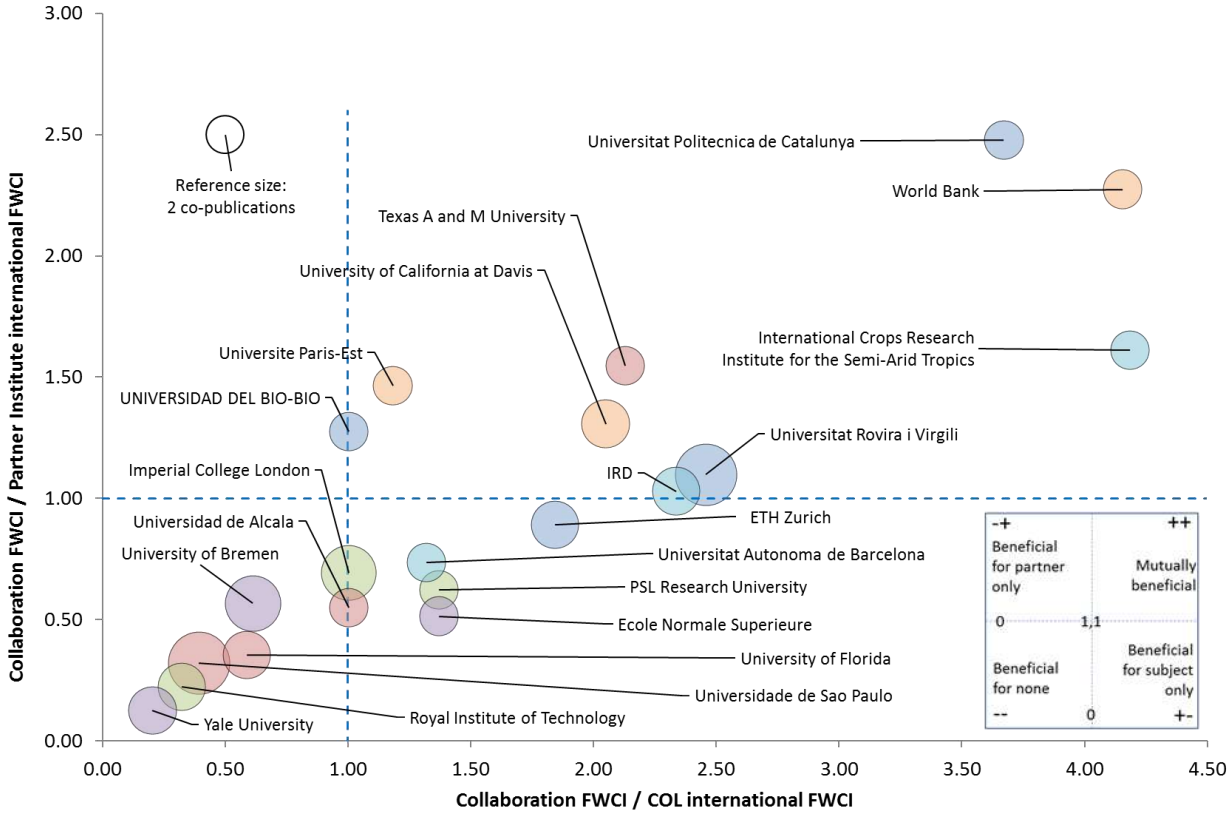


Figure 7.8— *Collaboration quadrant of Colombia's Top 20 collaborations in SDG7-related research with other institutions. Collaboration FWCI refers to the FWCI of all SDG7-related research co-authored by Colombia and the partner institute during the period 2007-2016. Bubble size corresponds to number of co-authored publications (reference bubble depicted at top left of chart). Impact of collaboration between partners can be interpreted based on quadrant position as described in legend on right. (Source: Scopus).*

7.6.3 **Collaboration chart**

Figure 7.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG7. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 7.9 shows where there may be potential to improve output and impact through partnership. Among Colombia's top 20 partners, Universidade de Sao Paulo and Royal Institute of Technology produce the highest number of SDG7 publications with 224 and 223 SDG7 publications, respectively. Among Colombia's top 20 partners, Yale University and International Crops Research Institute for the Semi-Arid Tropics have the highest FWCI for SDG7 research. Colombia may want to leverage its existing relationships with these institutes to increase its publication output and impact in SDG7 research.

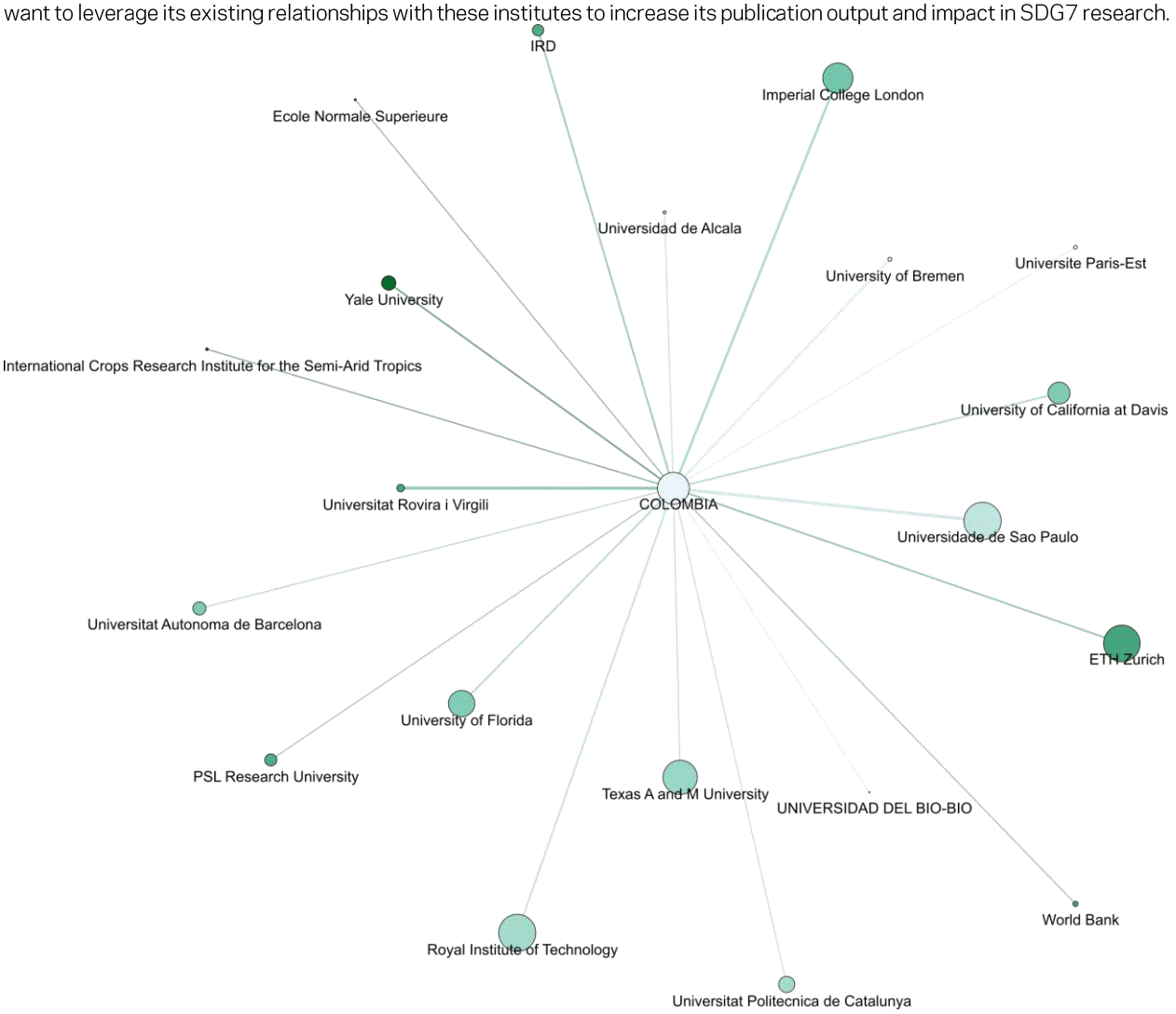


Figure 7.9— *Chart showing Colombia's top 20 collaborators on SDG7 from 2007-2016. Circle (node) size is proportional to the number of SDG7 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (3.37) and lightest shade of green indicating the lowest FWCI (1.03). (Source: Scopus).*

Chapter 8
Decent Work and Economic Growth

In this Chapter, we assess research related to SDG8, which aims to promote inclusive and sustainable economic growth, employment, and decent work for all. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

8.1 Key Findings

Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all

WORLD RESEARCH OUTPUT

20,592

Number of SDG8 publications, 2007-2016.

SDG8 PATENTS

116

Number of SDG8 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

79

Colombia's SDG8 publications, 2007-2016.

COLOMBIA RESEARCH OUTPUT CAGR

24%

Compound annual growth rate for Colombia's 2007-2016 SDG8 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

10

Colombia's SDG8 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

1.08

Average field-weighted citation impact for Colombia's SDG8 publications, 2007-2016.

8.2 SDG8 – Promote inclusive and sustainable economic growth, employment and decent work for all

According to the United Nations,

> *"Roughly half the world's population still lives on the equivalent of about US$2 a day. And in too many places, having a job doesn't guarantee the ability to escape from poverty. This slow and uneven progress requires us to rethink and retool our economic and social policies aimed at eradicating poverty.*
> *A continued lack of decent work opportunities, insufficient investments and under-consumption lead to an erosion of the basic social contract underlying democratic societies: that all must share in progress. The creation of quality jobs will remain a major challenge for almost all economies well beyond 2015.*
> *Sustainable economic growth will require societies to create the conditions that allow people to have quality jobs that stimulate the economy while not harming the environment. Job opportunities and decent working conditions are also required for the whole working age population."*[13]

The targets for SDG8, according to the United Nations are:

- *"Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries.*
- *Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors.*
- *Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services.*
- *Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead.*
- *By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value.*
- *By 2020, substantially reduce the proportion of youth not in employment, education or training.*
- *Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms.*
- *Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment.*
- *By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products.*
- *Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all.*
- *Increase Aid for Trade support for developing countries, in particular least developed countries, including through the Enhanced Integrated Framework for Trade-Related Technical Assistance to Least Developed Countries.*
- *By 2020, develop and operationalize a global strategy for youth employment and implement the Global Jobs Pact of the International Labour Organization."*[13]

[13] http://www.un.org/sustainabledevelopment/economic-growth/

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG8 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

8.3 SDG8: Leaders in the field

8.3.1 Top 5 countries conducting SDG8 research

The top 5 countries publishing on SDG 8 based on cumulative publication output from 2007-2016 is indicated by Table 8.1 and Figure 8.1. China ranks 1st in Publication Count and Percentage of Global Output, closely followed by the United States. The United Kingdom and Australia follow with 1,000-2,000 SDG8 publications. The United States SDG8 research yielded the highest citation count with 43,751 citations. The United Kingdom ranks 1st in terms of FWCI with an FWCI of 1.79, which is higher than the world average of 1.0 for SDG8 research.

Table 8.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
China	3,888	18.88%	24,094	0.73
United States	3,356	16.30%	43,751	1.50
United Kingdom	1,775	8.62%	25,795	1.79
Australia	1,133	5.50%	14,963	1.62
India	811	3.94%	6,785	0.91
World	20,592	100.00%	67,716	1.00

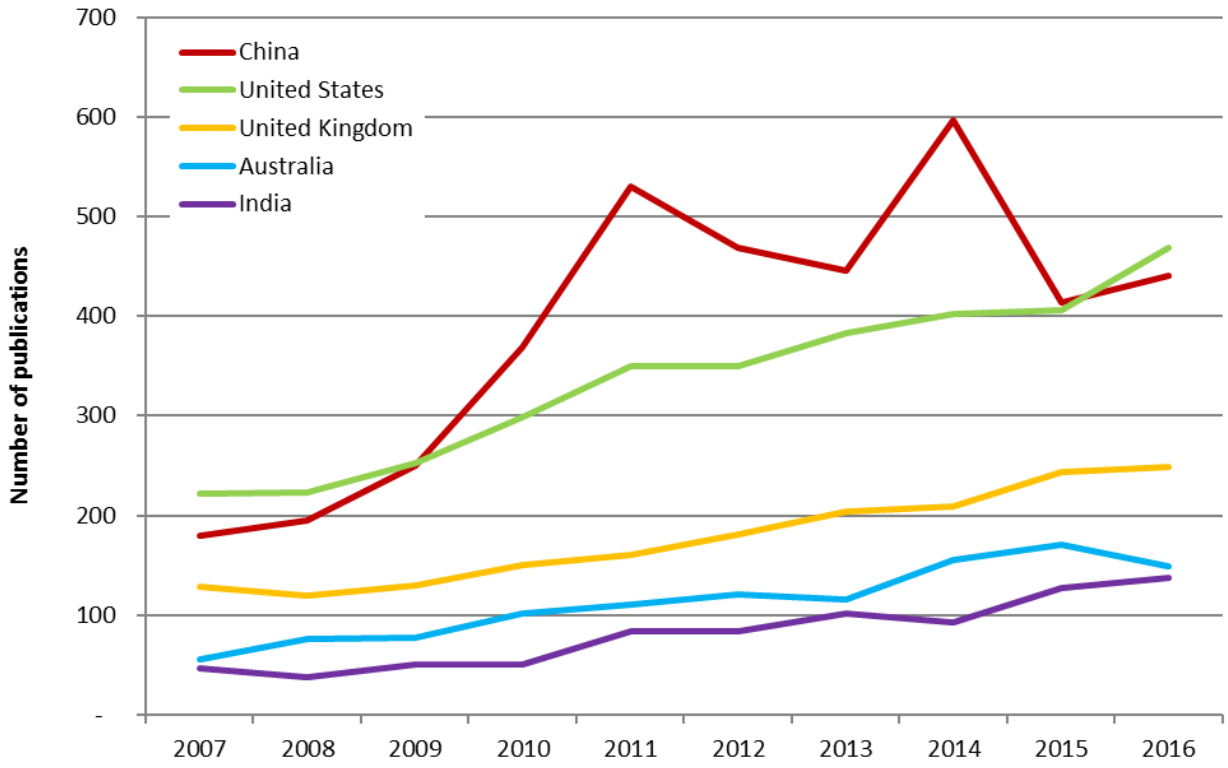


Figure 8.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG8 research. (Source: Scopus)*

8.3.2 Top 20 institutes conducting SDG8 research

A list of the top 20 research institutes publishing SDG8-related research is shown in Table 8.2. China claims the top 3 ranks with the Chinese Academy of Sciences ranking 1st in Publication Count and Citation Count followed by Beijing Normal University, and the Institute of Geographical Sciences and Natural Resources Research. Harvard University sits in 1st place with an FWCI if 4.57, more than 4.5 times higher than the world average. The University of Oxford also has a high FWCI, at more than 3 times higher than the global average. The trends in publication output from 2007-2016 are shown in Figure 8.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Chinese Academy of Sciences (China)	469	5,783	1.14
2	Beijing Normal University (China)	154	1,533	1.31
3	Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences (China)	152	1,300	1.18
4	Wageningen University & Research (Netherlands)	128	2,046	2.46
5	Tsinghua University (China)	120	1,980	1.49
6	Griffith University Queensland (Australia)	113	1,623	1.86
7	University of Queensland (Australia)	110	1,683	1.74
8	The Bucharest University of Economic Studies (Romania)	93	65	0.36
9	University of Cambridge (United Kingdom)	91	2,513	3.04
10	Nanjing University (China)	90	757	0.73
11	Peking University (China)	90	1,204	1.59
12	University of Oxford (United Kingdom)	85	1,762	3.13
13	United Nations (United States)	84	1,196	1.61
14	Ministry of Education China (China)	81	1,850	1.42
15	Wuhan University (China)	81	397	0.44
16	Monash University (Australia)	80	1,373	2.09
17	Universiti Teknologi Malaysia (Malaysia)	80	543	0.68
18	Graduate University of Chinese Academy of Sciences (China)	79	952	0.85
19	Universiti Kebangsaan Malaysia (Malaysia)	77	311	0.55
20	Harvard University (United States)	77	2,824	4.57

Table 8.2— *Top 20 research Institutes ranked based on SDG8 publication output and FWCI from 2007-2016. (Source: Scopus)*

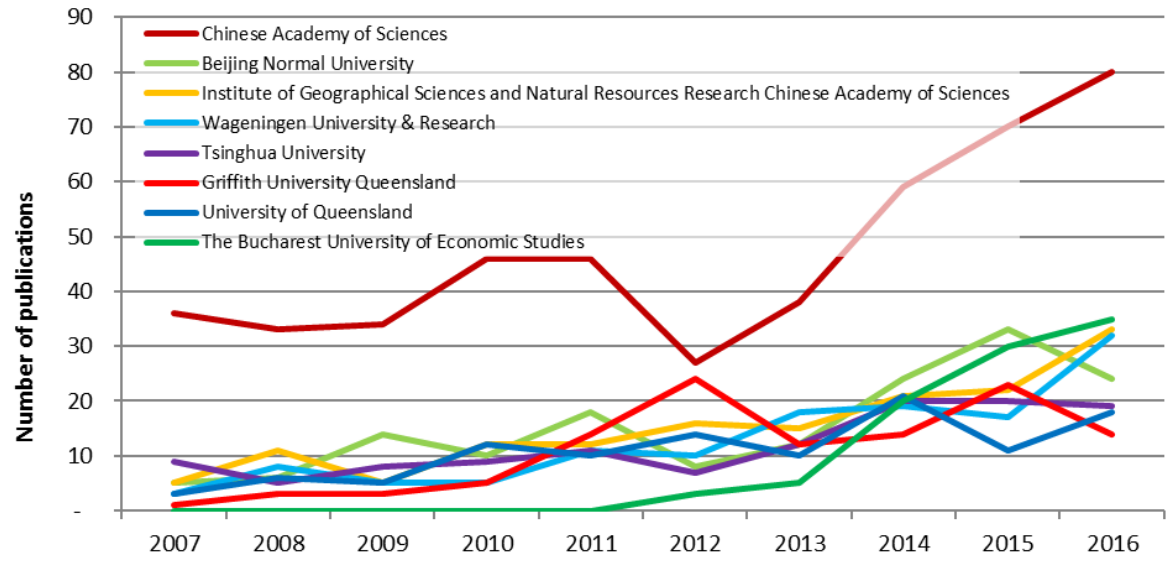


Figure 8.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG8. (Source: Scopus)*

8.3.3 Top 20 researchers conducting SDG8 research

A list of the top 20 researchers publishing in the SDG8 field based on publication output from 2007-2016 is shown in Table 8.3.
Sarkis J., Huang G., and Yang Z. are the top 3 researchers in terms of h-index, with an h-index of 62, 50, and 50, respectively.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Geng Y.	Shanghai Jiaotong University (China)	35	807	2.39	41
2	Huang G.	Beijing Normal University (China)	22	316	1.75	50
3	YANG Z.	Beijing Normal University (China)	22	420	1.72	50
4	Weaver D.	Griffith University (Australia)	20	420	2.67	23
5	Hall C.	University of Canterbury (New Zealand)	18	596	5.34	43
6	Siwar C.	Universiti Kebangsaan Malaysia (Malaysia)	18	41	0.50	12
7	Chen B.	Beijing Normal University (China)	17	278	1.35	46
8	Deng X.	Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences (China)	17	155	1.19	24
9	Gößling S.	Lunds Universitet (Sweden)	16	631	5.73	32
10	Shahbaz M.	COMSATS Institute of Information Technology Lahore (Pakistan)	16	278	3.36	27
11	Ulgiati S.	Universita degli Studi di Napoli Parthenope (Italy)	16	340	2.90	38
12	Li Y.	Beijing Normal University (China)	16	194	1.84	33
13	Fang C.	Chinese Academy of Sciences (China)	16	225	1.80	16
14	Ruhanen L.	University of Queensland (Australia)	14	222	2.21	12
15	Zuo J.	Shenzhen University (China)	14	127	1.68	23
16	Yuan X.	Shandong University (China)	14	116	1.38	14
17	Sha J.	China University of Geosciences, Beijing (China)	14	34	0.65	4
18	Schandl H.	Commonwealth Scientific and Industrial Research Organization (Australia)	13	475	6.21	20
19	Sarkis J.	Worcester Polytechnic Institute (United States)	13	378	3.12	62
20	Tvaronaičienė M.	Vilniaus Gedimino technikos universitetas (Lithuania)	13	245	2.90	16

Table 8.3— *Top 20 researchers publishing SDG8 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG8 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

8.3.4 **Top 10 journals publishing SDG8 research**

A list of the top 10 journals publishing SDG8-related research from 2007-2016 is shown in Table 8.4. *Advanced Materials Research* published the most SDG8 publications (434) followed by *Sustainability*, *Journal of Sustainable Tourism*, and other journals with more than 100 publications. *Journal of Cleaner Production* ranks 1st in FWCI followed by *Journal of Sustainable Tourism* and *Ecological Economics* in the 2nd and 3rd place, respectively. As for CiteScore, *Renewable and Sustainable Energy Reviews* sits in the 1st place with 7.66 followed *Journal of Cleaner Production* of 3.70 and *Energy Policy* of 3.52.

Rank	Journal	Publication count	FWCI	CiteScore
1	Advanced Materials Research	434	0.25	0.17
2	Sustainability	378	1.13	0.92
3	Journal of Sustainable Tourism	250	2.69	3.02
4	Journal of Cleaner Production	238	2.87	3.70
5	Acta Ecologica Sinica	216	0.26	0.55
6	WIT Transactions on Ecology and the Environment	202	0.07	0.08
7	Renewable and Sustainable Energy Reviews	198	1.16	7.66
8	Applied Mechanics and Materials	188	0.26	0.11
9	Energy Policy	177	1.66	3.52
10	Ecological Economics	127	2.66	3.42

Table 8.4— *Top 10 journals based on SDG8 publication output from 2007-2016. FWCI is mean FWCI for any SDG8 publications in the journal during the period; CiteScore is based on data for the journal as a whole. (Source: Scopus)*

8.4 Research efforts focused on SDG8

8.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 8.3, China and the United States are the leaders in terms of SDG8 research output by at least 1,500 publications. The United Kingdom and Australia follow. Among comparators, Colombia has the lowest output in this field, just below Mexico. However, as shown in Table 8.5, Colombia has the greatest a Compound Annual Growth Rate (CAGR) at 24.10% per annum. Mexico, India, and Brazil also see marked increases in publication output with a CAGR above 12%.

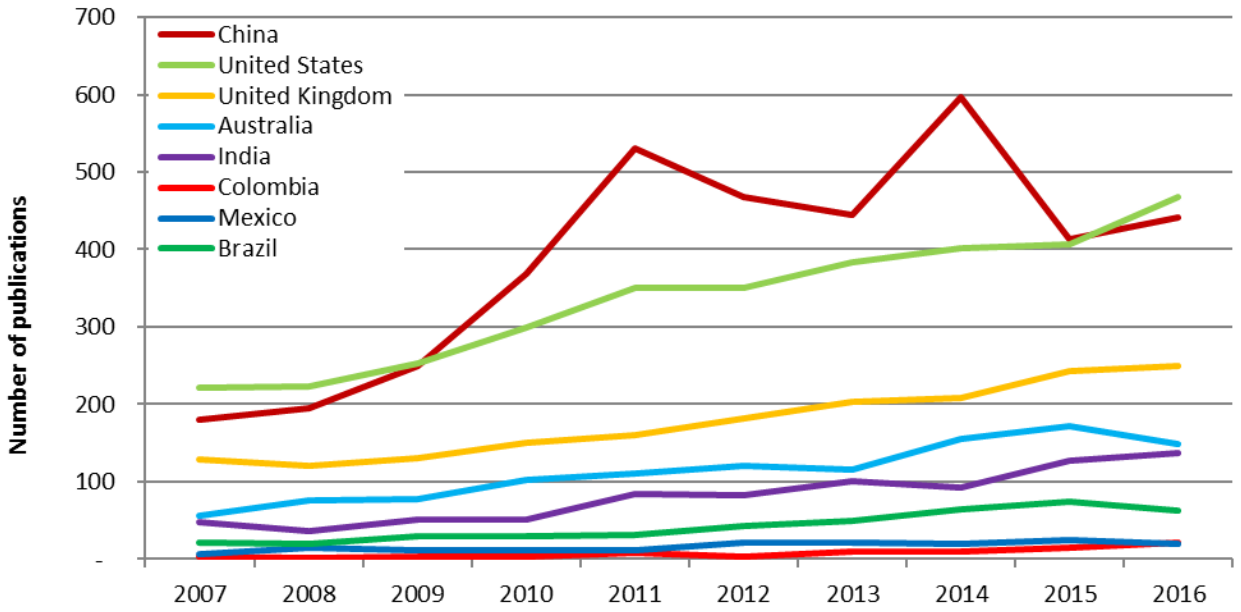


Figure 8.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
China	3,888	10.50%
United States	3,356	8.60%
United Kingdom	1,775	7.60%
Australia	1,133	11.50%
India	811	12.60%
Colombia	79	24.10%
Mexico	160	14.30%
Brazil	428	12.20%
World	20,592	8.80%

Table 8.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

8.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG8 related research from 2006-2017 is 1.00.

Country	FWCI
China	0.73
United States	1.50
United Kingdom	1.79
Australia	1.62
India	0.91
Colombia	1.08
Mexico	1.17
Brazil	0.98
World	1.00

Comparing the FWCI of publications from each of the eight countries included in this chapter reveals the impact of research from each country (Table 8.6). Most notably, the United Kingdom achieves the highest FWCI among comparator countries, followed by Australia and the United States, both at or above 50% more than the world average.

Table 8.6— *FWCI for SDG8 research from 2007-2016 per country and world. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

8.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 8.4 and Table 8.7, the United States leads in terms of publications that are among the top 10% most cited. The United Kingdom and China, then Australia, and finally India, follow in that order. Colombia has a very small number of publications among the top 10% most cited during this time period. According to Table 8.7, China leads in growth with a high CAGR of over 21% per annum, followed by Brazil and the United States at over 11%.

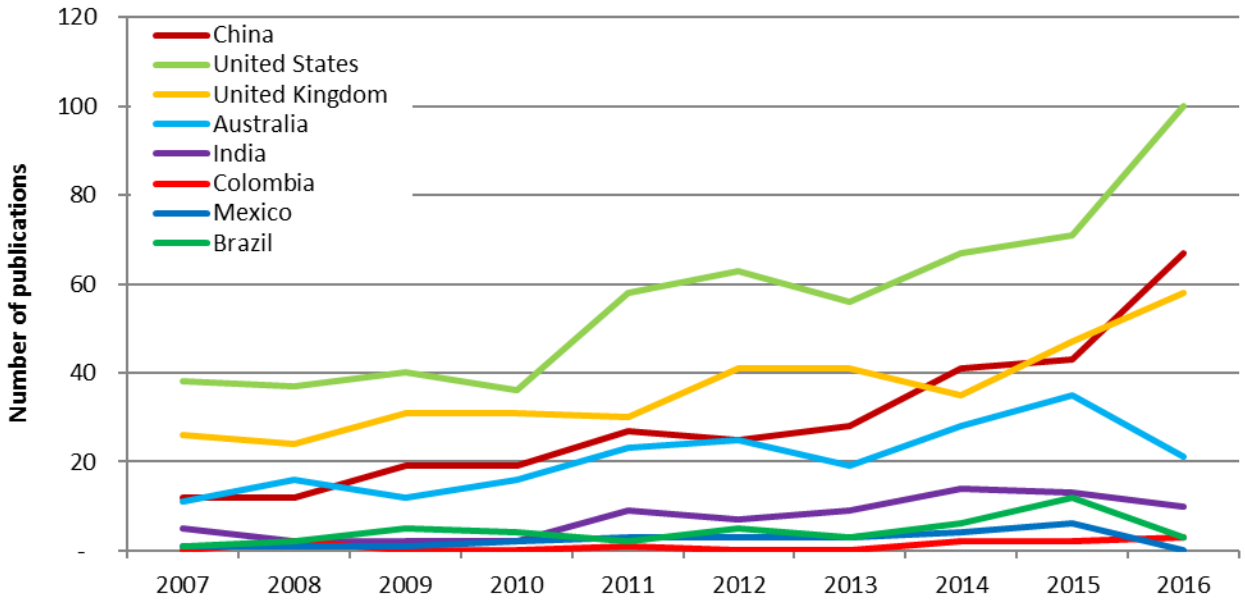


Figure 8.4— *Top 10% most cited publications on SDG8 from 2007-2016 per country. CAGR shown at top of each bar. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
China	293	21.06%
United States	566	11.35%
United Kingdom	364	9.32%
Australia	206	7.45%
India	73	8.01%
Colombia	10	-
Mexico	24	-100.00%
Brazil	43	12.98%
World	2,202	13.43%

Table 8.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG8 publications from 2007-2016. (Source: Scopus)*

8.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 8.8 provides the count of SDG8 publications from each country that have been cited in patents and the number of patents that have cited these publications. The findings show that patent citation count is related to publication count in that the leaders in publication output have the highest patent citation count. The United Kingdom had 3 publications cited in 6 patents and the United states has 3 publications cited in 4 patents. Colombia, Mexico, and Brazil have no patent citations.

Country	Patent Cited Publications	Patents Citing Publications
China	2	2
United States	3	4
United Kingdom	3	6
Australia	2	2
India	2	3
Colombia	-	-
Mexico	-	-
Brazil	-	-
World	22	127

Table 8.8— *Number of publications cited in USPTO, WIPO, or EPO patents and number of USPTO, WIPO, or EPO patents citing publications on SDG8 from 2007 to 2016. (Source: Scopus and LexisNexis)*

8.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG1. To identify patents relevant to SDG1, we retrieved all the publications citing any research retrieved using the SDG8 search query. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO. From 2006 to 2016, the United States applied for the most SDG8-related grants with 7 patent applications and 73 granted in this field. Colombia and other countries either have no grant and/or no patents granted in this field. Note that China, India, and Australia may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
China	2	-	2	1.72%
United States	7	73	80	68.97%
United Kingdom	-	-	-	0.00%
Australia	1	-	1	0.86%
India	4	-	4	3.45%
Colombia	-	-	-	0.00%
Mexico	-	-	-	0.00%
Brazil	-	-	-	0.00%
World	35	81	116	

Table 8.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

8.4.6 **Research Focus**

Within the topic of SDG8-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG8-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG8 research is shown in Figure 8.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG8 research from Colombia, the term that stands out as unique to Colombia is 'Data Envelopment Analysis', 'Productivity', 'Decomposition Analysis', 'Information Analysis', 'Crashworthiness', and 'Active Networks'. Among the top 50 key phrases the terms 'Economic Growth', 'Tourism'; and 'Climate Change' were common among the countries analyzed. The terms 'Conservation' and 'Management' stand out as unique to the Latin American countries. Figure 8.5 provides a visualization of the top 50 key phrases for SDG8 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

Colombia

Mexico

Figure 8.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Brazil

China

United States

United Kingdom

Australia

India

8.5 The reach of Colombia's SDG8 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

8.5.1 Downloads

As shown in the Figure 8.6, the mean count of downloads per ScienceDirect publication fluctuates considerably across the period for all countries. The fluctuations likely stem from the fact that most data points were based on less than 100 SD publications per year. Therefore, the results shown should be interpreted with caution.

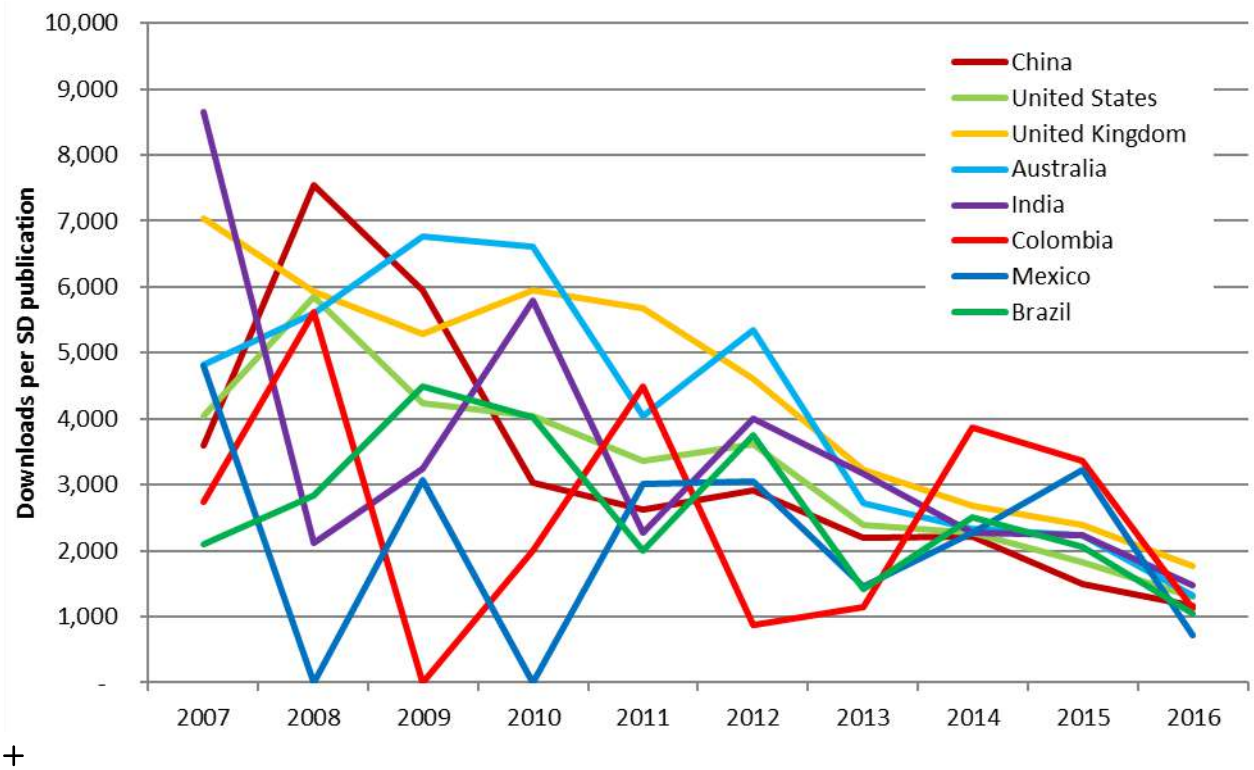


Figure 8.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

8.5.2 **Field Weighted Download Impact (FWDI)**

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. Interestingly, the United Kingdom, India, and Colombia have an FWDI for the period of 2007-2016 well above the world average for SDG8 research (Figure 8.7). However, given the very low count of SD publications from Colombia, Mexico, and Brazil (i.e. less than 100 SD publications for the full period) interpretation of this metric should focus on the top 5 countries only. All countries had an FWDI at or above the world average for SDG8 research.

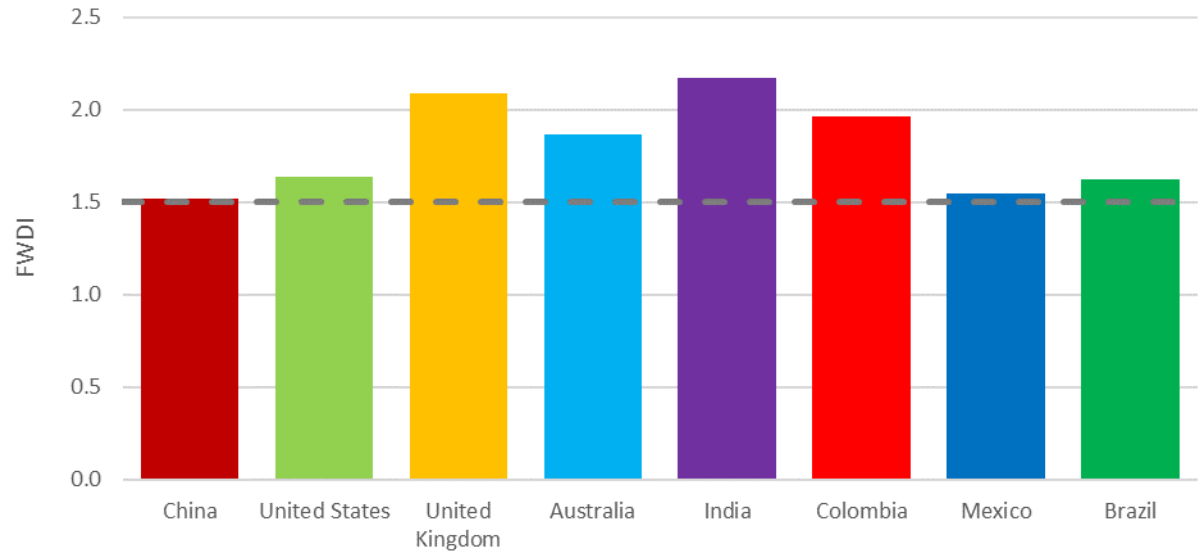


Figure 8.7 — *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. (Source: ScienceDirect)*

8.6 SDG8 collaboration network

8.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG8-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 8.10-8.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG8 publications with. Among academic partner institutes, Colombia has published the most SDG8 papers in collaboration with Royal Institute of Technology (4 publications from 2007-2016) based on Table 8.10. The University of Gottingen produced 3 publications in collaboration with Colombia. Stanford University, Harvard University, Universidad de Cadiz, and the United Nations each co-authored 2 publications with Colombia. Other institutes among the top 20 each co-authored one collaborative publication. The FWCI of collaborative publications with top foreign partner institutes is above the world average except for those with the Royal Institute of Technology, the University of Gottingen, and the United Nations.

Country	Institution (Country)	Publication Count	FWCI
Colombia	Royal Institute of Technology (Sweden)	4	0.33
	University of Gottingen (Germany)	3	0.25
	Stanford University (United States)	2	6.91
	Harvard University (United States)	2	3.59
	Universidad de Cadiz (Spain)	2	1.64
	United Nations (United States)	2	0.00
	Universite Catholique de Louvain (Belgium)	1	10.07
	University of Bonn (Germany)	1	10.07
	University of British Columbia (Canada)	1	10.07
	Yale University (United States)	1	9.73
	Universidade Federal do Ceara (Brazil)	1	6.55
	Fundacao Oswaldo Cruz (Brazil)	1	6.55
	World Health Organization (Switzerland)	1	6.55
	Universidade de Brasilia (Brazil)	1	6.55
	Eastern Mediterranean University (Turkey)	1	3.89
	Institut Catala de la Salut (Spain)	1	3.66
	Universidad Nacional Autonoma de Mexico (Mexico)	1	3.66
	Universidad Autonoma de Yucatan (Mexico)	1	3.13
	University of Wales Trinity Saint David (United Kingdom)	1	2.68
	INRA Institut National de La Recherche Agronomique (France)	1	2.15

Table 8.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	Texas A and M University (United States)	5	2.61
	Yale University (United States)	4	4.04
	Wageningen University & Research (Netherlands)	4	2.77
	Arizona State University (United States)	4	2.54
	University of Toronto (Canada)	3	7.95
	Michigan State University (United States)	3	1.24
	University of Georgia (United States)	3	0.86
	University of Massachusetts Lowell (United States)	3	0.22
	University of Oxford (United Kingdom)	2	9.24
	University of Washington (United States)	2	6.83
	World Health Organization (Switzerland)	2	6.65
	University of Bergen (Norway)	2	6.44
	University of Arizona (United States)	2	4.30
	Bill and Melinda Gates Foundation (United States)	2	3.90
	Colorado State University (United States)	2	3.46
	Universidad Nacional de Colombia (Colombia)	2	3.40
	Harvard University (United States)	2	3.36
	Food and Agriculture Organization of the United Nations (Italy)	2	3.23
	North Carolina State University (United States)	2	3.08
	University of Massachusetts (United States)	2	2.80

+

Table 8.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	Harvard University (United States)	8	9.45
	Imperial College London (United Kingdom)	6	9.17
	Stanford University (United States)	5	11.16
	University of Oxford (United Kingdom)	5	9.97
	Wageningen University & Research (Netherlands)	5	2.05
	Monash University (Australia)	4	10.82
	University of Oslo (Norway)	4	10.76
	United Nations (United States)	4	3.05
	World Health Organization (Switzerland)	4	2.56
	Chiang Mai University (Thailand)	4	1.79
	Lund University (Sweden)	3	15.73
	Flinders University (Australia)	3	13.97
	University of California at San Diego (United States)	3	13.86
	University of East Anglia (United Kingdom)	3	5.76
	University of Tennessee, Knoxville (United States)	3	2.53
	London School of Hygiene and Tropical Medicine (United Kingdom)	3	1.79
	Virginia Polytechnic Institute and State University (United States)	3	1.29
	KU Leuven (Belgium)	3	0.53
	Yunnan Agriculture University (China)	3	0.53
	University of Wolverhampton (United Kingdom)	3	0.53

Table 8.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
China	Hong Kong Polytechnic University (Hong Kong)	27	2.03
	National Institute for Environmental Studies of Japan (Japan)	24	3.13
	University of Regina (Canada)	24	1.97
	University of Hong Kong (Hong Kong)	18	1.60
	City University of Hong Kong (Hong Kong)	16	1.67
	Chinese University of Hong Kong (Hong Kong)	13	1.35
	Wageningen University & Research (Netherlands)	13	0.99
	Harvard University (United States)	12	7.87
	University of Cambridge (United Kingdom)	12	5.42
	Universita degli Studi di Napoli Parthenope (Italy)	12	3.57
	University of South Australia (Australia)	12	1.28
	University of Tsukuba (Japan)	11	1.41
	Arizona State University (United States)	10	1.46
	Stanford University (United States)	8	8.06
	University of Maryland (United States)	8	6.20
	International Institute for Applied Systems Analysis, Laxenburg (Austria)	8	4.88
	National University of Singapore (Singapore)	8	2.53
	University of Melbourne (Australia)	8	1.24
	University of Macau (Macao)	8	0.80
	Colorado State University (United States)	8	0.02

Table 8.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for China. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	Chinese Academy of Sciences (China)	62	2.30
	Peking University (China)	23	3.70
	World Health Organization (Switzerland)	21	7.02
	University of Cambridge (United Kingdom)	21	5.57
	International Institute for Applied Systems Analysis, Laxenburg (Austria)	19	5.34
	Tsinghua University (China)	18	3.49
	University of Oxford (United Kingdom)	17	6.48
	University of British Columbia (Canada)	17	2.77
	Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences (China)	17	2.60
	London School of Hygiene and Tropical Medicine (United Kingdom)	15	7.08
	Universidade de Sao Paulo (Brazil)	15	4.25
	Zhejiang University (China)	15	1.70
	Wageningen University & Research (Netherlands)	14	4.22
	University of Toronto (Canada)	14	3.52
	Beijing Normal University (China)	14	2.40
	CAS - Shenyang Institute of Applied Ecology (China)	13	4.78
	University of Oslo (Norway)	12	9.97
	University College London (United Kingdom)	11	9.06
	CNRS (France)	11	4.47
	University of Stellenbosch (South Africa)	11	1.32

+

Table 8.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	Harvard University (United States)	21	9.78
	Wageningen University & Research (Netherlands)	17	5.66
	Chinese Academy of Sciences (China)	15	4.63
	Stanford University (United States)	13	12.49
	United Nations (United States)	12	3.71
	World Health Organization (Switzerland)	11	10.61
	University of Washington (United States)	10	13.59
	CNRS (France)	10	1.26
	Lund University (Sweden)	9	7.54
	Ghent University (Belgium)	9	2.38
	Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences (China)	8	4.35
	University of Toronto (Canada)	8	4.23
	KU Leuven (Belgium)	8	3.32
	Columbia University (United States)	7	10.53
	Monash University (Australia)	7	7.65
	University of New South Wales (Australia)	7	4.75
	Australian National University (Australia)	7	2.79
	Universitat Autonoma de Barcelona (Spain)	7	1.21
	University of Oslo (Norway)	6	14.90
	Macquarie University (Australia)	6	5.13

Table 8.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Australia	Chinese Academy of Sciences (China)	13	1.89
	Shandong University (China)	12	1.81
	Imperial College London (United Kingdom)	9	7.25
	Harvard University (United States)	8	12.94
	World Health Organization (Switzerland)	8	8.01
	Wageningen University & Research (Netherlands)	7	3.33
	Texas A and M University (United States)	7	1.39
	Stanford University (United States)	6	17.75
	University of Oxford (United Kingdom)	6	9.15
	United Nations (United States)	6	2.66
	Shandong Jianzhu University (China)	6	2.12
	University of California at Davis (United States)	6	2.04
	University of Otago (New Zealand)	6	1.57
	University of Auckland (New Zealand)	6	1.15
	Colorado State University (United States)	5	6.97
	University of British Columbia (Canada)	5	4.25
	CAS - Research Center for Eco-Environmental Sciences (China)	5	2.85
	Hong Kong Polytechnic University (Hong Kong)	5	2.44
	University of the Witwatersrand (South Africa)	5	2.16
	Massey University (New Zealand)	5	1.91

+

Table 8.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Australia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
India	Harvard University (United States)	11	11.46
	King's College London (United Kingdom)	6	9.02
	Technical University of Denmark (Denmark)	6	0.69
	Stanford University (United States)	5	20.11
	London School of Hygiene and Tropical Medicine (United Kingdom)	5	3.98
	United Nations (United States)	5	1.10
	University of California at San Francisco (United States)	4	22.21
	University of Oslo (Norway)	4	21.00
	World Health Organization (Switzerland)	4	14.30
	University of Pennsylvania (United States)	4	2.38
	Wageningen University & Research (Netherlands)	4	1.28
	National University of Singapore (Singapore)	4	0.58
	Bill and Melinda Gates Foundation (United States)	3	17.60
	Columbia University (United States)	3	16.35
	Universidade de Sao Paulo (Brazil)	3	14.79
	University of Oxford (United Kingdom)	3	14.04
	Council for Scientific and Industrial Research South Africa (South Africa)	3	8.32
	University of Cambridge (United Kingdom)	3	4.82
	University of Melbourne (Australia)	3	4.42
	University of Stellenbosch (South Africa)	3	3.64

+

Table 8.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for India. (Source: Scopus)*

8.6.2 **Collaboration impact analysis**

To visualize the citation impact of collaborations, the ratio of FWCI from SDG8 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG8 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG8 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. As shown in Figure 8.8, the University of Bonn and the University of British Columbia sit at the upper part of the top right quadrant, indicating that they've developed a highly mutually beneficial collaboration with Colombia. Other institutes, such as Yale University, also locate in the same quadrant indicating the mutually beneficial collaboration in terms of citation impact. Harvard University sits in the bottom right meaning the collaboration yields a citation advantage to Colombia but not Harvard. The United Nations, the University of Gottingen, and the Royal Institute of Technology are all in the bottom left quadrant indicating that the collaborations do not bring any citation advantage to either Colombia or these partners.

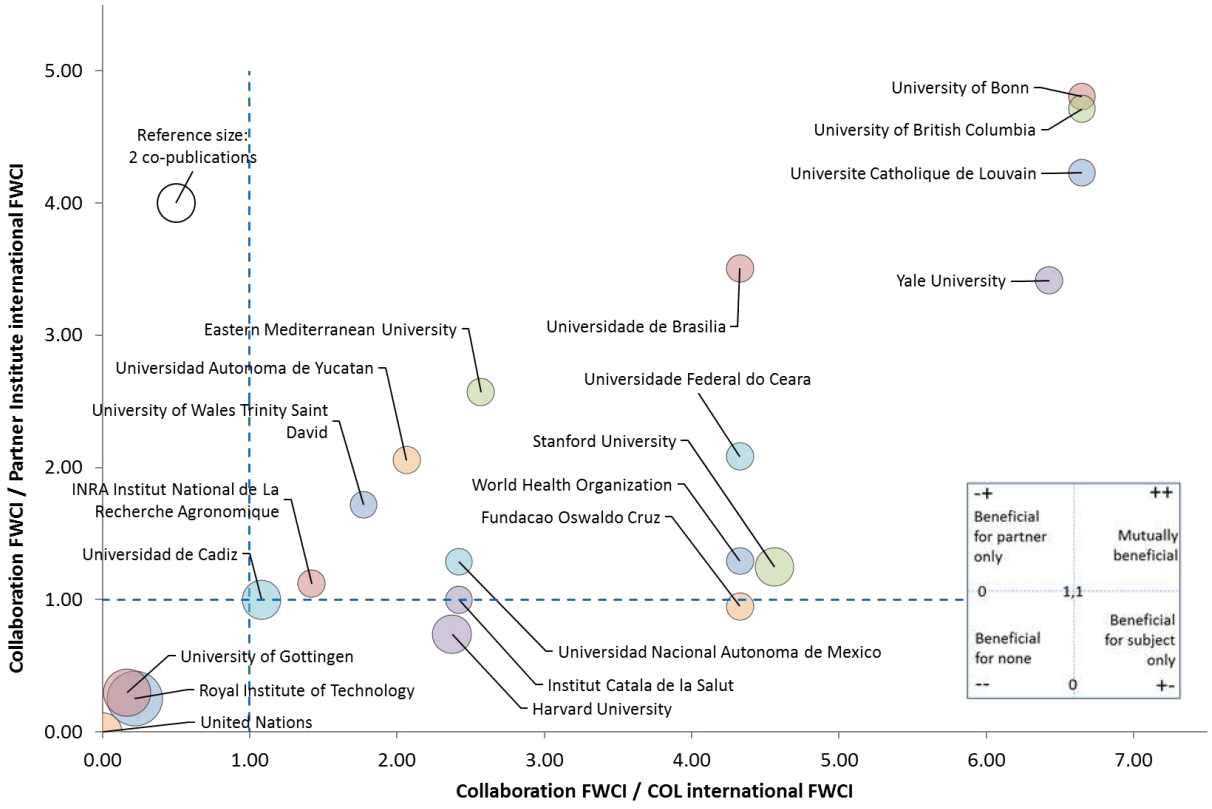


Figure 8.8— *Collaboration quadrant of Colombia's Top 20 collaborations in SDG8-related research with other institutions. Collaboration FWCI refers to the FWCI of all SDG8-related research co-authored by Colombia and the partner institute during the period 2007-2016. Bubble size corresponds to number of co-authored publications (reference bubble depicted at top left of chart). Impact of collaboration between partners can be interpreted based on quadrant position as described in legend on right. (Source: Scopus).*

8.6.3 **Collaboration chart**

Figure 8.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG8. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 8.9 shows where there may be potential to improve output and impact through partnership. Colombia publishes only 1-4 SDG8 publications with its top 20 partners. Among Colombia's top 20 partners, the United Nations and Harvard produce the highest number of SDG8 publications with 84 and 77 SDG8 publications, respectively. Harvard University, Stanford University and the World Health Organization have the highest FWCI for SDG8 research among Colombia's top 20 partners (at 4.57, 4.44, and 4.31 respectively). Colombia may want to leverage its existing relationships with these institutes to increase its publication output and impact in SDG8 research.

Figure 8.9— *Chart showing Colombia's top 20 collaborators on SDG8 from 2007-2016. Circle (node) size is proportional to the number of SDG8 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (4.57) and lightest shade of green indicating the lowest FWCI (0.80). (Source: Scopus).*

Chapter 9
Industry, Innovation and Infrastructure

In this Chapter, we assess research related to SDG9, which aims to build resilient infrastructure, promote sustainable industrialization, and foster innovation. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

9.1 Key Findings

Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation

WORLD RESEARCH OUTPUT

74,897

Number of SDG9 publications, 2007-2016.

SDG9 PATENTS

1,103

Number of SDG9 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

274

Colombia's SDG9 publications, 2007-2016.

COLOMBIA RESEARCH OUTPUT CAGR

22%

Compound annual growth rate for Colombia's 2007-2016 SDG9 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

28

Colombia's SDG9 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

1.01

Average field-weighted citation impact for Colombia's SDG9 publications, 2007-2016.

9.2 SDG9 – Build resilient infrastructure, promote sustainable industrialization and foster innovation

According to the United Nations,

> *"Investments in infrastructure – transport, irrigation, energy and information and communication technology – are crucial to achieving sustainable development and empowering communities in many countries. It has long been recognized that growth in productivity and incomes, and improvements in health and education outcomes require investment in infrastructure.*
> *Inclusive and sustainable industrial development is the primary source of income generation, allows for rapid and sustained increases in living standards for all people, and provides the technological solutions to environmentally sound industrialization.*
> *Technological progress is the foundation of efforts to achieve environmental objectives, such as increased resource and energy-efficiency. Without technology and innovation, industrialization will not happen, and without industrialization, development will not happen."*[14]

The targets for SDG9, according to the United Nations are:

- *"Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all.*
- *Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries.*
- *Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets.*
- *By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.*
- *Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending.*
- *Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States 18.*
- *Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities.*
- *Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020."*[14]

[14] http://www.un.org/sustainabledevelopment/infrastructure-industrialization/

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG9 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

9.3 SDG9: Leaders in the field

9.3.1 Top 5 countries conducting SDG1 research

The top 5 countries publishing on SDG 9 based on cumulative publication output from 2007-2016 is indicated by Table 9.1 and Figure 9.1. The United States ranks 1st in Publication Count, Percentage of Global Output, and Citation Count, followed by China, the United Kingdom, Germany, and Australia. The United Kingdom ranks 1st in FWCI with 1.69, which is higher than the world average. All other countries' FWCI exceed the average as well except for China.

Table 9.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	14,202	18.96%	182,798	1.52
China	9,751	13.02%	56,167	0.77
United Kingdom	6,238	8.33%	88,104	1.69
Germany	4,101	5.48%	49,736	1.57
Australia	3,963	5.29%	51,593	1.57
World	74,897	100.00%	273,408	1.13

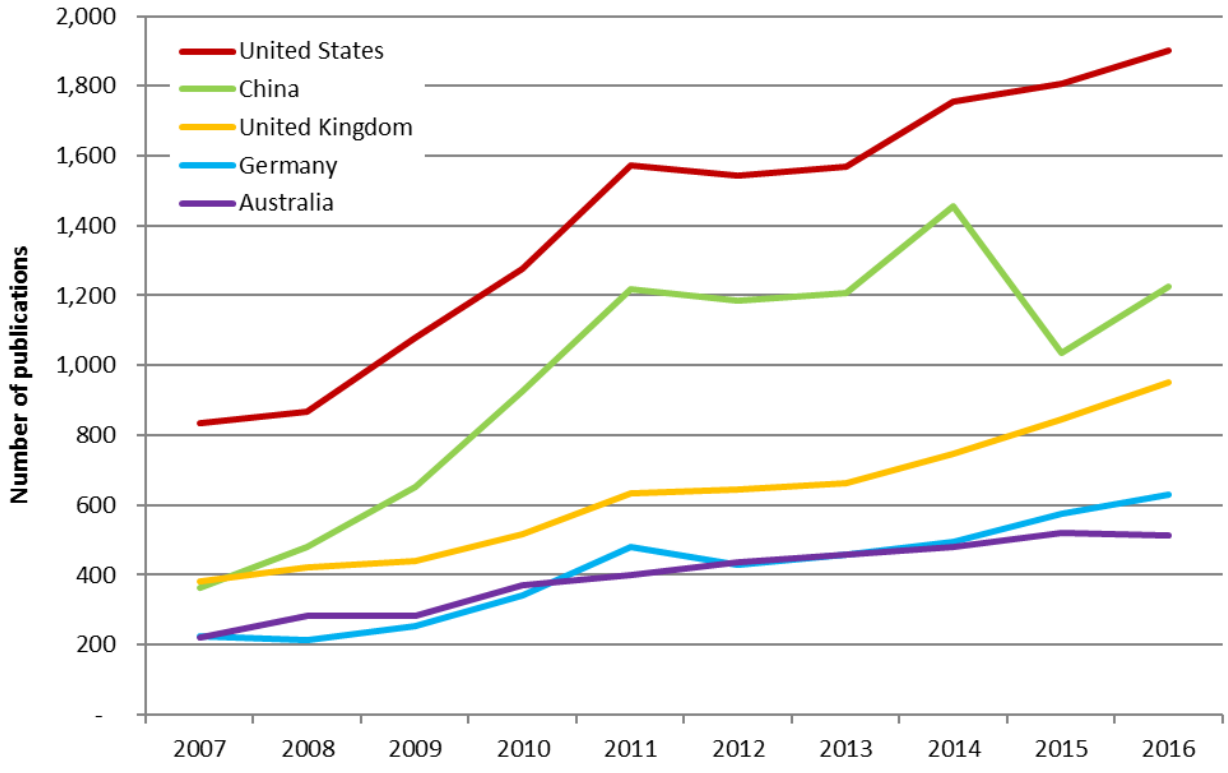


Figure 9.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG9 research. (Source: Scopus)*

9.3.2 Top 20 institutes conducting SDG9 research

A list of the top 20 research institutes publishing SDG9-related research is shown in Table 9.2. The Chinese Academy of Sciences ranks 1st according to Publication Count and Citation Count followed by Wageningen University & Research, and the CNRS. The University of California at Berkeley sits in 1st place in terms of FWCI with an FWCI of 2.81, much higher than the world average. Wageningen University & Research also has an FWCI nearly 2.5 times higher than the world average. All top 20 institutes except for Universidade de Sao Paulo have an FWCI above the global average. The trends in publication output from 2007-2016 are shown in Figure 9.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Chinese Academy of Sciences (China)	753	9,821	1.28
2	Wageningen University & Research (Netherlands)	502	12,588	2.48
3	CNRS (France)	397	6,257	2.06
4	Delft University of Technology (Netherlands)	387	5,876	1.74
5	Tsinghua University (China)	355	5,189	1.47
6	Universiti Teknologi Malaysia (Malaysia)	339	2,283	1.40
7	Arizona State University (United States)	324	4,705	1.97
8	University of Queensland (Australia)	322	6,320	1.90
9	Universidade de Sao Paulo (Brazil)	322	2,148	0.97
10	Politecnico di Milano (Italy)	315	2,828	2.01
11	CSIRO (Australia)	304	7,300	2.36
12	U.S. Department of Agriculture (United States)	297	5,308	1.65
13	Hong Kong Polytechnic University (Hong Kong)	296	5,106	2.13
14	Ministry of Education China (China)	287	4,033	1.07
15	ETH Zurich (Switzerland)	287	5,346	2.20
16	Royal Institute of Technology (Sweden)	275	2,464	1.58
17	CNR (Italy)	272	3,783	1.67
18	University of California at Berkeley (United States)	266	8,077	2.81
19	Georgia Institute of Technology (United States)	259	3,956	2.27
20	University of British Columbia (Canada)	258	5,599	1.97

Table 9.2— *Top 20 research Institutes ranked based on SDG9 publication output and FWCI from 2007-2016. (Source: Scopus)*

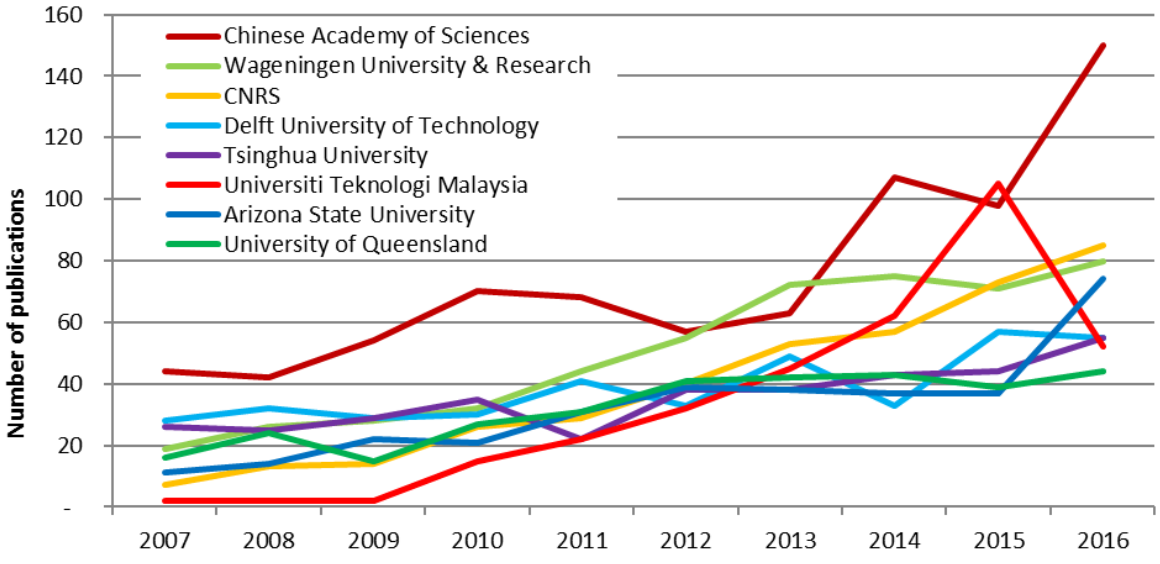


Figure 9.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG9. (Source: Scopus)*

9.3.3 Top 20 researchers conducting SDG9 research

A list of the top 20 researchers publishing in the SDG9 field based on publication output from 2007-2016 is shown in Table 9.3. Taisch M. ranks 1st in Publication Count followed by Haapala K. and Vinodh S.
Sarkis J., Yang Z., and Chen B. are the top 3 researchers based on h-index, with an h-index of 62, 50, and 46, respectively.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Taisch M.	Politecnico di Milano (Italy)	53	408	2.16	15
2	Haapala K.	Oregon State University (United States)	44	277	1.74	12
3	Vinodh S.	National Institute of Technology Tiruchirappalli (India)	44	439	1.34	22
4	Dornfeld D.	UC Berkeley (United States)	39	993	4.44	37
5	Sarkis J.	Worcester Polytechnic Institute (United States)	37	2,013	4.99	62
6	Zuo J.	Shenzhen University (China)	37	516	1.76	23
7	Geng Y.	Shanghai Jiaotong University (China)	36	859	2.53	41
8	Blevis E.	Indiana University (United States)	33	640	2.61	15
9	Germani M.	Universita Politecnica delle Marche (Italy)	33	111	1.41	12
10	Jardim-Gonçalves R.	Instituto de Desenvolvimento de Novas Tecnologias (Portugal)	32	212	2.17	17
11	Chen B.	Beijing Normal University (China)	31	721	2.24	46
12	Brent A.	Universiteit Stellenbosch (South Africa)	29	295	0.68	20
13	Govindan K.	Syddansk Universitet (Denmark)	28	829	7.18	37
14	Seliger G.	Technische Universitat Berlin (Germany)	28	891	5.48	21
15	El-Halwagi M.	Texas A and M University (United States)	28	338	1.75	40
16	Umeda Y.	University of Tokyo (Japan)	28	225	0.84	18
17	YANG Z.	Beijing Normal University (China)	27	534	1.70	50
18	Kara S.	University of New South Wales (UNSW) Australia (Australia)	26	1,036	5.84	27
19	Sutherland J.	Purdue University (United States)	26	1,288	5.12	31
20	Jawahir I.	University of Kentucky (United States)	26	715	5.11	33

Table 9.3— *Top 20 researchers publishing SDG9 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG9 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

9.3.4 **Top 10 journals publishing SDG9 research**

A list of the top 10 journals publishing SDG9-related research from 2007-2016 is shown in Table 9.4. *Advanced Materials Research* published the most SDG 9 publications (1386) followed by *Journal of Cleaner Production*, and *Sustainability*. All top 10 journals have published more than 300 publications. *Journal of Cleaner Production* ranks 1st according to FWCI followed by *Procedia Engineering* and *Renewable and Sustainable Energy Reviews* in the 2nd and 3rd place, respectively. As for CiteScore, *Renewable and Sustainable Energy Reviews* sits in the 1st place with 7.66 followed by *Journal of Cleaner Production* of 3.70.

Rank	Journal	Publication count	FWCI	CiteScore
1	Advanced Materials Research	1,386	0.48	0.17
2	Journal of Cleaner Production	1,189	3.04	3.70
3	Sustainability	721	1.05	0.92
4	Applied Mechanics and Materials	593	0.47	0.11
5	Lecture Notes in Computer Science	520	0.96	0.50
6	Renewable and Sustainable Energy Reviews	501	1.21	7.66
7	Proceedings of the 28th International Business Information Management Association Conference - Vision 2020: Innovation Management, Development Sustainability, and Competitive Economic Growth	439	0.26	0.00
8	Procedia Engineering	415	1.98	0.48
9	WIT Transactions on Ecology and the Environment	408	0.08	0.08
10	Proceedings of the 27th International Business Information Management Association Conference - Innovation Management and Education Excellence Vision 2020: From Regional Development Sustainability to Global Economic Growth, IBIMA 2016	397	0.70	0.00

Table 9.4— *Top 10 journals based on SDG9 publication output from 2007-2016. FWCI is mean FWCI for any SDG9 publications in the journal during the period; CiteScore is based on data for the journal as a whole. (Source: Scopus)*

9.4 Research efforts focused on SDG9

9.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 9.3, the United States leads in terms of research output related to SDG9. China follows with 4,000 fewer publications. Among comparators, Colombia has the lowest output in this field, just below Mexico. However, as shown in Table 9.5, Colombia has the highest Compound Annual Growth Rate (CAGR) of 22.00% in this field of research. Brazil, Mexico and China also see marked increases in publication output with a CAGR above 14%.

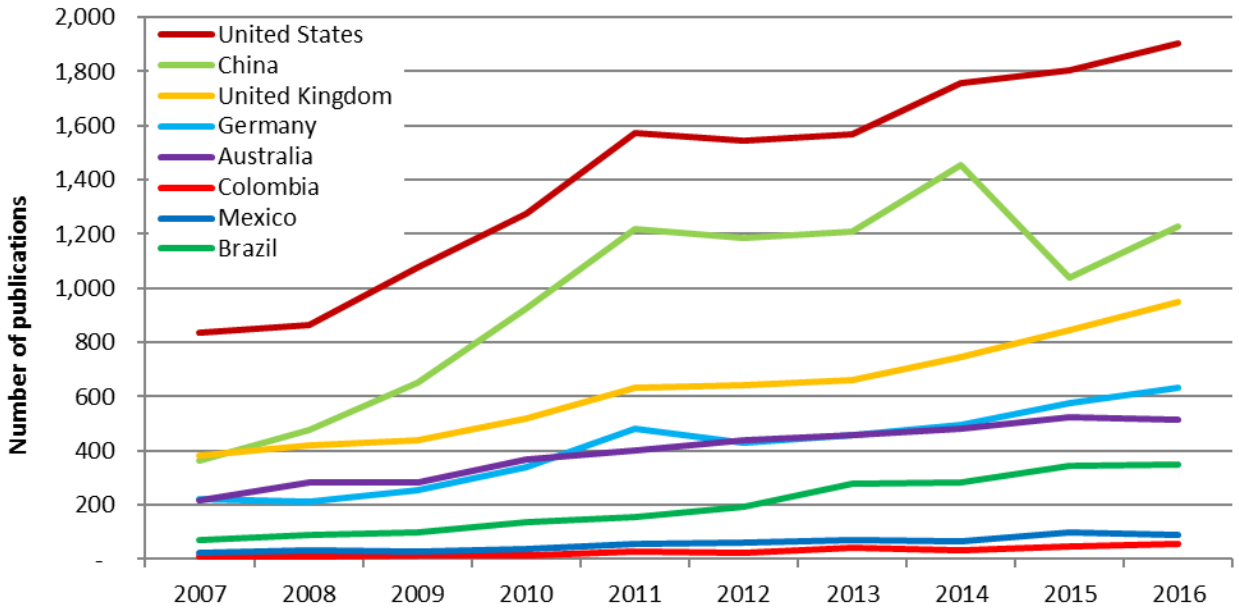


Figure 9.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	14,202	9.60%
China	9,751	14.50%
United Kingdom	6,238	10.70%
Germany	4,101	12.30%
Australia	3,963	9.90%
Colombia	274	22.00%
Mexico	564	16.50%
Brazil	1,998	19.70%
World	74,897	10.20%

Table 9.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

9.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG9 related research from 2006-2017 is 1.13.

Country	FWCI
United States	1.52
China	0.77
United Kingdom	1.69
Germany	1.57
Australia	1.57
Colombia	1.01
Mexico	1.16
Brazil	0.84
World	1.13

Comparing the FWCI of publications from each of the eight countries included in this chapter reveals the impact of research from each country (Table 9.6). Most notably, the United Kingdom achieves the highest FWCI among comparator countries. Germany, Australia, and the United States follow with an FWCI approximately 50% higher than the world average.

Table 9.6— *FWCI for SDG9 research from 2007-2016 per country and world. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

9.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 9.4 and Table 9.7, the United States leads in terms of publications that are among the top 10% most cited. The United Kingdom and China, then Germany and Australia follow in that order. Colombia had a very small number of publications among the top 10% most cited during this time period. According to Table 9.7, Brazil and China are the top 2 countries by CAGR at around 30%, while Colombia and Mexico have a CAGR for top 10% publications near 20%.

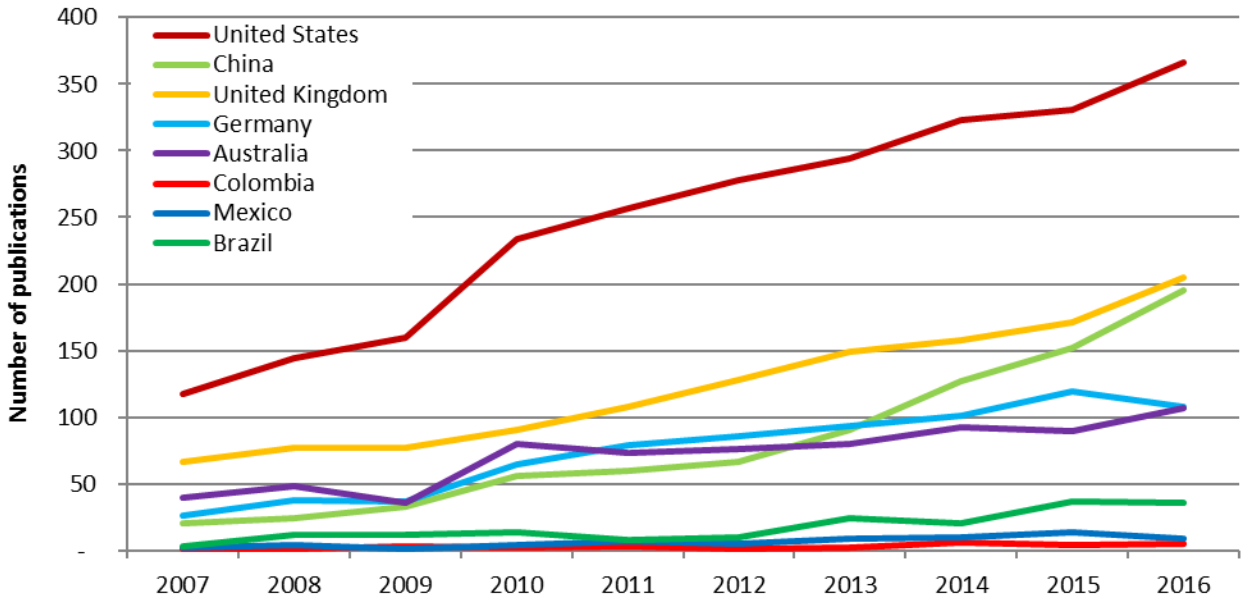


Figure 9.4— *Top 10% most cited publications on SDG9 from 2007-2016 per country. CAGR shown at top of each bar. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
United States	2,504	13.51%
China	825	28.79%
United Kingdom	1,231	13.23%
Germany	752	17.14%
Australia	722	11.55%
Colombia	28	19.58%
Mexico	65	18.19%
Brazil	176	31.80%
World	9,583	16.53%

Table 9.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG9 publications from 2007-2016. (Source: Scopus)*

9.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 9.8 provides the count of SDG9 publications from each country that have been cited in patents and the number of patents that have cited these publications. The findings show that patent citation count is related to publication count in that the leaders in publication output have the highest patent citation count. The United States leads with 136 publications cited in 486 patents. China, the United Kingdom, Germany, and Australia have comparable counts of patent cited publications. Colombia has 2 patent cited publications and 2 patents citing publications.

Country	Patent Cited Publications	Patents Citing Publications
United States	136	486
China	46	121
United Kingdom	35	76
Germany	34	68
Australia	23	42
Colombia	2	2
Mexico	2	16
Brazil	8	11
World	443	1,261

Table 9.8— *Number of publications cited in USPTO, WIPO, or EPO patents and number of USPTO, WIPO, or EPO patents citing publications on SDG9 from 2007 to 2016. (Source: Scopus and LexisNexis)*

9.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG9. To identify patents relevant to SDG9, we retrieved all the patents citing any SDG9-related publication. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO. From 2006 to 2016, the United States had 171 patent applications and 510 patents granted in this field, leading in this indicator. Germany follows with one seventh the number of patents. Colombia either has no grant and/or no patents granted in this field. Note that China and Australia may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	171	510	681	61.74%
China	17	5	22	1.99%
United Kingdom	22	21	43	3.90%
Germany	58	30	88	7.98%
Australia	9	8	17	1.54%
Colombia	-	-	-	0.00%
Mexico	1	1	2	0.18%
Brazil	2	-	2	0.18%
World	465	638	1,103	

Table 9.9— *Number of patents applied for and granted during the period 2006-2016. (Source: LexisNexis)*

9.4.6 **Research Focus**

Within the topic of SDG9-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG9-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG9 research is shown in Figure 9.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG9 research from Colombia, the term that stands out as unique to Colombia is 'Cement Industry', 'Scheduling', and 'Growth (Materials)'. Among the top 50 key phrases the terms 'Innovation', 'Environmental Management', 'Supply Chain Management', 'Construction Industry', 'Technology', 'Construction Industry', and 'Supply Chains' were common among the countries analyzed. The term 'Industrial Management' stand out as unique to the Latin American countries. Figure 9.5 provides a visualization of the top 50 key phrases for SDG9 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

Colombia

Mexico

Figure 9.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Brazil

United States

China

United Kingdom

Germany

Australia

9.5 The reach of Colombia's SDG9 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

9.5.1 Downloads

As shown in the Figure 9.6, the mean count of downloads per ScienceDirect publication fluctuates considerably from 2007-2011 and then converges to a similar trend for all countries. The fluctuations likely stem from the fact that most data points were based on less than 100 SD publications per year from 2007-2011. It should be noted that for Colombia and Mexico, the results shown are based on very small counts of SD articles and should be interpreted with caution.

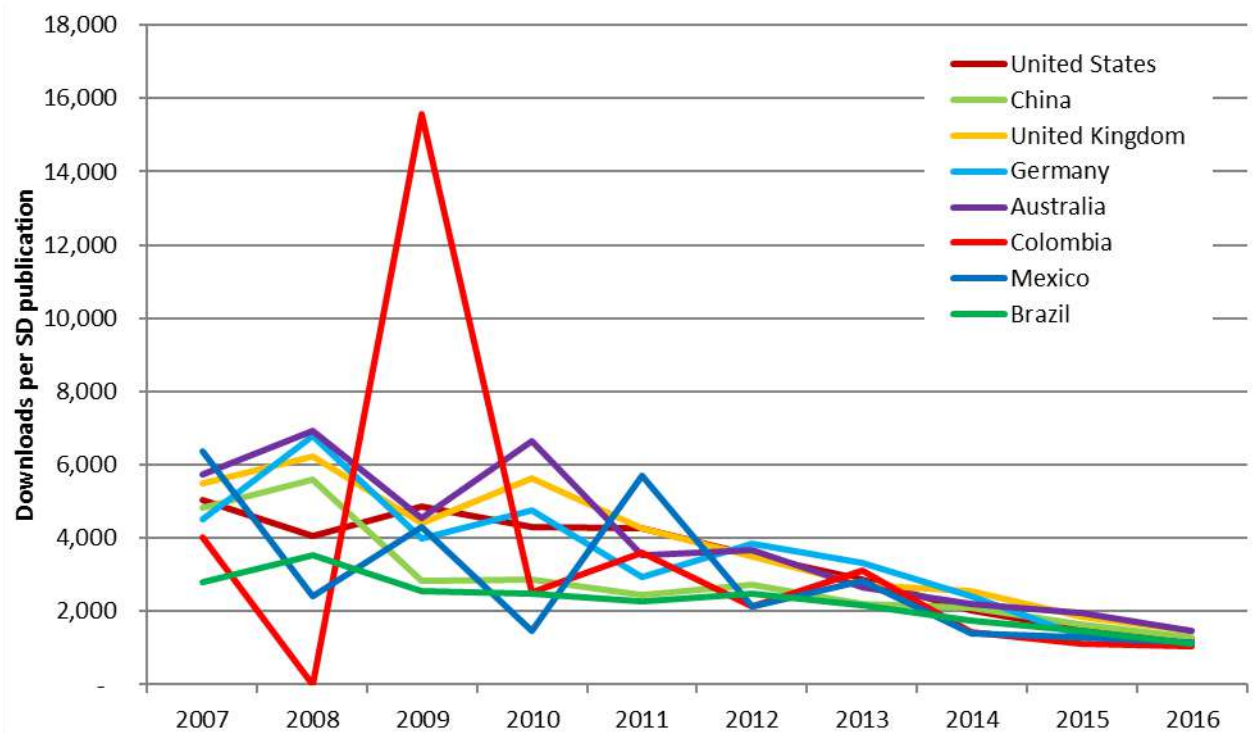


Figure 9.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

9.5.2 **Field Weighted Download Impact (FWDI)**

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. Interestingly, Australia has the highest mean FWDI for the period of 2007-2016 (Figure 9.7). However, given the very low count of SD publications from Colombia, and Mexico (i.e. less than 100 SD publications for the full period) interpretation of this metric should focus on the other countries only.

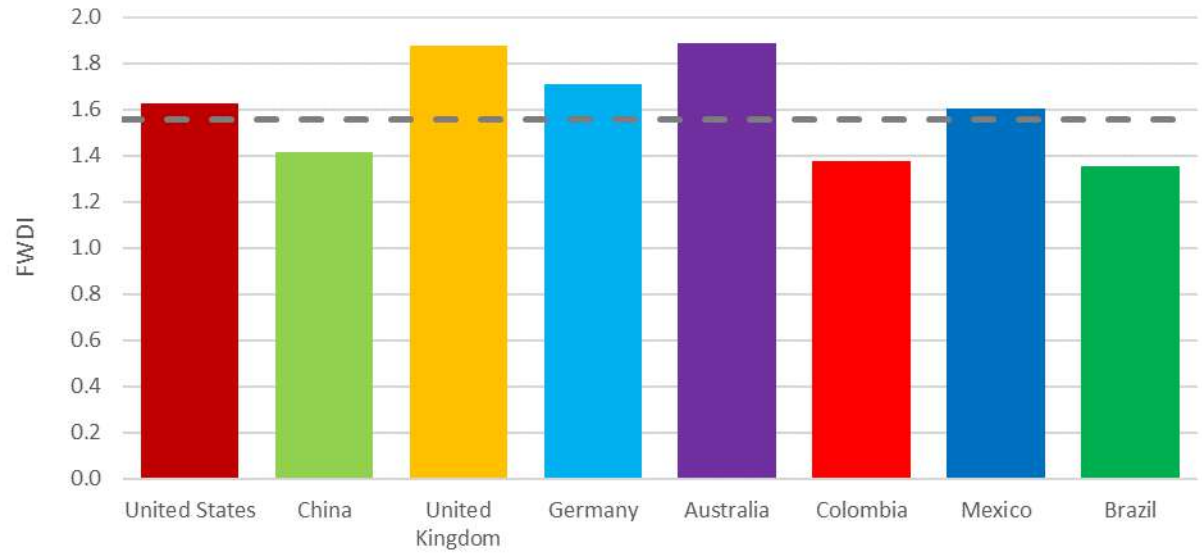


Figure 9.7— *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. (Source: ScienceDirect)*

9.6 SDG9 collaboration network

9.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG9-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 9.10-9.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG9 publications with. Among top partner institutes, Colombia published the most SDG9 papers in collaboration with Wageningen University & Research (5 publications from 2007-2016) with an FWCI more than 3 times higher than the overall average (Table 9.10). Universitat Autonoa de Barcelona and the University of Leeds also produce 5 collaborative publications with Colombia. Universitat Rovira i Virgili, the United Nations, and Universitat Politecnica de Catalunya each co-authored 4 collaborative publications with Colombia. The FWCI of those collaborative publications ranges, with 17 of the 20 top collaborations having an FWCI above the global average.

Country	Institution (Country)	Publication Count	FWCI
Colombia	Wageningen University & Research (Netherlands)	5	3.20
	Universitat Autonoma de Barcelona (Spain)	5	1.62
	University of Leeds (United Kingdom)	5	1.53
	Universitat Rovira i Virgili (Spain)	4	5.41
	United Nations (United States)	4	2.97
	Universitat Politecnica de Catalunya (Spain)	4	1.87
	Imperial College London (United Kingdom)	3	1.60
	Purdue University (United States)	3	1.21
	Royal Institute of Technology (Sweden)	3	0.99
	Instituto Tecnologico de Estudios Superiores de Monterrey (Mexico)	3	0.29
	Iowa State University (United States)	3	0.28
	International Food Policy Research Institute (United States)	2	6.83
	International Crops Research Institute for the Semi-Arid Tropics (India)	2	6.83
	World Bank (United States)	2	5.68
	University of Wisconsin (United States)	2	3.84
	Rhodes University (South Africa)	2	3.61
	Centro Internacional de la Papa (Peru)	2	3.41
	Texas A and M University (United States)	2	2.73
	Universidad Central de Las Villas (Cuba)	2	2.11
	IRTA - Institute of Agrifood Research and Technology (Spain)	2	2.07

Table 9.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	Texas A and M University (United States)	19	1.91
	Wageningen University & Research (Netherlands)	12	2.63
	King Abdulaziz University (Saudi Arabia)	12	1.52
	Universitat Politecnica de Catalunya (Spain)	12	0.40
	Griffith University Queensland (Australia)	11	3.21
	CNRS (France)	8	3.39
	INRA Institut National de La Recherche Agronomique (France)	8	3.30
	U.S. Department of Agriculture (United States)	8	1.08
	CSIC (Spain)	7	2.03
	Clark University (United States)	6	3.35
	University of California at San Diego (United States)	6	3.17
	University of Vermont (United States)	6	2.26
	University of California at Berkeley (United States)	6	1.24
	CSIRO (Australia)	5	4.21
	ETH Zurich (Switzerland)	5	2.33
	Arizona State University (United States)	5	2.15
	Technical University of Denmark (Denmark)	5	1.77
	New Mexico State University (United States)	5	0.81
	SUNY Albany (United States)	4	4.87
	University of California at Santa Barbara (United States)	4	3.58

Table 9.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	INRA Institut National de La Recherche Agronomique (France)	14	4.31
	CIRAD (France)	13	0.74
	University of Oxford (United Kingdom)	12	2.97
	University of Florida (United States)	12	1.52
	Wageningen University & Research (Netherlands)	11	2.27
	CNRS (France)	10	2.41
	CSIRO (Australia)	9	5.31
	U.S. Department of Agriculture (United States)	9	1.70
	Universidade do Porto (Portugal)	9	1.29
	Ericsson Sweden (Sweden)	8	1.36
	Woods Hole Oceanographic Institution (United States)	7	4.70
	Technische Universitat Berlin (Germany)	7	2.02
	Yale University (United States)	7	1.99
	University of British Columbia (Canada)	6	7.28
	Harvard University (United States)	6	5.42
	ETH Zurich (Switzerland)	6	5.04
	University of East Anglia (United Kingdom)	6	3.12
	IRD (France)	6	2.61
	Chalmers University of Technology (Sweden)	6	2.45
	Texas A and M University (United States)	6	2.09

Table 9.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	Chinese Academy of Sciences (China)	105	2.73
	Wageningen University & Research (Netherlands)	50	3.80
	University of British Columbia (Canada)	49	2.53
	ETH Zurich (Switzerland)	45	3.15
	University of Toronto (Canada)	45	1.69
	University of Cambridge (United Kingdom)	40	4.63
	University of Queensland (Australia)	40	3.51
	Tsinghua University (China)	39	2.73
	CNRS (France)	36	3.01
	CSIRO (Australia)	36	2.76
	McGill University (Canada)	34	3.06
	Universidade de Sao Paulo (Brazil)	32	2.41
	Zhejiang University (China)	32	1.59
	University of Oxford (United Kingdom)	31	2.97
	National University of Singapore (Singapore)	31	2.46
	Hong Kong Polytechnic University (Hong Kong)	30	4.27
	University of Waterloo (Canada)	29	3.77
	Beijing Normal University (China)	29	3.24
	Ministry of Education China (China)	28	1.17
	Imperial College London (United Kingdom)	27	3.76

+

Table 9.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
China	Hong Kong Polytechnic University (Hong Kong)	108	1.93
	City University of Hong Kong (Hong Kong)	56	1.42
	University of Hong Kong (Hong Kong)	41	1.67
	Georgia Institute of Technology (United States)	29	4.16
	National Institute for Environmental Studies of Japan (Japan)	29	3.58
	Nanyang Technological University (Singapore)	26	2.39
	University of South Australia (Australia)	26	1.70
	Wageningen University & Research (Netherlands)	25	1.59
	National University of Singapore (Singapore)	24	3.08
	University of Adelaide (Australia)	24	1.81
	Arizona State University (United States)	24	1.42
	University of Michigan (United States)	23	2.61
	CSIRO (Australia)	22	1.99
	University of Nebraska (United States)	21	3.26
	University of Nottingham (United Kingdom)	21	3.09
	Colorado State University (United States)	20	0.45
	Hong Kong University of Science and Technology (Hong Kong)	19	4.61
	University of Cambridge (United Kingdom)	17	2.29
	International Institute for Applied Systems Analysis, Laxenburg (Austria)	17	1.74
	Chinese University of Hong Kong (Hong Kong)	17	1.39

+

Table 9.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for China. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	Wageningen University & Research (Netherlands)	66	3.29
	CNRS (France)	40	4.44
	Delft University of Technology (Netherlands)	33	2.34
	University of Queensland (Australia)	29	3.42
	European Commission Joint Research Centre Institute (Belgium)	28	2.32
	Harvard University (United States)	27	7.19
	INRA Institut National de La Recherche Agronomique (France)	27	4.58
	University of British Columbia (Canada)	26	3.63
	CSIRO (Australia)	24	3.75
	Ghent University (Belgium)	24	3.09
	CSIC (Spain)	24	2.77
	University of Sydney (Australia)	24	2.51
	Technical University of Denmark (Denmark)	23	3.44
	ETH Zurich (Switzerland)	23	3.37
	CNR (Italy)	23	3.29
	University of Copenhagen (Denmark)	23	2.70
	Universite Paris Saclay (France)	22	5.13
	KU Leuven (Belgium)	22	3.05
	Politecnico di Milano (Italy)	22	2.93
	Chinese Academy of Sciences (China)	20	3.06

+

Table 9.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Germany	Wageningen University & Research (Netherlands)	57	3.03
	ETH Zurich (Switzerland)	53	3.11
	CNRS (France)	42	3.97
	CNR (Italy)	25	2.57
	European Commission Joint Research Centre Institute (Belgium)	25	2.24
	Delft University of Technology (Netherlands)	25	2.09
	Technical University of Denmark (Denmark)	24	5.36
	Politecnico di Milano (Italy)	22	2.71
	Royal Institute of Technology (Sweden)	22	2.30
	CEA (France)	22	2.26
	INRA Institut National de La Recherche Agronomique (France)	21	5.50
	Ghent University (Belgium)	21	3.25
	Universite Paris Saclay (France)	21	2.27
	Chinese Academy of Sciences (China)	20	2.66
	University of New South Wales (Australia)	19	7.81
	University of Manchester (United Kingdom)	19	3.13
	University of Copenhagen (Denmark)	18	5.25
	Lund University (Sweden)	18	4.49
	Utrecht University (Netherlands)	18	4.38
	Ecole Polytechnique Federale de Lausanne (EPFL) (Switzerland)	18	1.92

+

Table 9.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Germany. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Australia	Wageningen University & Research (Netherlands)	29	4.56
	Chinese Academy of Sciences (China)	24	2.82
	Hong Kong Polytechnic University (Hong Kong)	22	1.75
	National University of Singapore (Singapore)	21	3.96
	CNRS (France)	17	2.93
	University of Auckland (New Zealand)	17	2.51
	U.S. Department of Agriculture (United States)	16	3.66
	North China Electric Power University (China)	16	1.52
	University of Cambridge (United Kingdom)	14	4.46
	University of Hong Kong (Hong Kong)	14	3.41
	University College London (United Kingdom)	14	2.02
	Imperial College London (United Kingdom)	14	1.88
	ETH Zurich (Switzerland)	13	3.71
	University of Washington (United States)	13	3.65
	Chongqing University (China)	13	1.74
	Shandong University (China)	12	1.85
	Delft University of Technology (Netherlands)	12	1.38
	Universiti Tun Hussein Onn Malaysia (Malaysia)	12	0.66
	University of Oxford (United Kingdom)	11	4.39
	Instituto Tecnologico de Estudios Superiores de Monterrey (Mexico)	11	3.21

Table 9.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Australia. (Source: Scopus)*

9.6.2 **Collaboration impact analysis**

To visualize the citation impact of collaborations, the ratio of FWCI from SDG9 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG9 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG9 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. As shown in Figure 9.8, the World Bank sits at the far upper top right indicating that they've developed a mutually beneficial collaboration with Colombia. Other institutes, such as the International Food Policy Research Institute, are also in the same quadrant and therefore result in mutually beneficial collaborations in terms of citation impact. Imperial College London sits in the bottom right quadrant, meaning that the collaboration yields a citation advantage to Colombia but not to the partner. Iowa State University and Purdue University are both in the bottom left quadrant indicating that these collaborations do not yield any citation advantage to Colombia or either partner.

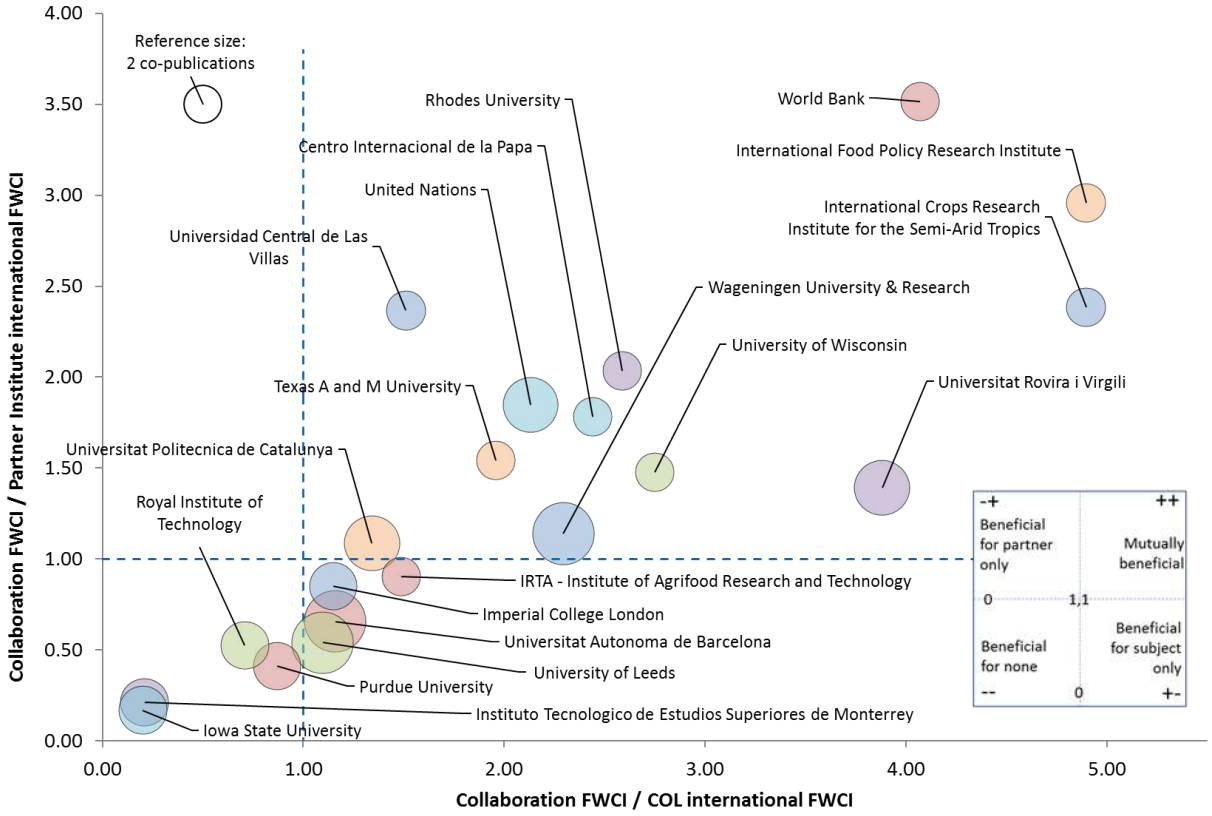


Figure 9.8— *Collaboration quadrant of Colombia's Top 20 collaborations in SDG9-related research with other institutions. Collaboration FWCI refers to the FWCI of all SDG9-related research co-authored by Colombia and the partner institute during the period 2007-2016. Bubble size corresponds to number of co-authored publications (reference bubble depicted at top left of chart). Impact of collaboration between partners can be interpreted based on quadrant position as described in legend on right. (Source: Scopus).*

9.6.3 **Collaboration chart**

Figure 9.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG9. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 9.9 shows where there may be potential to improve output and impact through partnership. Currently, Colombia produces the most co-authored papers with Wageningen University & Research, which produces the highest number of publications (among Colombia's top 20 partners) with 502 SDG9 publications. Royal Institute of Technology is the second most prolific among Colombia's top 20 foreign partner institutes, with 275 publications, 3 of which are co-authored with Colombia. Among Colombia's top 20 partners, Universitat Rovira i Virgili has the highest FWCI for SDG9 research. Colombia may want to leverage its existing relationships with these institutes to increase its publication output and impact in SDG9 research.

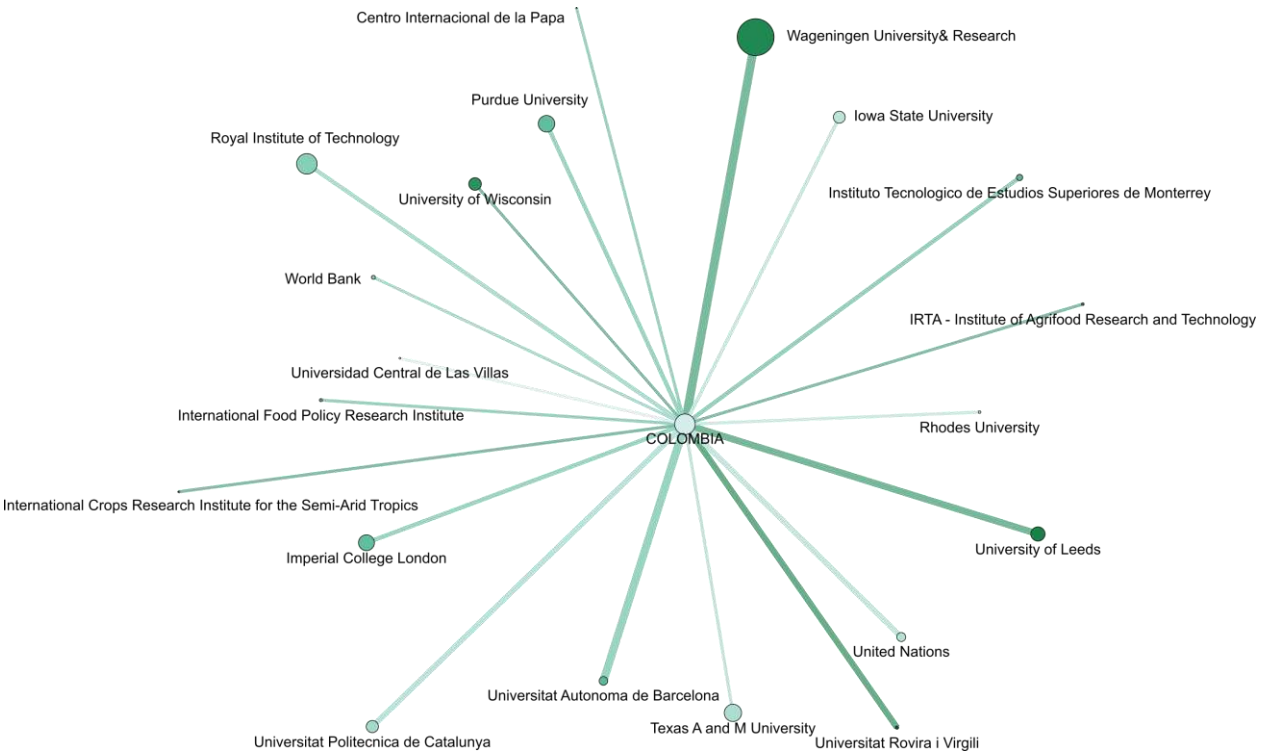


Figure 9.9— *Chart showing Colombia's top 20 collaborators on SDG9 from 2007-2016. Circle (node) size is proportional to the number of SDG9 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (2.79) and lightest shade of green indicating the lowest FWCI (0.85). (Source: Scopus).*

Chapter 10
Reduced Inequalities

In this Chapter, we assess research related to SDG10, which aims to reduce inequality within and among countries. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

10.1 **Key Findings**

Goal 10: Reduce inequality within and among countries

WORLD RESEARCH OUTPUT

9,860

Number of SDG10 publications, 2007-2016.

SDG10 PATENTS

113

Number of SDG10 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

55

Colombia's SDG10 publications, 2007-2016.

WORLD RESEARCH OUTPUT CAGR

12%

Compound annual growth rate for all 2007-2016 SDG10 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

8

Colombia's SDG10 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

1.23

Average field-weighted citation impact for Colombia's SDG10 publications, 2007-2016.

10.2 SDG10 – Reduce inequality within and among countries

According to the United Nations,

> *"The international community has made significant strides towards lifting people out of poverty. The most vulnerable nations – the least developed countries, the landlocked developing countries and the small island developing states – continue to make inroads into poverty reduction. However, inequality still persists and large disparities remain in access to health and education services and other assets.*
> *Additionally, while income inequality between countries may have been reduced, inequality within countries has risen. There is growing consensus that economic growth is not sufficient to reduce poverty if it is not inclusive and if it does not involve the three dimensions of sustainable development – economic, social and environmental.*
> *To reduce inequality, policies should be universal in principle paying attention to the needs of disadvantaged and marginalized populations."*[15]

The targets for SDG10, according to the United Nations are:

- *"By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average.*
- *By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status.*
- *Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard.*
- *Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality.*
- *Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations.*
- *Ensure enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions in order to deliver more effective, credible, accountable and legitimate institutions.*
- *Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies.*
- *Implement the principle of special and differential treatment for developing countries, in particular least developed countries, in accordance with World Trade Organization agreements.*
- *Encourage official development assistance and financial flows, including foreign direct investment, to States where the need is greatest, in particular least developed countries, African countries, small island developing States and landlocked developing countries, in accordance with their national plans and programmes.*
- *By 2030, reduce to less than 3 per cent the transaction costs of migrant remittances and eliminate remittance corridors with costs higher than 5 per cent."*[15]

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG10 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

[15] http://www.un.org/sustainabledevelopment/inequality/

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

10.3 SDG10: Leaders in the field

10.3.1 Top 5 countries conducting SDG10 research

The top 5 countries publishing on SDG 10 based on cumulative publication output from 2007-2016 is indicated by Table 10.1 and Figure 10.1. The United States ranks 1st in Publication Count, Percentage of Global Output, and Citation Count. China and the United Kingdom follow with approximately 800 fewer publications than the United States. The United Kingdom ranks 1st according to FWCI with an FWCI of 1.85, which is much higher than the world average. All other countries' FWCI exceed the world average as well.

Table 10.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	1,917	19.44%	30,060	1.63
China	1,117	11.33%	10,448	1.15
United Kingdom	1,069	10.84%	20,973	1.85
Australia	562	5.70%	12,212	1.75
Canada	455	4.61%	7,774	1.80
World	9,860	100.00%	40,660	1.13

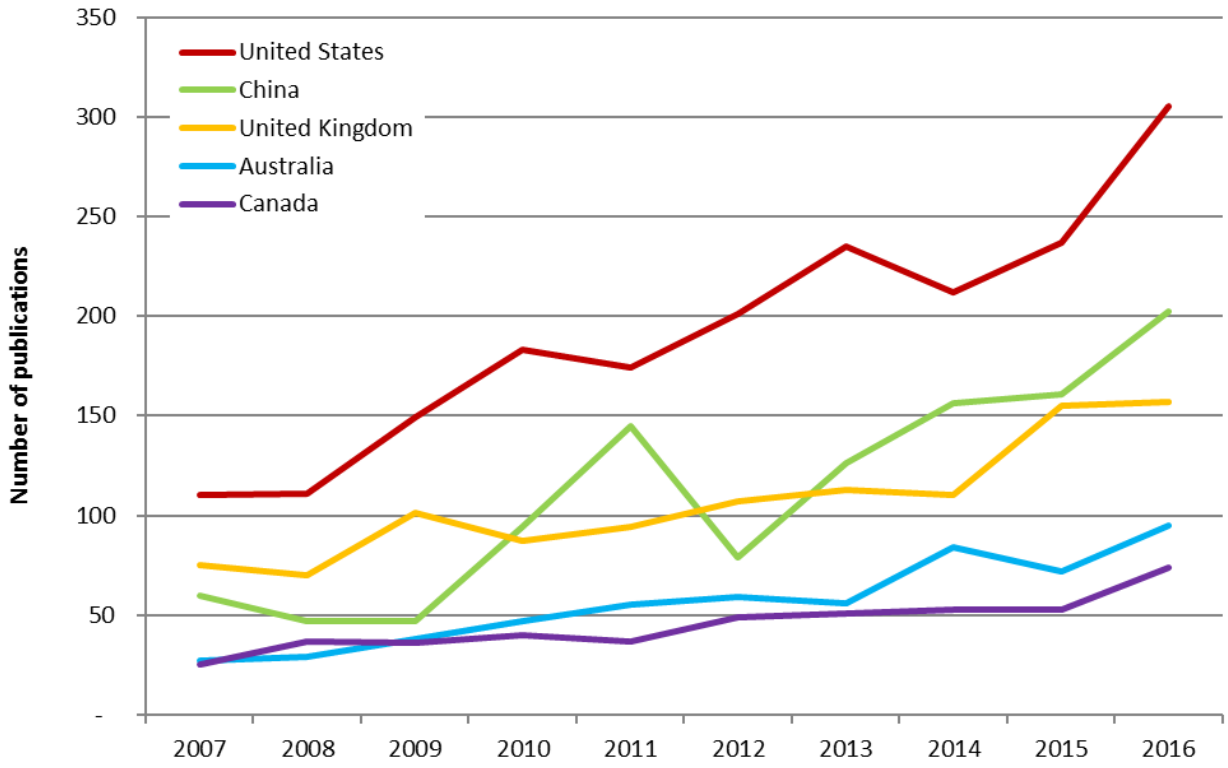


Figure 10.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG10 research. (Source: Scopus)*

10.3.2 Top 20 institutes conducting SDG10 research

A list of the top 20 research institutes publishing SDG10-related research is shown in Table 10.2. The Chinese Academy of Sciences ranks 1st in Publication Count followed by Wageningen University & Research, and the CNRS. The University of Oxford sits in 1st place according to Citation Count with 2,494 citations and 1st according to FWCI with an FWCI of 3.49. University College London also has a high FWCI that is more than 2.5 times higher than the average. The FWCI of all top 20 institutes is above the global average for SDG10 research. The trends in publication output from 2007-2016 are shown in Figure 10.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Chinese Academy of Sciences (China)	192	2,169	1.22
2	Wageningen University & Research (Netherlands)	82	1,507	2.58
3	CNRS (France)	72	1,484	1.71
4	University of British Columbia (Canada)	66	1,326	2.31
5	U.S. Department of Agriculture (United States)	59	1,601	1.96
6	Universidade de Sao Paulo (Brazil)	59	869	1.82
7	University College London (United Kingdom)	56	2,651	4.57
8	University of Toronto (Canada)	54	1,243	2.34
9	INRA Institut National de La Recherche Agronomique (France)	53	1,238	1.89
10	University of Oxford (United Kingdom)	50	3,494	4.92
11	University of Queensland (Australia)	48	571	1.52
12	Tsinghua University (China)	48	650	1.69
13	World Health Organization (Switzerland)	48	800	3.15
14	CSIC (Spain)	46	865	1.64
15	Zhejiang University (China)	45	627	1.64
16	University of Melbourne (Australia)	44	1,543	2.66
17	London School of Economics (United Kingdom)	44	597	1.67
18	University of Cambridge (United Kingdom)	44	762	2.27
19	University of Leeds (United Kingdom)	44	512	1.60
20	University of Sydney (Australia)	43	1,129	3.44

Table 10.2— *Top 20 research Institutes ranked based on SDG10 publication output and FWCI from 2007-2016. (Source: Scopus)*

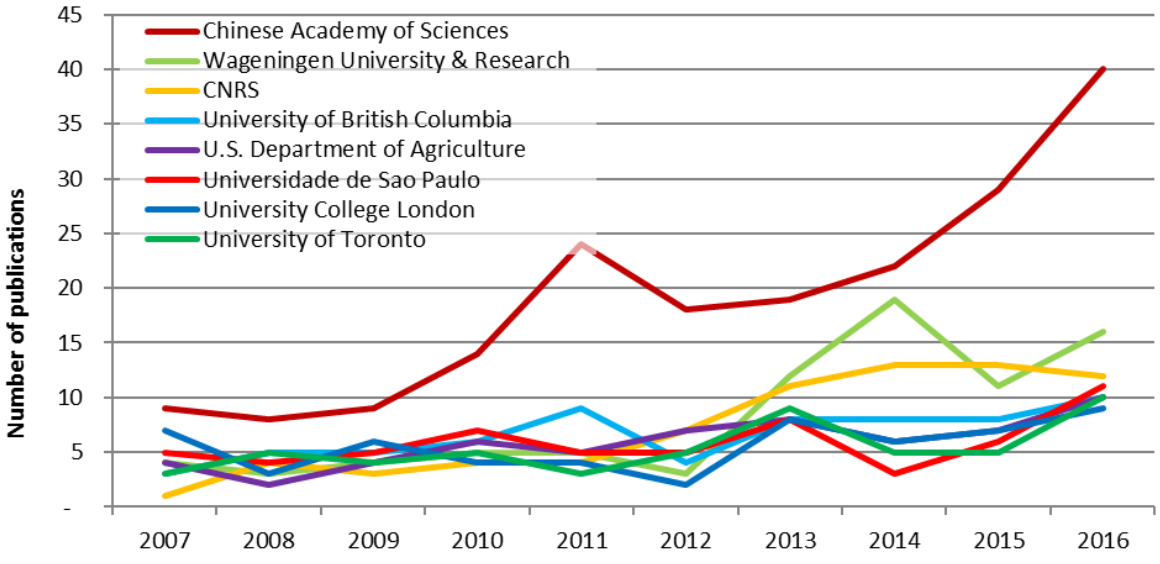


Figure 10.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG10. (Source: Scopus)*

10.3.3 Top 20 researchers conducting SDG10 research

A list of the top 20 researchers publishing in the SDG10 field based on publication output from 2007-2016 is shown in Table 10.3. Geng Y. ranks 1st in Publication Count followed by Hanlon P. and Salvati L
Bhutta Z., Zhang F., and Oenema O. are the top 3 researchers in terms of h-index, with an h-index of of 87, 72, and 49, respectively.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Geng Y.	Shanghai Jiaotong University (China)	9	143	1.93	41
2	Hanlon P.	University of Glasgow (United Kingdom)	9	114	1.00	18
3	Salvati L.	Council for Agricultural Research and Economics (CREA) (Italy)	8	57	1.37	27
4	Zhang F.	China Agricultural University (China)	7	179	1.79	72
5	Huang B.	Chinese Academy of Sciences (China)	7	138	1.47	17
6	Mihelcic J.	University of South Florida Tampa (United States)	7	210	1.15	26
7	Liu L.	University of Central Missouri (United States)	7	86	1.15	8
8	Friel S.	Australian National University (Australia)	6	1,008	8.70	32
9	Shahbaz M.	COMSATS Institute of Information Technology Lahore (Pakistan)	6	114	4.92	27
10	Jorgenson A.	Boston College (United States)	6	136	3.33	26
11	van Ittersum M.	Wageningen University and Research Centre (Netherlands)	6	210	3.20	35
12	Devereux S.	Institute of Development Studies (IDS), University of Sussex (United Kingdom)	6	50	2.49	16
13	Dasgupta P.	University of Cambridge (United Kingdom)	6	111	2.45	31
14	Oenema O.	Wageningen University and Research Centre (Netherlands)	6	50	2.30	49
15	Zuo J.	Shenzhen University (China)	6	73	1.73	23
16	Duro J.	Universitat Rovira i Virgili (Spain)	6	55	1.30	11
17	Pokrovskaia N.	Saint Petersburg State University (Russian Federation)	6	2	1.07	1
18	Xue B.	Shenyang Institute of Applied Ecology Chinese Academy of Sciences (China)	6	34	0.65	17
19	Štreimikiene D.	Lithuanian Energy Institute (Lithuania)	6	46	0.33	17
20	Bhutta Z.	Hospital for Sick Children University of Toronto (Canada)	5	148	10.35	87

Table 10.3— *Top 20 researchers publishing SDG10 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG10 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. Source: Scopus)*

10.3.4 **Top 10 journals publishing SDG10 research**

A list of the top 10 journals publishing SDG10-related research from 2007-2016 is shown in Table 10.4. *Sustainability* published the most SDG 10 publications (123) followed by *Renewable and Sustainable Energy Reviews, Journal of Cleaner Production,* and other journals with more than thirty publications. All top 10 journals have more than 30 publications in the field. *Journal of Cleaner Production* ranks 1st in FWCI followed by *Ecological Economics* and *Land Use Policy* in the 2nd and 3rd place, respectively. As for CiteScore, *Renewable and Sustainable Energy Reviews* sits in the 1st place with a CiteScore of 7.66 followed by *PLoS ONE* with a CiteScore of4.29 and *Journal of Cleaner Production* with a CiteScore of 3.70.

Rank	Journal	Publication count	FWCI	CiteScore
1	Sustainability	123	1.00	0.92
2	Renewable and Sustainable Energy Reviews	95	0.99	7.66
3	Journal of Cleaner Production	87	2.80	3.70
4	Acta Ecologica Sinica	76	0.18	0.55
5	Energy Policy	74	1.43	3.52
6	PLoS ONE	68	1.34	4.29
7	Ecological Economics	65	2.66	3.42
8	WIT Transactions on Ecology and the Environment	57	0.06	0.08
9	Mediterranean Journal of Social Sciences	45	0.42	0.00
10	Land Use Policy	39	1.62	2.89

Table 10.4— *Top 10 journals based on SDG10 publication output from 2007-2016. FWCI is mean FWCI for any SDG10 publications in the journal during the period; CiteScore is based on data for the journal as a whole. (Source: Scopus)*

10.4 Research efforts focused on SDG10

10.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 10.3, the United States is by far the leader in terms of research output related to SDG10. China follows, along with the United Kingdom, then Australia, Canada, and Brazil. Among comparators, Colombia has the lowest output in this field, just below Mexico. As shown in Table 10.5, Australia, China and Brazil rank among the top 3 in publication output growth with a CAGR above 13%.

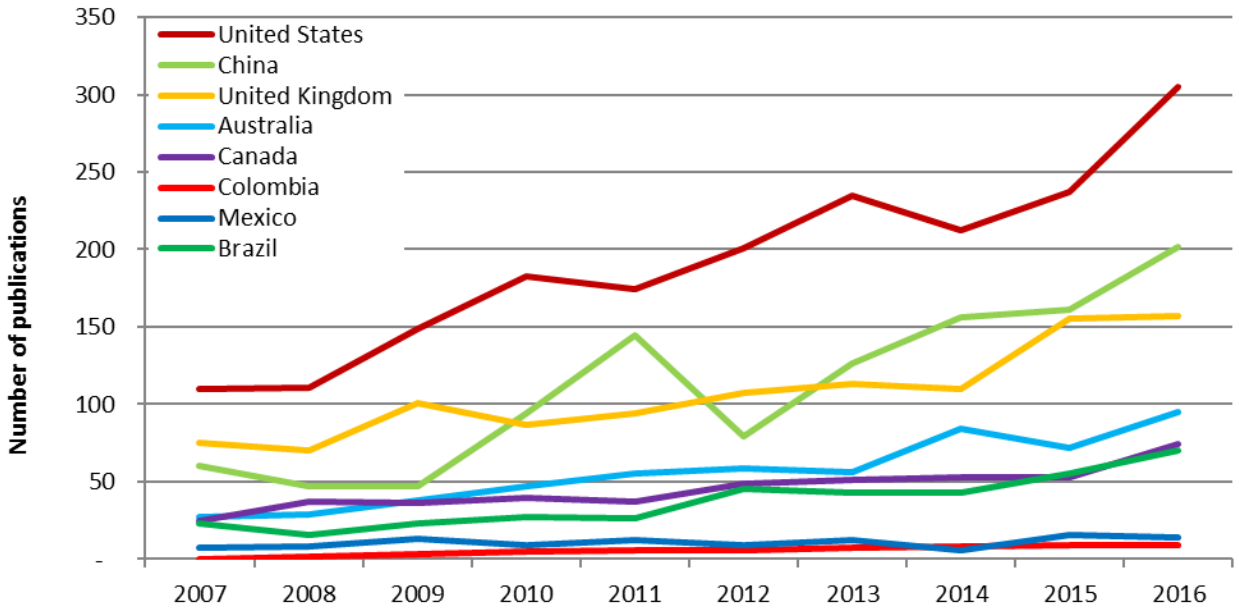


Figure 10.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	1,917	12.00%
China	1,117	14.40%
United Kingdom	1,069	8.60%
Australia	562	15.00%
Canada	455	12.80%
Colombia	55	-
Mexico	106	8.00%
Brazil	371	13.20%
World	9,860	12.40%

Table 10.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

10.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG10 related research from 2006-2017 is 1.13.

Country	FWCI
United States	1.63
China	1.15
United Kingdom	1.85
Australia	1.75
Canada	1.80
Colombia	1.23
Mexico	1.55
Brazil	1.02
World	1.13

Comparing the FWCI of publications from each of the eight countries included in this chapter reveals the impact of SDG10 research from each country (Table 10.6). Most notably, the United Kingdom achieves the highest FWCI among comparator countries, closely followed by Canada and Australia with an FWCI 80% higher than the world average.

Table 10.6— *FWCI for SDG10 research from 2007-2016 per country and world. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

10.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 10.4 and Table 10.7, the United States leads in terms of publications that are among the top 10% most cited. The United Kingdom and China, then Australia and Canada follow in that order. Colombia has a very small number of publications among the top 10% most cited during this time period. According to Table 10.7, China is the top country in terms of growth, with a CAGR approaching 40%. Canada and the United States also have high growth of 13% or more annually.

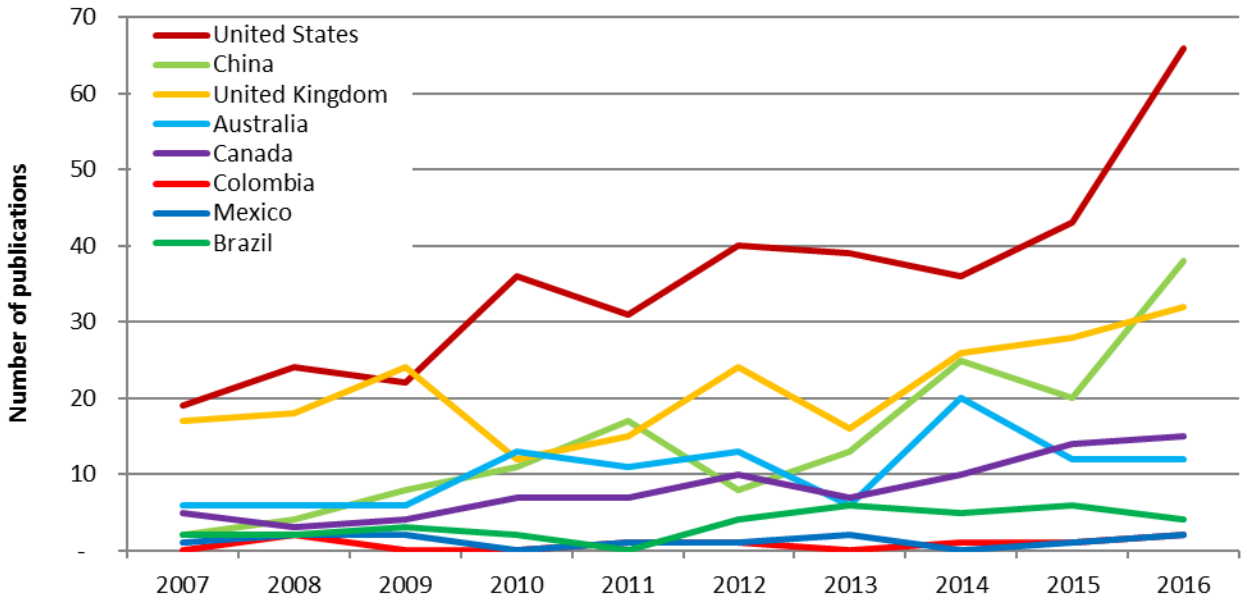


Figure 10.4— *Top 10% most cited publications on SDG10 from 2007-2016 per country. CAGR shown at top of each bar. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
United States	356	14.84%
China	146	38.70%
United Kingdom	212	7.28%
Australia	105	8.01%
Canada	82	12.98%
Colombia	8	-
Mexico	12	8.01%
Brazil	34	8.01%
World	1,177	12.85%

Table 10.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG10 publications from 2007-2016. (Source: Scopus)*

10.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 10.8 provides the count of SDG10 publications from each country that have been cited in patents and the number of patents that have cited these publications. The findings show that patent citation count is related to publication count in that the leaders in publication output have the highest patent citation count. The United States leads with 21 patent cited publications and 67 patent citing publications followed by Mexico, the United Kingdom, China, Australia, and Canada. Colombia and Mexico have no patent citations.

Country	Patent Cited Publications	Patents Citing Publications
United States	21	67
China	4	6
United Kingdom	7	13
Australia	4	6
Canada	1	1
Colombia	-	-
Mexico	3	20
Brazil	-	-
World	46	119

Table 10.8— *Number of publications cited in USPTO, WIPO, or EPO patents and number of USPTO, WIPO, or EPO patents citing publications on SDG10 from 2007 to 2016. (Source: Scopus and LexisNexis)*

10.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG10. To identify patents relevant to SDG10, we retrieved all the patents citing any SDG10-related publication. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO. From 2006 to 2016, the United States has 14 patent applications and 55 patents granted in this field. Australia, the United Kingdom, China and Canada each had 1-4 patents during the period. Colombia and other countries either have no grant and/or no patents granted in this field. Note that China and Australia may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	14	55	69	61.06%
China	1	-	1	0.88%
United Kingdom	1	1	2	1.77%
Australia	2	2	4	3.54%
Canada	1	-	1	0.88%
Colombia	-	-	-	0.00%
Mexico	-	-	-	0.00%
Brazil	-	-	-	0.00%
World	39	74	113	

Table 10.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

10.4.6 **Research Focus**

Within the topic of SDG10-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG10-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG10 research is shown in Figure 10.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG10 research from Colombia, terms that stand out as unique to Colombia are 'Design', 'Growth (Materials)', 'Product Design', 'Personnel', 'Accreditation', 'Carbon Dioxide', 'Carbon Monoxide', 'Coal Dust' and 'Mine Dust'. Among the top 50 key phrases the terms 'Developing Countries' and 'Alternative Agriculture' were common among the countries analyzed. Figure 10.5 provides a visualization of the top 50 key phrases for SDG10 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

Colombia

Figure 10.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Mexico

Brazil

United States

United Kingdom

China

Australia

Canada

10.5 The reach of Colombia's SDG10 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

10.5.1 Downloads

As shown in the Figure 10.6, the mean count of downloads per ScienceDirect publication is similar across all countries with some fluctuations shared among countries (for example, as seen from 2012-2014). It should be noted that all the data points were based on less than 100 SD publications per year. Therefore, the results shown should be interpreted with caution.

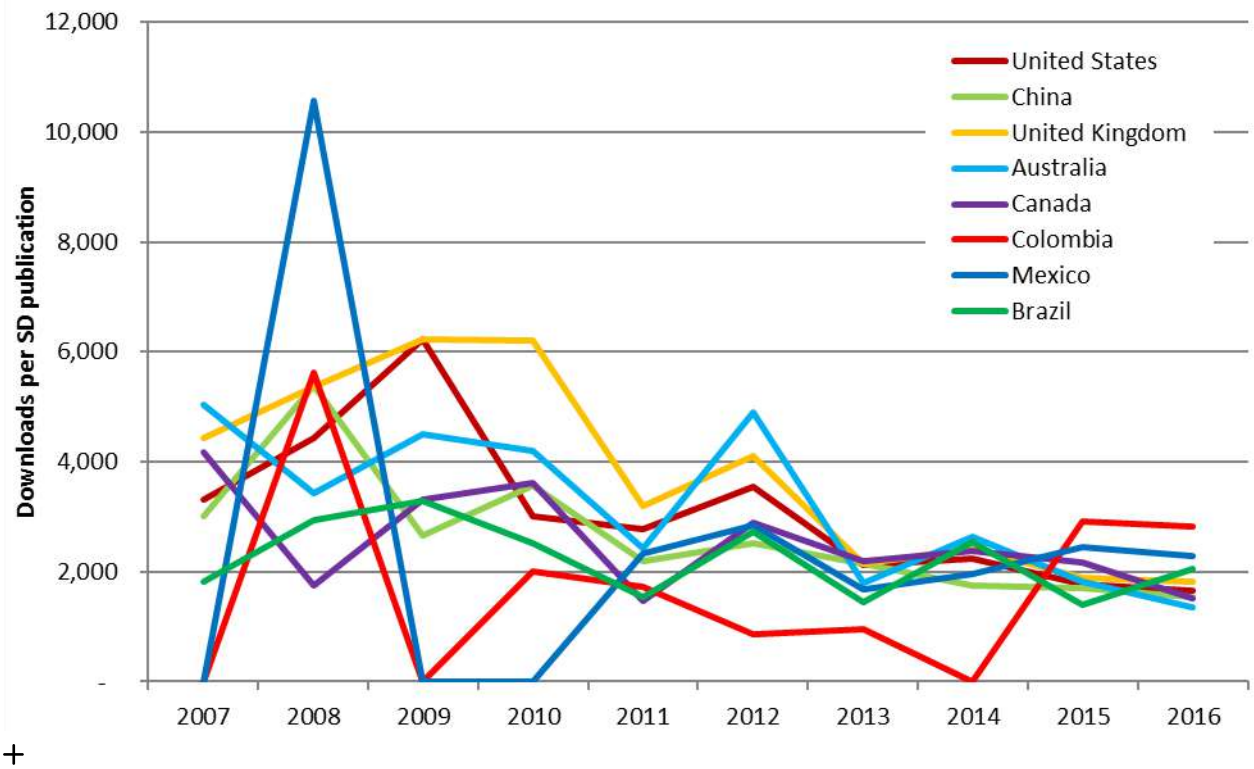


Figure 10.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

10.5.2 **Field Weighted Download Impact (FWDI)**

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. The world average FWDI for SDG10 research is 1.42 (Figure 10.7). However, given the very low count of SD publications from Colombia, Mexico, and Brazil (i.e. less than 100 SD publications for the full period) interpretation of this metric should focus on the other countries only. All top 5 countries have an FWDI above the average for all SDG10 research.

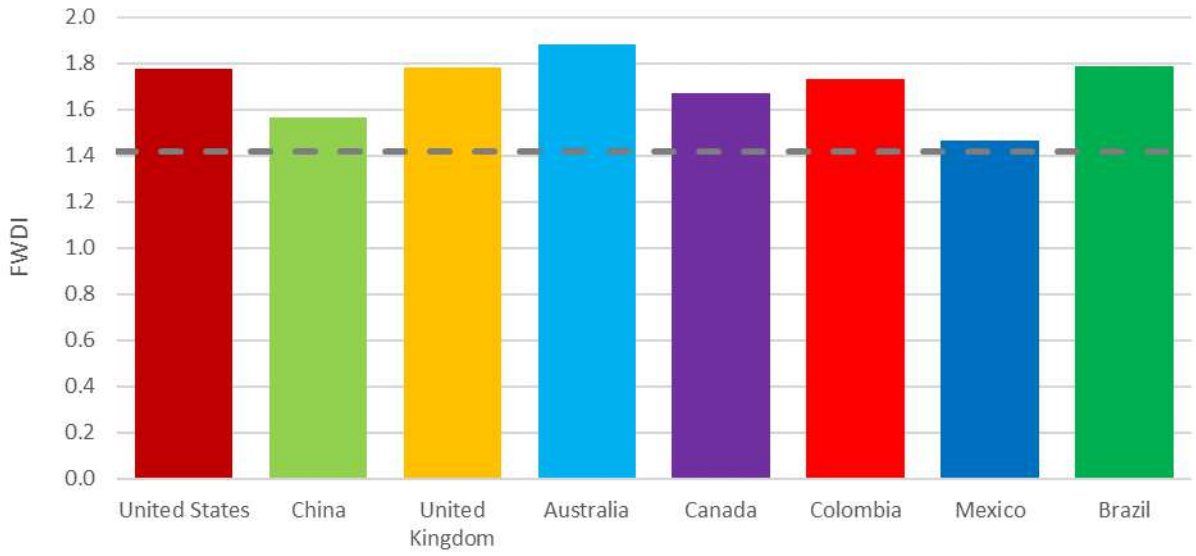


Figure 10.7 — *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. (Source: ScienceDirect)*

10.6 SDG10 collaboration network

10.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG10-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 10.10-10.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG10 publications with. Among academic partner institutes, Colombia has published the most SDG10 papers in collaboration with Wageningen University & Research (3 publications from 2007-2016) with an FWCI nearly 9 times higher than the world average (Table 10.10). Aarhus University, the University of Cape Town, and the Royal Institute of Technology each have 3 collaborative publications with Colombia. Other top 20 institutes each produce 2 publications with Colombia. The FWCI of those collaborative publications ranges from 13.48 to 4.16, except for those with the Royal Institute of Technology whose FWCI is lower than the global average.

Country	Institution (Country)	Publication Count	FWCI
Colombia	Wageningen University & Research (Netherlands)	3	8.86
	Aarhus University (Denmark)	3	7.51
	University of Cape Town (South Africa)	3	7.29
	Royal Institute of Technology (Sweden)	3	0.21
	World Health Organization (Switzerland)	2	13.48
	Universidade de Brasilia (Brazil)	2	13.48
	Harvard University (United States)	2	13.48
	Universidade de Sao Paulo (Brazil)	2	11.02
	Washington University St. Louis (United States)	2	10.65
	Karolinska Institutet (Sweden)	2	10.47
	Erasmus University Rotterdam (Netherlands)	2	10.47
	University of Coimbra (Portugal)	2	10.47
	University College London (United Kingdom)	2	10.47
	Dartmouth College (United States)	2	10.44
	Chinese Academy of Medical Sciences (China)	2	10.32
	National Health Service (United Kingdom)	2	10.32
	Mansoura University (Egypt)	2	10.32
	Ludwig-Maximilians-University Munchen (Germany)	2	10.32
	Imperial College London (United Kingdom)	2	10.32
	Cornell University (United States)	2	4.16

Table 10.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	World Health Organization (Switzerland)	4	14.34
	U.S. Department of Agriculture (United States)	3	10.23
	Universidad Nacional de Colombia (Colombia)	3	8.18
	Imperial College London (United Kingdom)	3	7.04
	King Abdulaziz University (Saudi Arabia)	3	2.37
	Kyung Hee University (South Korea)	2	28.24
	King's College London (United Kingdom)	2	28.24
	University of Wisconsin (United States)	2	16.86
	University of Toronto (Canada)	2	12.89
	Harvard University (United States)	2	12.89
	University of Pennsylvania (United States)	2	12.89
	University of Delhi (India)	2	12.78
	Columbia University (United States)	2	12.78
	James Cook University Queensland (Australia)	2	12.78
	University of Hong Kong (Hong Kong)	2	12.48
	University of Virginia (United States)	2	11.21
	Emory University (United States)	2	10.90
	University of Liverpool (United Kingdom)	2	10.83
	Aarhus University (Denmark)	2	10.45
	University of Cape Town (South Africa)	2	10.44

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Table 10.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	Harvard University (United States)	7	8.91
	University of Florida (United States)	7	1.05
	World Health Organization (Switzerland)	5	7.45
	United Nations (United States)	5	6.98
	London School of Hygiene and Tropical Medicine (United Kingdom)	5	6.59
	University College London (United Kingdom)	4	14.14
	U.S. Department of Agriculture (United States)	4	1.37
	Universidad de Sonora (Mexico)	4	0.65
	Johns Hopkins University (United States)	3	9.95
	University of Toronto (Canada)	3	9.95
	Universidade do Porto (Portugal)	3	8.80
	Virginia Polytechnic Institute and State University (United States)	3	8.36
	Wageningen University & Research (Netherlands)	3	8.28
	University of Oxford (United Kingdom)	3	8.15
	Australian National University (Australia)	3	7.82
	Imperial College London (United Kingdom)	3	7.47
	Brown University (United States)	3	6.18
	CIRAD (France)	3	1.84
	IRD (France)	3	1.82
	Universidad Peruana Cayetano Heredia (Peru)	3	1.38

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Table 10.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	World Health Organization (Switzerland)	23	4.27
	Chinese Academy of Sciences (China)	22	2.03
	University of Toronto (Canada)	15	3.79
	University College London (United Kingdom)	13	9.16
	University of British Columbia (Canada)	13	4.67
	Universidade de Sao Paulo (Brazil)	13	3.85
	Wageningen University & Research (Netherlands)	12	4.12
	Australian National University (Australia)	11	7.75
	Tsinghua University (China)	10	4.57
	Imperial College London (United Kingdom)	10	4.04
	CNRS (France)	10	3.61
	University of Cambridge (United Kingdom)	10	2.67
	Vrije Universiteit (Netherlands)	10	2.47
	University of Oxford (United Kingdom)	9	3.79
	ETH Zurich (Switzerland)	9	2.94
	International Institute for Applied Systems Analysis, Laxenburg (Austria)	9	2.83
	Zhejiang University (China)	8	2.46
	Embrapa - Empresa Brasileira de Pesquisa Agropecuaria (Brazil)	8	2.34
	China Agricultural University (China)	8	1.88
	University of Oslo (Norway)	7	6.37

Table 10.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
China	Wageningen University & Research (Netherlands)	16	3.08
	University of Hong Kong (Hong Kong)	11	3.65
	University of British Columbia (Canada)	9	3.76
	Hong Kong Polytechnic University (Hong Kong)	8	1.77
	Arizona State University (United States)	8	1.69
	University of Western Australia (Australia)	7	3.97
	Purdue University (United States)	7	1.74
	University of Melbourne (Australia)	6	4.34
	University of Maryland (United States)	6	1.82
	Michigan State University (United States)	6	1.42
	U.S. Department of Agriculture (United States)	5	8.07
	City University of Hong Kong (Hong Kong)	5	2.43
	Universite du Quebec a Montreal (Canada)	5	1.52
	Kyushu University (Japan)	5	0.25
	Queensland University of Technology (Australia)	4	11.78
	Aarhus University (Denmark)	4	8.18
	University of Pennsylvania (United States)	4	6.07
	Yale University (United States)	4	5.95
	University of California at Riverside (United States)	4	3.12
	University of New South Wales (Australia)	4	2.14

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Table 10.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for China. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	Wageningen University & Research (Netherlands)	12	4.56
	World Health Organization (Switzerland)	11	6.92
	Ghent University (Belgium)	10	1.72
	Harvard University (United States)	9	11.57
	Aarhus University (Denmark)	8	7.77
	University of Toronto (Canada)	8	6.11
	United Nations (United States)	8	4.89
	University of Melbourne (Australia)	7	4.74
	Stockholm Environment Institute (Sweden)	7	3.09
	World Bank (United States)	6	7.49
	Australian National University (Australia)	6	5.68
	University of Sydney (Australia)	6	5.38
	University of Cape Town (South Africa)	6	4.62
	University of the Witwatersrand (South Africa)	5	6.76
	Erasmus University Rotterdam (Netherlands)	5	6.45
	Karolinska Institutet (Sweden)	5	5.87
	University of British Columbia (Canada)	5	5.40
	University of Athens (Greece)	5	4.88
	Boston University (United States)	5	4.79
	Monash University (Australia)	5	4.78

+

Table 10.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Australia	University College London (United Kingdom)	10	4.54
	World Health Organization (Switzerland)	9	3.93
	Imperial College London (United Kingdom)	7	5.26
	University of Toronto (Canada)	7	4.71
	University of British Columbia (Canada)	6	5.42
	Chinese Academy of Sciences (China)	6	1.77
	Harvard University (United States)	5	7.06
	University of Oxford (United Kingdom)	5	6.72
	Wageningen University & Research (Netherlands)	5	5.66
	University of California at Berkeley (United States)	5	4.06
	Chinese Academy of Agricultural Sciences (China)	5	1.40
	University of Southampton (United Kingdom)	4	9.24
	United Nations (United States)	4	6.95
	London School of Hygiene and Tropical Medicine (United Kingdom)	4	6.85
	University of Hong Kong (Hong Kong)	4	5.63
	University of Cape Town (South Africa)	4	5.47
	University of Cambridge (United Kingdom)	4	2.46
	Universidad de Sonora (Mexico)	4	0.65
	Fudan University (China)	3	16.73
	Aarhus University (Denmark)	3	12.18

+

Table 10.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Australia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Canada	Harvard University (United States)	9	11.68
	University College London (United Kingdom)	8	10.96
	Chinese Academy of Sciences (China)	7	1.98
	University of Washington (United States)	6	14.83
	London School of Hygiene and Tropical Medicine (United Kingdom)	6	11.68
	United Nations (United States)	6	5.89
	University of Stellenbosch (South Africa)	5	4.46
	University of Wisconsin (United States)	5	4.19
	Johns Hopkins University (United States)	4	14.69
	Aga Khan University (Pakistan)	4	11.59
	World Health Organization (Switzerland)	4	9.44
	Yale University (United States)	4	9.04
	Erasmus University Rotterdam (Netherlands)	4	8.23
	University of Cape Town (South Africa)	4	7.52
	University of East Anglia (United Kingdom)	4	6.84
	University of Queensland (Australia)	4	6.64
	Columbia University (United States)	4	5.69
	University of California at Berkeley (United States)	4	1.54
	Brown University (United States)	3	13.07
	Woods Hole Oceanographic Institution (United States)	3	11.64

Table 10.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Canada. (Source: Scopus)*

10.6.2 **Collaboration impact analysis**

To visualize the citation impact of collaborations, the ratio of FWCI from SDG10 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG10 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG10 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. As shown in Figure 10.8, Imperial College London sits at the far upper top right, indicating that they've developed a highly mutually beneficial collaboration with Colombia in terms of citation impact. Other institutes, such as the World Health Organization, are also in the same quadrant revealing that collaborations with these partners is mutually beneficial in terms of citation impact. The Royal Institute of Technology, in the bottom left quadrant, indicates that the collaboration does not yield any citation advantage to either Colombia or its partner.

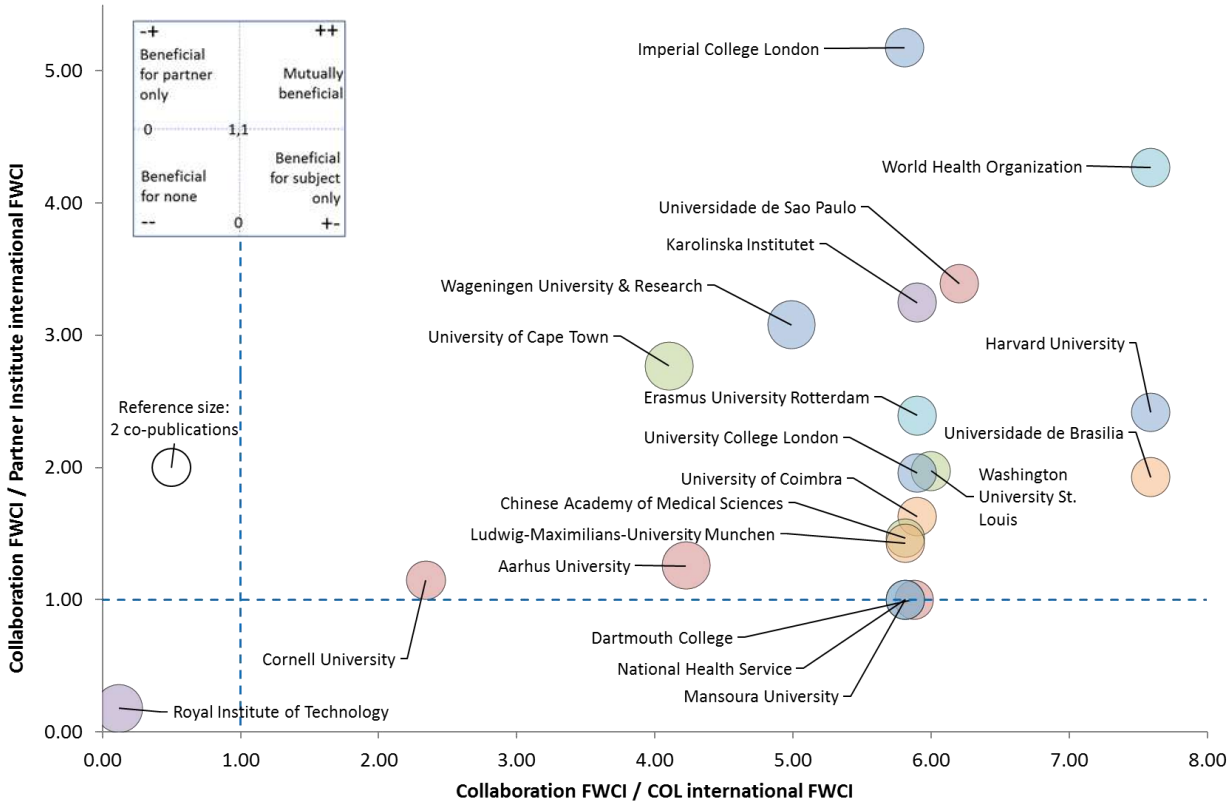

Figure 10.8— *Collaboration quadrant of Colombia's Top 20 collaborations in SDG10-related research with other institutions. Collaboration FWCI refers to the FWCI of all SDG10-related research co-authored by Colombia and the partner institute during the period 2007-2016. Bubble size corresponds to number of co-authored publications (reference bubble depicted at top left of chart). Impact of collaboration between partners can be interpreted based on quadrant position as described in legend on top left. (Source: Scopus).*

10.6.3 **Collaboration chart**

Figure 10.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG10. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 10.9 shows where there may be potential to improve output and impact through partnership. Colombia has co-authored 2-3 publications with each of its top 20 foreign partner institutes. Colombia co-authored 3 publications with Wageningen University & Research, which produces the highest number of publications (among Colombia's top 20 partners) at 82 SDG10 publications. Universidade de Sao Paulo and University College of London are the second and third most prolific among Colombia's top 20 foreign partner institutes, with 59 and 56 publications, respectively. Among Colombia's top 20 partners, National Health Service has the highest FWCI for SDG10 research. Colombia may want to leverage its existing relationships with these institutes to increase its publication output and impact in SDG10 research.

Figure 10.9— *Chart showing Colombia's top 20 collaborators on SDGX from 2007-2016. Circle (node) size is proportional to the number of SDGX publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (10.32) and lightest shade of green indicating the lowest FWCI (1.02). (Source: Scopus).*

Chapter 11
Sustainable Cities and Communities

In this Chapter, we assess research related to SDG11, which aims to make cities inclusive, safe, resilient, and sustainable. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

11.1 Key Findings

Goal 11: Make cities inclusive, safe, resilient and sustainable

WORLD RESEARCH OUTPUT

59,895

Number of SDG11 publications, 2007-2016.

SDG11 PATENTS

647

Number of SDG11 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

229

Colombia's SDG11 publications, 2007-2016.

COLOMBIA'S RESEARCH OUTPUT CAGR

42%

Compound annual growth rate for Colombia's 2007-2016 SDG11 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

32

Colombia's SDG11 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

1.27

Average field-weighted citation impact for Colombia's SDG11 publications, 2007-2016.

11.2 SDG11 – Make cities inclusive, safe, resilient and sustainable

According to the United Nations,

> *"Cities are hubs for ideas, commerce, culture, science, productivity, social development and much more. At their best, cities have enabled people to advance socially and economically.*
> *However, many challenges exist to maintaining cities in a way that continues to create jobs and prosperity while not straining land and resources. Common urban challenges include congestion, lack of funds to provide basic services, a shortage of adequate housing and declining infrastructure.*
> *The challenges cities face can be overcome in ways that allow them to continue to thrive and grow, while improving resource use and reducing pollution and poverty. The future we want includes cities of opportunities for all, with access to basic services, energy, housing, transportation and more."*[16]

The targets for SDG 11, according to the United Nations are:

- *"By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums.*
- *By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.*
- *By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.*
- *Strengthen efforts to protect and safeguard the world's cultural and natural heritage.*
- *By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.*
- *By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.*
- *By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, especially for women and children, older persons and persons with disabilities.*
- *Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning.*
- *By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels.*
- *Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials."*[16]

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG11 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

[16] http://www.un.org/sustainabledevelopment/cities/

11.3 SDG11: Leaders in the field

11.3.1 Top 5 countries conducting SDG11 research

The top 5 countries publishing on SDG11 based on cumulative publication output from 2007-2016 are shown in Table 11.1 and Figure 11.1. The United States ranks 1st according to Publication Count, Percentage of Global Output, and Citation Count. Italy ranks 1st in FWCI with 1.59, closely followed by the United Kingdom at 1.58, and Australia at 1.52, all much higher than the world average (1.05 for SDG11). Except for China, all other countries' FWCI exceed the global average as well.

Table 11.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	11,359	18.96%	140,647	1.41
China	8,867	14.80%	47,046	0.74
United Kingdom	5,261	8.78%	73,992	1.58
Australia	3,146	5.25%	42,190	1.52
Italy	2,950	4.93%	29,024	1.59
World	59,895	100.00%	206,762	1.05

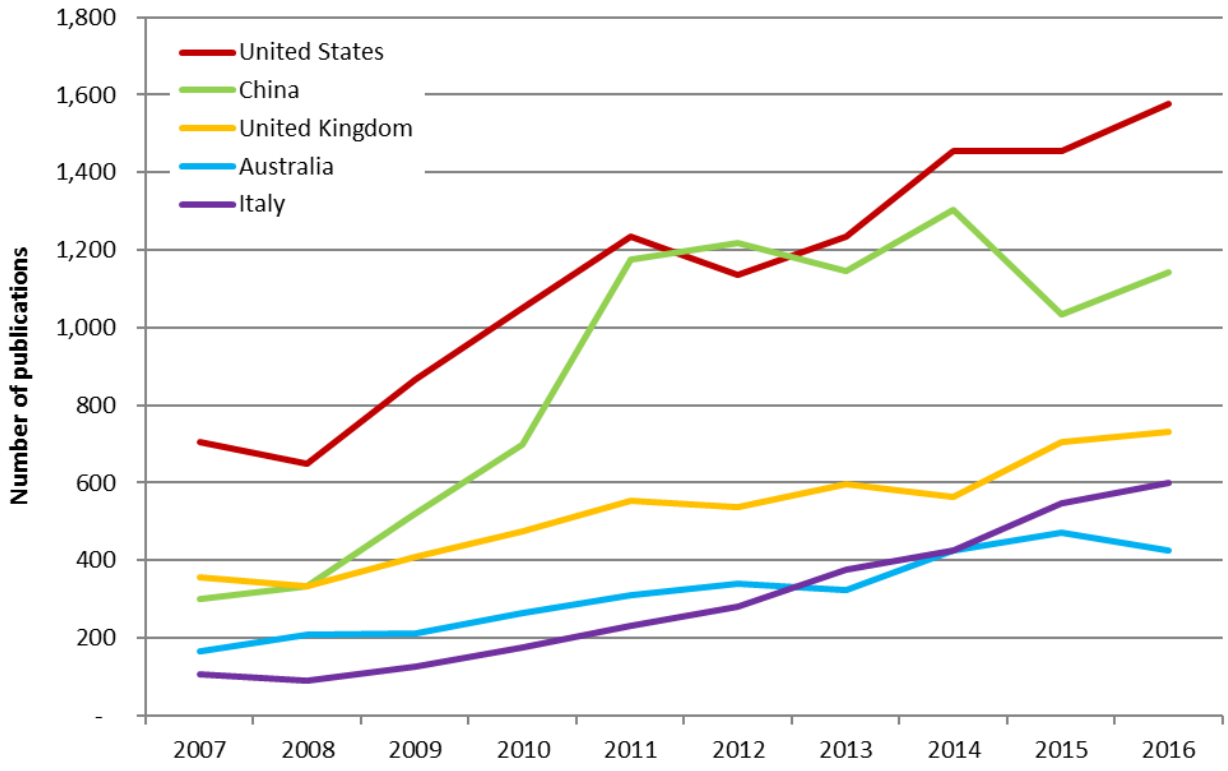

Figure 11.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG11 research. (Source: Scopus)*

11.3.2 Top 20 institutes conducting SDG11 research

A list of the top 20 research institutes publishing SDG11-related research is shown in Table 11.2. The Chinese Academy of Sciences (China) ranks 1st in Publication Count and surpasses the next ranked institute by more than 500 publications. All other top institutes have published between 200-400 publications. Among top 20 institutes, Wageningen University & Research (Netherlands) has the highest FWCI at over two times the world average. Except for Tongji University (China) and Islamic Asdad University (Iran), all the top 20 institutes have a mean FWCI above world average in this research field. The trends in publication output from 2007-2016 are shown in Figure 1.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Chinese Academy of Sciences (China)	913	8,984	1.13
2	Delft University of Technology (Netherlands)	373	4,533	1.74
3	Arizona State University (United States)	350	8,444	2.15
4	Beijing Normal University (China)	326	3,730	1.62
5	Wageningen University & Research (Netherlands)	325	9,017	2.37
6	Tsinghua University (China)	318	3,182	1.27
7	Ministry of Education China (China)	281	3,682	1.23
8	Universiti Teknologi Malaysia (Malaysia)	280	1,543	1.05
9	Universidade de Sao Paulo (Brazil)	256	2,411	1.18
10	University College London (United Kingdom)	254	4,774	2.11
11	Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences (China)	251	2,310	1.10
12	CNRS (France)	249	4,979	1.99
13	Hong Kong Polytechnic University (Hong Kong)	246	3,155	1.71
14	Tongji University (China)	245	797	0.67
15	Politecnico di Milano (Italy)	241	1,730	1.60
16	U.S. Department of Agriculture (United States)	239	5,313	2.13
17	Royal Institute of Technology (Sweden)	236	2,349	1.57
18	Islamic Azad University (Iran)	231	615	0.52
19	University of British Columbia (Canada)	224	3,929	1.90
20	Monash University (Australia)	222	3,993	1.73

Table 11.2— *Top 20 research Institutes ranked based on SDG11 publication output and FWCI from 2007-2016. (Source: Scopus)*

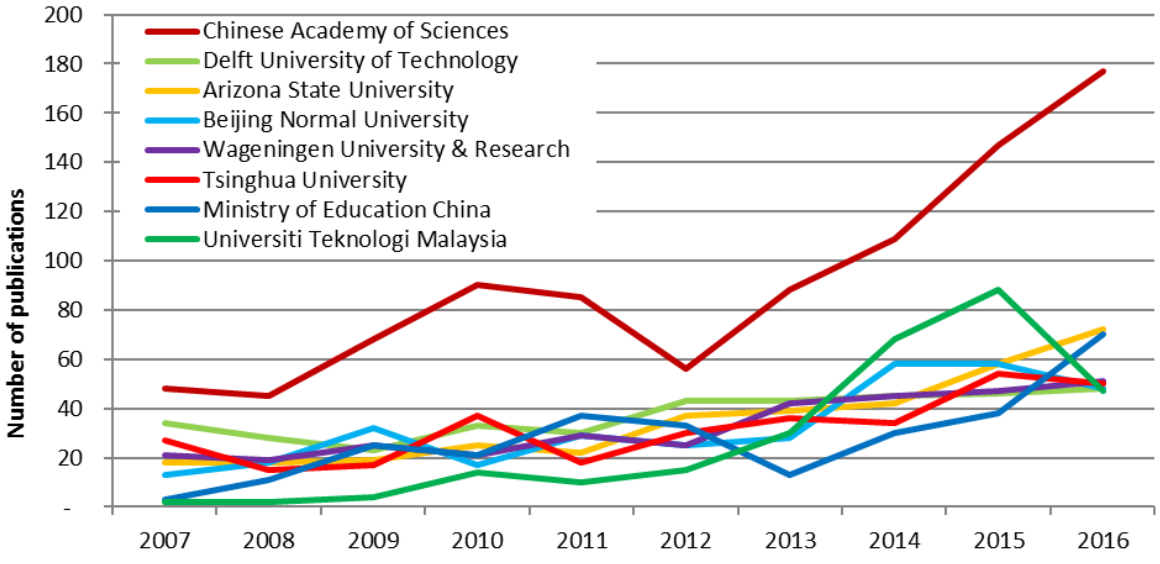

Figure 11.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG11. (Source: Scopus)*

11.3.3 Top 20 researchers conducting SDG11 research

A list of the top 20 researchers publishing in the SDG11 field based on publication output from 2007-2016 is shown in Table 11.3. Brown R.and Salvati L. rank 1st in Publication Count followed by Yang Z. and Chen B.
Yang Z, Chen B., and Nijkamp P. are the top 3 researchers in this list in terms of H-index.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Brown R.	Monash University (Australia)	48	1,460	2.37	24
2	Salvati L.	Council for Agricultural Research and Economics (CREA) (Italy)	48	351	1.53	27
3	YANG Z.	Beijing Normal University (China)	47	695	1.23	50
4	Chen B.	Beijing Normal University (China)	45	899	1.89	46
5	Scholz M.	University of Salford (United Kingdom)	39	506	0.90	26
6	Zeiler W.	Technische Universiteit Eindhoven (Netherlands)	39	42	0.49	8
7	Zhang X.	City University of Hong Kong (China)	38	700	2.46	18
8	Gabarrell X.	Institut de Ciencia i Tecnologia Ambientals (ICTA)-UAB (Spain)	35	614	1.76	26
9	Geng Y.	Shanghai Jiaotong University (China)	34	787	2.51	41
10	Chan E.	Hong Kong Polytechnic University (China)	34	562	1.49	23
11	Wang R.	Research Center for Eco-Environmental Sciences Chinese Academy of Sciences (China)	34	290	0.69	13
12	Rogers C.	University of Birmingham (United Kingdom)	33	372	2.94	23
13	Shen L.	Chongqing University (China)	33	641	2.26	38
14	Rieradevall J.	Institut de Ciencia i Tecnologia Ambientals (ICTA)-UAB (Spain)	33	659	2.03	29
15	Macharis C.	Vrije Universiteit Brussel (Belgium)	33	131	1.85	23
16	Nijkamp P.	Uniwersytet im. Adama Mickiewicza w Poznaniu (Poland)	30	595	1.86	43
17	Liu G.	Beijing Normal University (China)	29	282	0.93	13
18	Tighe S.	University of Waterloo (Canada)	29	44	0.30	11
19	Butler D.	University of Exeter (United Kingdom)	27	611	4.58	31
20	Wu J.	Arizona State University (United States)	27	2,352	4.01	50

Table 11.3— *Top 20 researchers publishing SDG11 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG11 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

11.3.4 Top 10 journals publishing SDG11 research

A list of the top 10 journals publishing SDG11-related research from 2007-2016 is shown in Table 11.4. *Advanced Materials Research* published 1,234 SDG11 related publications, making it the highest ranked journal in terms of SDG11 publications. The FWCI and CiteScore for *Sustainability Advanced Materials Research* is well below 1. Only *Journal of Cleaner Production* and *Renewable and Sustainable Energy Reviews* have an FWCI and CiteScore above 1.

Rank	Journal	Publication count	FWCI	CiteScore
1	Advanced Materials Research	1,234	0.44	0.17
2	Sustainability	776	0.95	0.92
3	WIT Transactions on Ecology and the Environment	733	0.08	0.08
4	Applied Mechanics and Materials	712	0.32	0.11
5	Journal of Cleaner Production	705	3.04	3.70
6	Procedia Engineering	612	1.77	0.48
7	Proceedings of the 27th International Business Information Management Association Conference - Innovation Management and Education Excellence Vision 2020: From Regional Development Sustainability to Global Economic Growth, IBIMA 2016	397	0.70	0.00
8	Renewable and Sustainable Energy Reviews	367	1.25	7.66
9	Proceedings of the 25th International Business Information Management Association Conference - Innovation Vision 2020: From Regional Development Sustainability to Global Economic Growth, IBIMA 2015	364	0.51	0.00
10	Acta Ecologica Sinica	342	0.22	0.55

Table 11.4— *Top 10 journals based on SDG11 publication output from 2007-2016. FWCI is mean FWCI for any SDG11 publications in the journal during the period; CiteScore is based on data for the journal as a whole. (Source: Scopus)*

11.4 Research efforts focused on SDG11

11.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 11.3, the United States is followed by China in terms of research output related to SDG11. However, while the United States has seen ongoing growth over the period, China has plateaued since 2011. The United Kingdom follows, along with Australia and Italy, which overtook Australia in 2013. Among comparators, Colombia has the lowest output in this field, just below Mexico. However, as shown in Table 1.5, Colombia has seen the greatest growth in research output in this field among comparators with a Compound Annual Growth Rate (CAGR) of 41.7%. All countries analysed have a CAGR above 8% in this field and the CAGR for all research in this field was 8.7%.

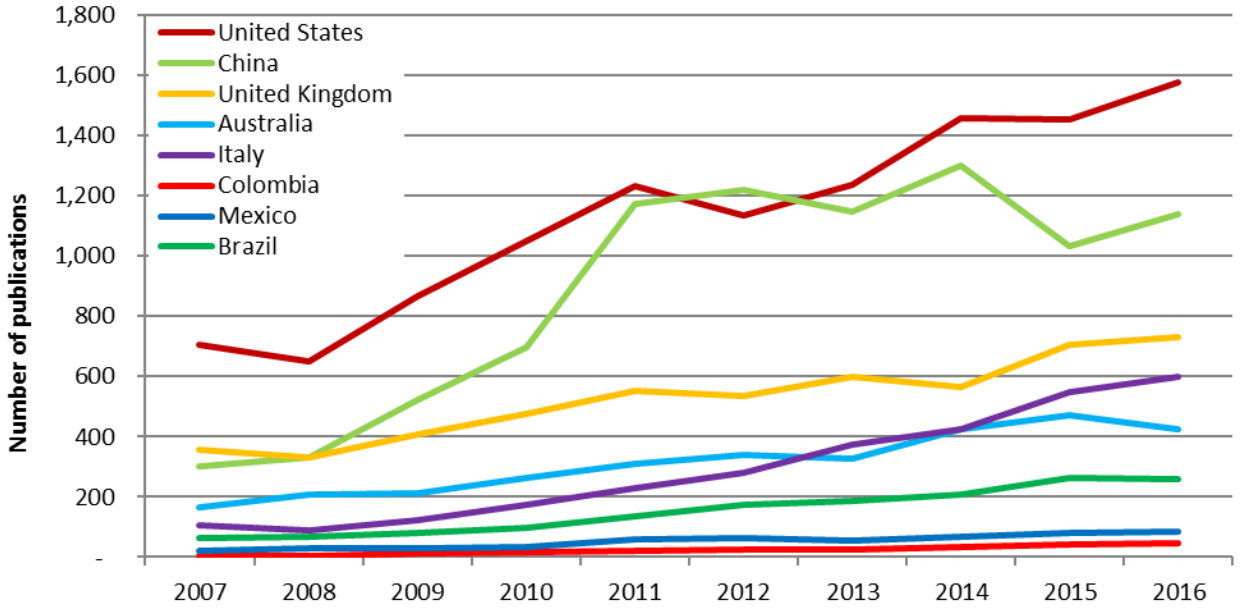

Figure 11.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	11,359	9.40%
China	8,867	16.00%
United Kingdom	5,261	8.40%
Australia	3,146	11.10%
Italy	2,950	21.30%
Colombia	229	41.70%
Mexico	525	16.10%
Brazil	1,531	16.50%
World	59,895	8.70%

Table 11.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

11.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG11 related research from 2006-2017 is 1.05.

Country	FWCI
United States	1.41
China	0.74
United Kingdom	1.58
Australia	1.52
Italy	1.59
Colombia	1.27
Mexico	0.95
Brazil	0.92
World	1.05

Comparing the FWCI of SDG11 publications from each of the eight countries included in this chapter reveals that Italy, United Kingdom and Australia leads in terms of FWCI (Table 11.6). Colombia's FWCI is above the world average for this field at 1.27 while China, Mexico and Brazil all have an FWCI below the world average for this subject.

Table 11.6— *FWCI per Comparator, 2007-2016. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

11.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 11.4 and Table 11.7, the United States leads in terms of SDG11 publications with 1,802 publications that are among the top 10% most cited. The United Kingdom follows with less than half the count of top 10% publications and Australia, China, and Italy all produce a similar count of top 10% publications, with China showing high growth during the period (CAGR of 32.9%). Colombia had 32 publications among the top 10% most cited during this time period.

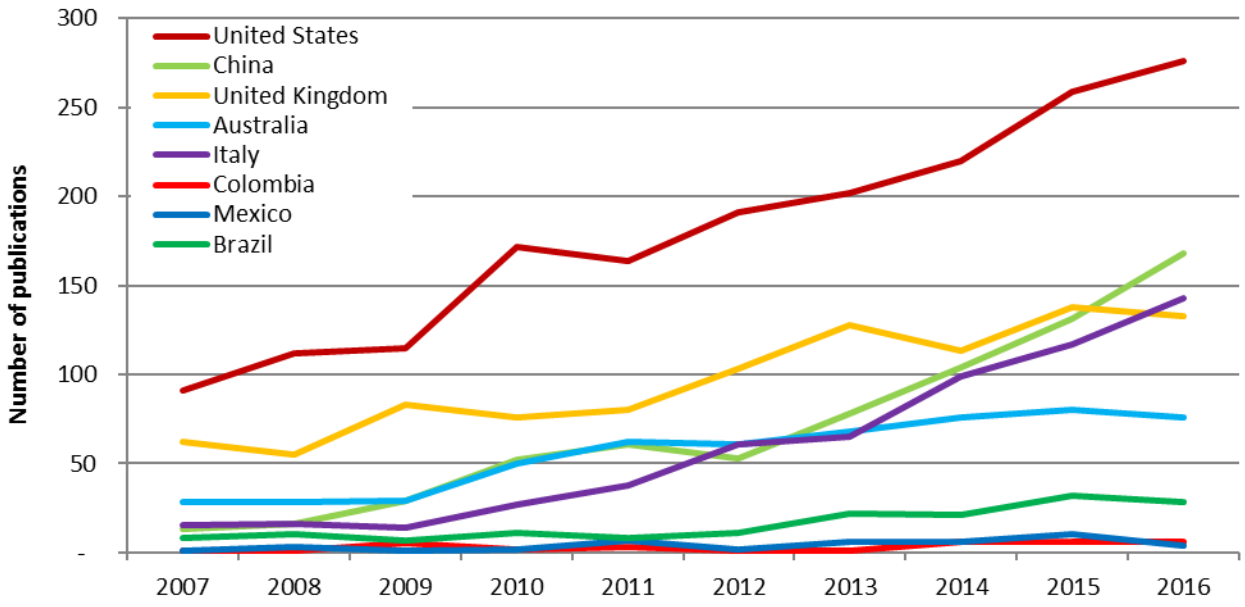

Figure 11.4— *Top 10% most cited publications on SDG11 from 2007-2016 per country. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
United States	1,802	13.12%
China	705	32.89%
United Kingdom	971	8.85%
Australia	558	11.73%
Italy	595	28.47%
Colombia	32	22.03%
Mexico	42	16.65%
Brazil	158	14.93%
World	7,075	14.91%

Table 11.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG11 publications from 2007-2016. (Source: Scopus)*

11.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 11.8 provides the count of SDG11 publications from each country that have been cited in patents and the number of patents that have cited these publications. For the United States, 86 US publications on SDG11 have been cited in 426 patents. The other top 5 countries had 12-14 publications cited in approximately 20 patents (nearly 60 patents for the United Kingdom). Colombia, has a single publication cited in a single patent.

Country	Patent Cited Publications	Patents Citing Publications
United States	86	426
China	14	18
United Kingdom	14	59
Australia	13	22
Italy	12	18
Colombia	1	1
Mexico	-	-
Brazil	3	3
World	227	751

Table 11.8— *Number of publications cited in patent and patents citing publications on SDG11 from 2007 to 2016. (Source: Scopus)*

11.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG11. To identify patents relevant to SDG11, we retrieved all the patents citing any SDG11-related publication. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO. From 2006 to 2016, the United States has the highest number of SDG11-related patents (both applied for and granted) with 123 patent applications and 303 patents granted (Table 11.9). The other top 5 countries have a small number of patents (10-25) during the period and Colombia applied for one patent and had none granted during the period. Note that China and Australia may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	123	303	426	65.84%
China	16	1	17	2.63%
United Kingdom	15	10	25	3.86%
Australia	1	10	11	1.70%
Italy	6	2	8	1.24%
Colombia	1	-	1	0.15%
Mexico	2	-	2	0.31%
Brazil	1	-	1	0.15%
World	285	362	647	

Table 11.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

11.4.6 **Research Focus**

Within the topic of SDG11-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG11-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG11 research is shown in Figure 11.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG11 research from Colombia, terms that stand out as unique to Colombia are 'Bamboo', 'Rainwater', 'Tank (Containers)', 'Buses', and 'Watersheds'. Among the top 50 key phrases the terms 'Transportation', 'Housing', 'Regional Planning', 'Environmental Management', 'Waste Management', 'Buildings', and 'Energy Efficiency' were common among the countries analyzed. Figure 11.5 provides a visualization of the top 50 key phrases for SDG11 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

Colombia

Mexico

Figure 11.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Brazil

United States

China

United Kingdom

Australia

Italy

11.5 The reach of Colombia's SDG11 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

11.5.1 Downloads

As shown in the Figure 11.6, the mean count of downloads per ScienceDirect publication is similar across all countries. For Colombia, there is a sharp peak in 2009, resulting from 4 SD articles in 2009 and 2015 from Colombia that were downloaded more than 10,000 times, resulting in a high 'mean' value. It should be noted that for Colombia, Mexico, and Brazil, the results shown are based on very small counts of SD articles and therefore, results that deviate greatly from the mean should be interpreted with caution.

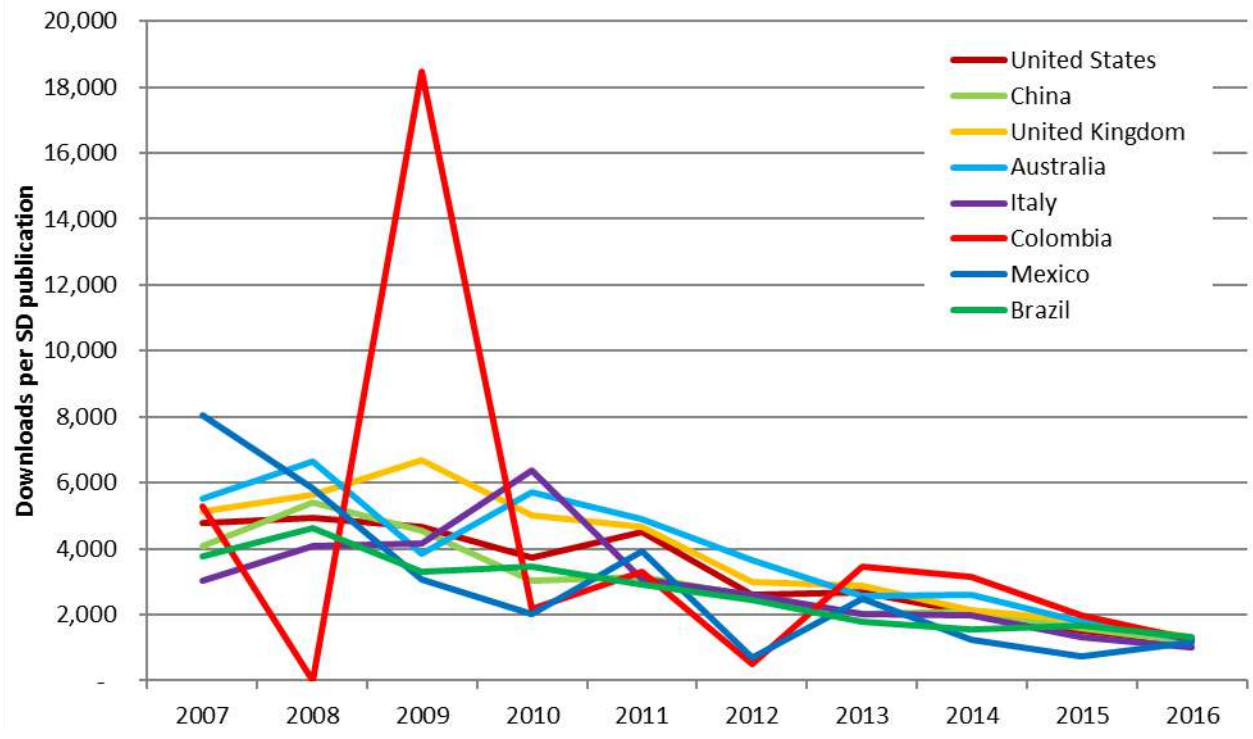

Figure 11.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

11.5.2 **Field Weighted Download Impact (FWDI)**

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. All countries analysed had an FWDI close to the world average for SDG11 research during the period of 2007-2016 (Figure 11.7).

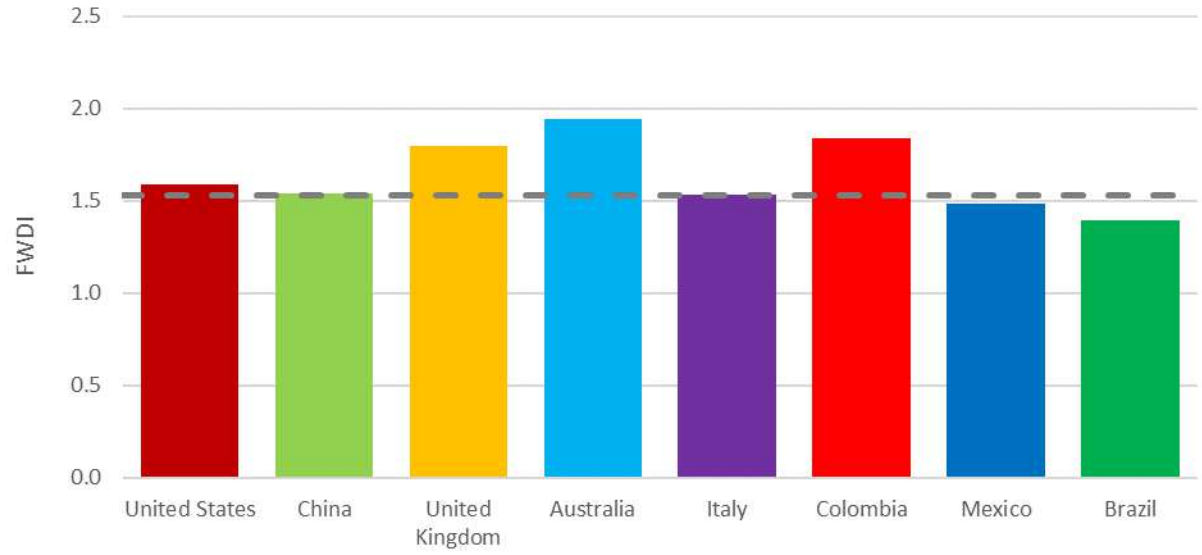

Figure 11.7 — *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. Grey dotted line indicates average for all SDG11 research. (Source: ScienceDirect)*

11.6 SDG11 collaboration network

11.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG11-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 11.10-11.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG11 publications with. Among academic partner institutes, Colombia has published the most SDG11 papers in collaboration with Universitat Autonoma de Barcelona (Spain; 6 publications from 2007-2016). The FWCI for these publications is just over 2 times the world average for SDG11 research.

Country	Institution (Country)	Publication Count	FWCI
Colombia	Universitat Autonoma de Barcelona (Spain)	6	2.18
	Universitat Rovira i Virgili (Spain)	5	4.56
	IRTA - Institute of Agrifood Research and Technology (Spain)	5	2.03
	Universidade de Sao Paulo (Brazil)	5	1.64
	CSIC (Spain)	4	2.33
	Universitat Politecnica de Catalunya (Spain)	4	1.68
	ETH Zurich (Switzerland)	4	1.37
	University of Leeds (United Kingdom)	4	1.33
	UNIVERSIDAD DEL BIO-BIO (Chile)	4	0.69
	Stanford University (United States)	3	4.41
	University College London (United Kingdom)	3	1.75
	KU Leuven (Belgium)	3	0.95
	Columbia University (United States)	3	0.19
	University of California at Berkeley (United States)	2	6.26
	Universite Catholique de Louvain (Belgium)	2	6.08
	University of Bonn (Germany)	2	5.08
	Georgia Institute of Technology (United States)	2	4.14
	Harvard University (United States)	2	3.31
	Imperial College London (United Kingdom)	2	2.72
	World Bank (United States)	2	2.59

Table 11.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	Texas A and M University (United States)	15	3.28
	King Abdulaziz University (Saudi Arabia)	7	3.58
	Arizona State University (United States)	7	0.76
	University of Arizona (United States)	6	0.29
	Imperial College London (United Kingdom)	5	3.52
	University of California at San Diego (United States)	5	2.43
	Universidade de Sao Paulo (Brazil)	5	0.70
	U.S. Department of Agriculture (United States)	5	0.46
	University of California at Santa Barbara (United States)	4	4.58
	University of California at Berkeley (United States)	4	0.58
	Delft University of Technology (Netherlands)	3	14.86
	City University of New York (United States)	3	3.70
	Universitat Autonoma de Barcelona (Spain)	3	3.41
	University of California at Davis (United States)	3	2.75
	Humboldt-Universitat zu Berlin (Germany)	3	2.44
	Technical University of Denmark (Denmark)	3	2.21
	Wageningen University & Research (Netherlands)	3	1.93
	Carnegie Mellon University (United States)	3	1.48
	Universidad Nacional de Colombia (Colombia)	3	1.47
	Instituto Nacional de Tecnologia Agropecuaria (Argentina)	3	1.20

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Table 11.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	Wageningen University & Research (Netherlands)	13	4.31
	Colorado State University (United States)	13	4.01
	CIRAD (France)	13	1.15
	CNRS (France)	11	3.18
	University of East Anglia (United Kingdom)	10	6.48
	University of Florida (United States)	9	4.32
	U.S. Department of Agriculture (United States)	9	3.83
	Universidad Nacional Autonoma de Mexico (Mexico)	9	1.99
	IRD (France)	8	5.30
	INRA Institut National de La Recherche Agronomique (France)	8	3.76
	University of Minho (Portugal)	8	0.85
	Lancaster University (United Kingdom)	7	5.69
	United Nations (United States)	7	1.49
	Harvard University (United States)	6	7.57
	ETH Zurich (Switzerland)	6	6.87
	Imperial College London (United Kingdom)	6	5.83
	University of Aberdeen (United Kingdom)	6	5.16
	University of Coimbra (Portugal)	6	1.54
	Technische Universitat Berlin (Germany)	5	3.63
	Universitat Politecnica de Catalunya (Spain)	5	0.56

+

Table 11.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	Chinese Academy of Sciences (China)	115	2.23
	Tsinghua University (China)	47	2.55
	Beijing Normal University (China)	45	3.56
	Peking University (China)	36	2.68
	Universidade de Sao Paulo (Brazil)	35	2.84
	Wageningen University & Research (Netherlands)	34	4.83
	National University of Singapore (Singapore)	34	3.41
	Zhejiang University (China)	33	2.30
	University of Cambridge (United Kingdom)	32	4.59
	University of British Columbia (Canada)	32	4.02
	University of Toronto (Canada)	32	1.87
	Ministry of Education China (China)	31	2.09
	Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences (China)	28	1.57
	McGill University (Canada)	27	2.49
	CNRS (France)	25	5.57
	Delft University of Technology (Netherlands)	25	2.99
	CSIRO (Australia)	24	5.01
	Erasmus University Rotterdam (Netherlands)	24	1.84
	University of Oxford (United Kingdom)	23	2.20
	CAS - Research Center for Eco-Environmental Sciences (China)	22	2.30

+

Table 11.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
China	Hong Kong Polytechnic University (Hong Kong)	102	1.67
	University of Hong Kong (Hong Kong)	60	1.58
	City University of Hong Kong (Hong Kong)	52	2.24
	Arizona State University (United States)	44	2.63
	Chinese University of Hong Kong (Hong Kong)	29	1.70
	National Institute for Environmental Studies of Japan (Japan)	27	2.78
	University of Regina (Canada)	26	2.33
	National University of Singapore (Singapore)	26	2.32
	Delft University of Technology (Netherlands)	25	1.97
	Wageningen University & Research (Netherlands)	24	2.96
	Royal Institute of Technology (Sweden)	22	1.48
	Purdue University (United States)	21	1.58
	Queensland University of Technology (Australia)	20	3.08
	University of Cambridge (United Kingdom)	20	2.43
	University of Michigan (United States)	19	2.11
	Hong Kong University of Science and Technology (Hong Kong)	18	2.35
	University of Toronto (Canada)	18	1.55
	International Institute for Applied Systems Analysis, Laxenburg (Austria)	17	2.47
	Texas A and M University (United States)	17	1.63
	University of British Columbia (Canada)	16	3.17

Table 11.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for China. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	Wageningen University & Research (Netherlands)	42	4.72
	University of Copenhagen (Denmark)	25	4.37
	Chinese Academy of Sciences (China)	22	2.64
	Harvard University (United States)	21	6.89
	University of Melbourne (Australia)	21	4.61
	Swedish University of Agricultural Sciences (Sweden)	20	4.28
	CNRS (France)	20	3.33
	Lund University (Sweden)	20	2.66
	Delft University of Technology (Netherlands)	20	2.19
	Humboldt-Universitat zu Berlin (Germany)	19	5.19
	ETH Zurich (Switzerland)	19	5.09
	INRA Institut National de La Recherche Agronomique (France)	19	4.40
	University of Sydney (Australia)	19	2.62
	European Commission Joint Research Centre Institute (Belgium)	18	2.65
	Universidade de Lisboa (Portugal)	17	2.76
	University of Cape Town (South Africa)	16	3.97
	Utrecht University (Netherlands)	16	3.69
	Universidade de Sao Paulo (Brazil)	16	3.63
	United Nations (United States)	16	2.33
	Stockholm Environment Institute (Sweden)	16	1.81

Table 11.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Australia	Chinese Academy of Sciences (China)	25	2.09
	Hong Kong Polytechnic University (Hong Kong)	23	1.69
	National University of Singapore (Singapore)	21	4.45
	Wageningen University & Research (Netherlands)	17	4.81
	University of Hong Kong (Hong Kong)	16	3.31
	Delft University of Technology (Netherlands)	16	0.90
	University of Cambridge (United Kingdom)	15	5.20
	University of Auckland (New Zealand)	14	2.96
	City University of Hong Kong (Hong Kong)	13	2.34
	University of Sheffield (United Kingdom)	12	7.45
	University of California at Berkeley (United States)	12	6.41
	Imperial College London (United Kingdom)	12	5.97
	Chongqing University (China)	12	2.12
	University College London (United Kingdom)	12	2.07
	University of Exeter (United Kingdom)	11	5.33
	Zhejiang University (China)	11	3.93
	Erasmus University Rotterdam (Netherlands)	11	2.40
	Harvard University (United States)	10	9.31
	Colorado State University (United States)	10	6.16
	University of British Columbia (Canada)	10	5.12

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Table 11.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Australia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Italy	European Commission Joint Research Centre Institute (Belgium)	91	2.54
	Wageningen University & Research (Netherlands)	25	3.08
	CSIC (Spain)	14	2.40
	European Commission (Belgium)	14	1.96
	University Politehnica of Bucharest (Romania)	13	2.25
	Beijing Normal University (China)	12	3.93
	Universitat Autonoma de Barcelona (Spain)	12	2.05
	CNRS (France)	12	1.31
	INRA Institut National de La Recherche Agronomique (France)	11	5.78
	Delft University of Technology (Netherlands)	11	3.19
	Technical University of Denmark (Denmark)	11	3.01
	KU Leuven (Belgium)	10	3.43
	Aristotle University of Thessaloniki (Greece)	10	3.16
	Aarhus University (Denmark)	10	2.35
	Ghent University (Belgium)	10	2.18
	Vrije Universiteit (Netherlands)	10	0.63
	Hellenic Centre for Marine Research (Greece)	9	3.93
	Imperial College London (United Kingdom)	9	3.80
	University of Copenhagen (Denmark)	9	3.52
	Universidade de Lisboa (Portugal)	9	3.22

Table 11.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Italy. (Source: Scopus)*

11.6.2 **Collaboration impact analysis**

To visualize the citation impact of collaborations, the ratio of FWCI from SDG11 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG11 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG11 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. For SDG11 research from 2007-2016, about half of Colombia's collaborations were mutually beneficial to both Colombia and the collaboration partner (Figure 11 .8 The two publications resulting from collaboration with the University of Bonn and with the University of California at Berkeley were highly mutually beneficial in terms of citation impact. A small number of publications with a few partners (Colombia University, University of Leeds, ETH Zurich, and Universidad del Bio-Bio) resulted in a low FWCI relative to Colombia and each partners respective FWCI for internationally collaborated research on SDG11.

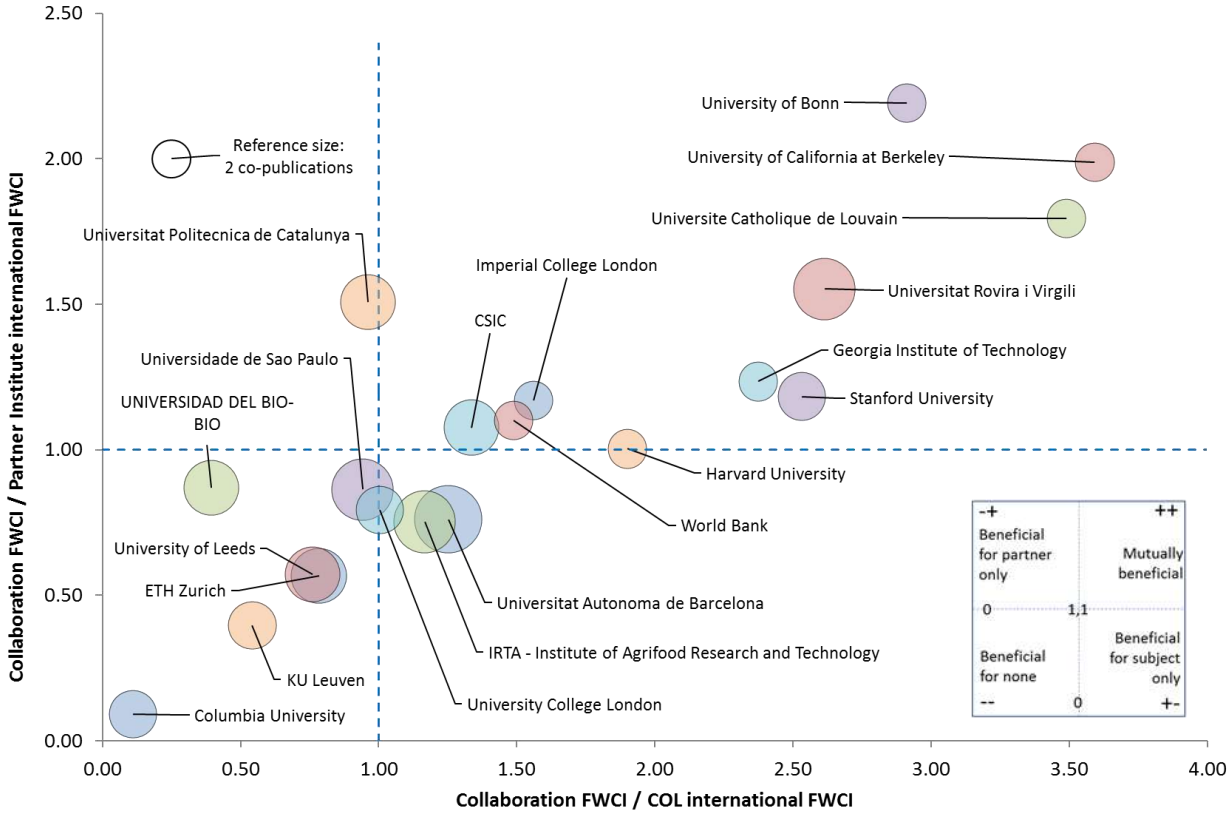


Figure 11.8— *Collaboration quadrant for Colombia and its top 20 collaborators on SDG1 from 2007-2016. (Source: Scopus).*

11.6.3 **Collaboration chart**

Figure 11.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG11. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 11.9 shows where there may be potential to improve output and impact through partnership. Colombia co-authored 2-6 publications with its top foreign partner institutes. Among Colombia's top 20 partners, Universidade de Sao Paulo and University College of London produce the highest number of SDG11 publications with 256 and 254 publications, respectively. Among Colombia's top 20 partners, Stanford University has the highest FWCI for SDG11 research. Colombia may want to leverage its existing relationships with these institutes to increase its publication output and impact in SDG11 research.

Figure 11.9— *Chart showing Colombia's top 20 collaborators on SDG11 from 2007-2016. Circle (node) size is proportional to the number of SDG11 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (3.03) and lightest shade of green indicating the lowest FWCI (0.62). (Source: Scopus).*

Chapter 12
Responsible Consumption and Production

In this Chapter, we assess research related to SDG12, which aims to ensure sustainable consumption and production patterns. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

12.1 Key Findings

Goal 12: Ensure sustainable consumption and production patterns

WORLD RESEARCH OUTPUT

78,468

Number of SDG12 publications, 2007-2016.

SDG12 PATENTS

2,284

Number of SDG12 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

363

Colombia's SDG12 publications, 2007-2016.

COLOMBIA'S RESEARCH OUTPUT CAGR

40%

Compound annual growth rate for Colombia's 2007-2016 SDG12 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

45

Colombia's SDG12 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

1.17

Average field-weighted citation impact for Colombia's SDG12 publications, 2007-2016.

12.2 SDG12 – Ensure sustainable consumption and production patterns

According to the United Nations,

> *"Sustainable consumption and production is about promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs and a better quality of life for all. Its implementation helps to achieve overall development plans, reduce future economic, environmental and social costs, strengthen economic competitiveness and reduce poverty.*
> *Sustainable consumption and production aims at "doing more and better with less," increasing net welfare gains from economic activities by reducing resource use, degradation and pollution along the whole lifecycle, while increasing quality of life. It involves different stakeholders, including business, consumers, policy makers, researchers, scientists, retailers, media, and development cooperation agencies, among others.*
> *It also requires a systemic approach and cooperation among actors operating in the supply chain, from producer to final consumer. It involves engaging consumers through awareness-raising and education on sustainable consumption and lifestyles, providing consumers with adequate information through standards and labels and engaging in sustainable public procurement, among others."*[17]

The targets for SDG 12, according to the United Nations are:

- *"Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries.*
- *By 2030, achieve the sustainable management and efficient use of natural resources.*
- *By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.*
- *By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment.*
- *By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.*
- *Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.*
- *Promote public procurement practices that are sustainable, in accordance with national policies and priorities.*
- *By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.*
- *Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production.*
- *Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products.*
- *Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities."*[17]

[17] http://www.un.org/sustainabledevelopment/sustainable-consumption-production/

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG12 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

12.3 SDG12: Leaders in the field

12.3.1 Top 5 countries conducting SDG12 research

The top 5 countries publishing on SDG12 based on cumulative publication output from 2007-2016 are shown in Table 12.1 and Figure 12.1. The United States ranks 1st according to Publication Count, Percentage of Global Output, and Citation Count. The United Kingdom ranks 1st in FWCI with 1.99, which is higher than the world average of 1.31 for SDG12. All other countries' FWCI exceed the world average for all research although China's FWCI is below the average for all SDG12 research.

Table 12.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	14,993	19.11%	269,796	1.74
China	10,023	12.77%	93,869	1.08
United Kingdom	5,936	7.56%	120,326	1.99
Germany	4,718	6.01%	77,142	1.73
Italy	4,572	5.83%	58,747	1.71
World	78,468	100.00%	417,068	1.31

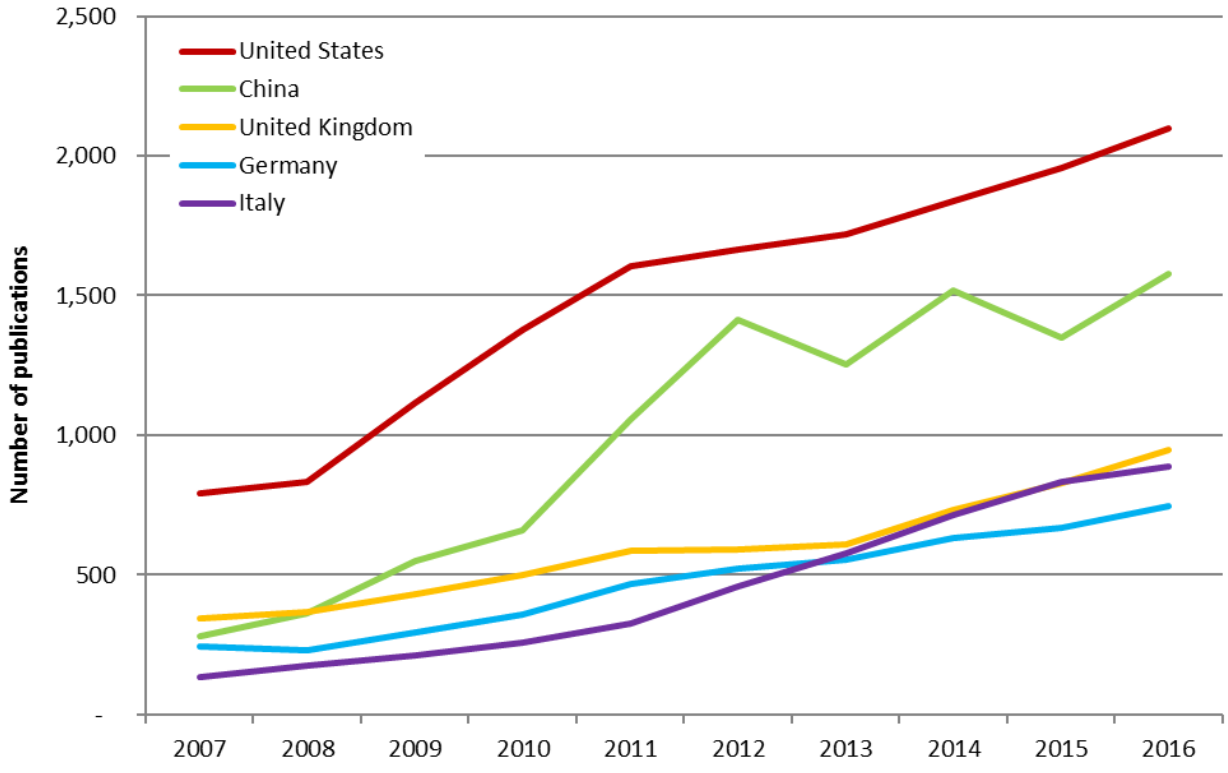


Figure 12.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG12 research. (Source: Scopus)*

12.3.2 Top 20 institutes conducting SDG12 research

A list of the top 20 research institutes publishing SDG12-related research is shown in Table 12.2. The Chinese Academy of Sciences (China) ranks 1st in Publication Count and surpasses the next ranked institute by 200 publications. Five institutes among the top 20 have published between 490-900 publications and the remaining have published 300-400 publications. Among the top 20 institutes, University of California at Berkley (United States) has the highest FWCI at 3.21. Except for Universidade de Sao Paulo (Brazil), all the top 20 institutes have a mean FWCI above world average in this research field. The trends in publication output from 2007-2016 are shown in Figure 12.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Chinese Academy of Sciences (China)	1,125	17,649	1.48
2	Wageningen University & Research (Netherlands)	881	20,366	2.33
3	U.S. Department of Agriculture (United States)	761	16,890	1.95
4	INRA Institut National de La Recherche Agronomique (France)	617	15,185	2.18
5	CNRS (France)	520	13,857	2.33
6	Universidade de Sao Paulo (Brazil)	492	4,845	1.21
7	CSIRO (Australia)	396	16,080	2.31
8	Tsinghua University (China)	395	7,040	1.83
9	Ministry of Education China (China)	389	6,102	1.67
10	Universiti Teknologi Malaysia (Malaysia)	357	3,855	1.96
11	Delft University of Technology (Netherlands)	355	7,960	1.82
12	CNR (Italy)	342	4,686	1.67
13	CSIC (Spain)	337	9,533	1.90
14	University of Queensland (Australia)	333	10,648	2.64
15	Ghent University (Belgium)	333	8,524	2.26
16	ETH Zurich (Switzerland)	333	8,656	2.51
17	Texas A and M University (United States)	315	5,859	1.78
18	University of California at Berkeley (United States)	312	9,311	3.21
19	Politecnico di Milano (Italy)	309	3,044	2.02
20	Technical University of Denmark (Denmark)	306	9,395	2.55

Table 12.2— *Top 20 research Institutes ranked based on SDG12 publication output and FWCI from 2007-2016. (Source: Scopus)*

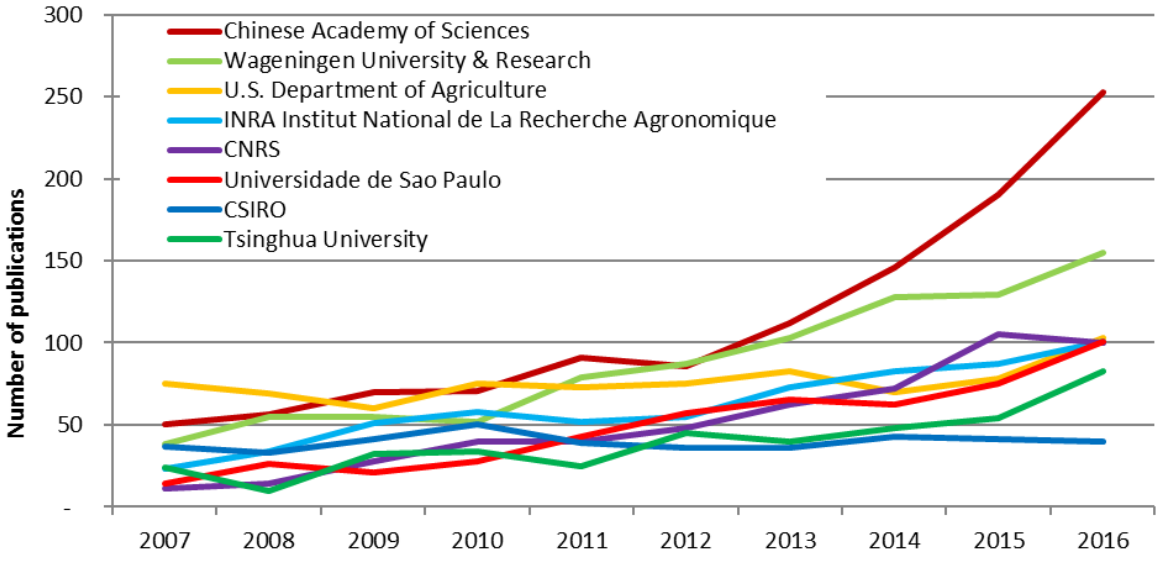


Figure 12.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG12. (Source: Scopus)*

12.3.3 Top 20 researchers conducting SDG12 research

A list of the top 20 researchers publishing in the SDG12 field based on publication output from 2007-2016 is shown in Table 12.3. Lal R. ranks 1st in Publication Count followed by Geng Y. and Dinçer I.
Geng Y., Dinçer I., and Zhang F. are the top 3 researchers in this list in terms of H-index.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Lal R.	Ohio State University (United States)	61	1,657	2.21	76
2	Geng Y.	Shanghai Jiaotong University (China)	56	1,290	2.50	41
3	Dinçer I.	University of Ontario Institute of Technology (Canada)	51	1,311	3.67	73
4	Sarkis J.	Worcester Polytechnic Institute (United States)	49	2,587	5.68	62
5	Chen B.	Beijing Normal University (China)	41	1,098	2.45	46
6	Ulgiati S.	Universita degli Studi di Napoli Parthenope (Italy)	41	919	2.02	38
7	El-Halwagi M.	Texas A and M University (United States)	41	608	1.77	40
8	Faaij A.	University of Groningen (Netherlands)	37	1,955	3.34	61
9	Dewulf J.	Universiteit Gent (Belgium)	37	786	2.18	45
10	Germani M.	Universita Politecnica delle Marche (Italy)	37	138	1.60	12
11	Taisch M.	Politecnico di Milano (Italy)	36	180	2.28	15
12	Lee K.	Universiti Sains Malaysia (Malaysia)	36	1,777	1.79	49
13	Gabarrell X.	Institut de Ciencia i Tecnologia Ambientals (ICTA)-UAB (Spain)	35	548	1.70	26
14	YANG Z.	Beijing Normal University (China)	35	603	1.70	50
15	Ng D.	The University of Nottingham Malaysia Campus (Malaysia)	34	486	3.40	29
16	Zhang F.	China Agricultural University (China)	33	886	2.35	72
17	Haapala K.	Oregon State University (United States)	33	232	1.78	12
18	Narodoslawsky M.	Technische Universitat Graz (Austria)	33	473	1.64	18
19	Webber M.	University of Texas at Austin (United States)	33	253	1.33	29
20	Huisingh D.	University of Tennessee, Knoxville (United States)	31	1,228	6.13	26

Table 12.3— *Top 20 researchers publishing SDG12 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG12 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

12.3.4 Top 10 journals publishing SDG12 research

A list of the top 10 journals publishing SDG12-related research from 2007-2016 is shown in Table 12.4. *Advanced Materials Research* published 1,554 SDG12 related publications, closely followed by *Journal of Cleaner Production*, making these the highest ranked journals in terms of SDG12 publications. Among these two top journals, only the *Journal of Cleaner Production* had an FWCI that exceeded the world average for SDG12 research and a CiteScore indicating an average of 3.7 citations per article. *Renewable and Sustainable Energy Reviews* ranks 1st in terms of CiteScore, with 7.66 citations per article on average, which is not surprising given that reviews garner more citations in general than original research.

Rank	Journal	Publication count	FWCI	CiteScore
1	Advanced Materials Research	1,554	0.55	0.17
2	Journal of Cleaner Production	1,509	3.27	3.70
3	Acta Horticulturae	828	1.09	0.20
4	Renewable and Sustainable Energy Reviews	819	1.34	7.66
5	Sustainability	782	1.09	0.92
6	Applied Mechanics and Materials	519	0.54	0.11
7	Energy Policy	404	1.83	3.52
8	WIT Transactions on Ecology and the Environment	390	0.10	0.08
9	Energy Procedia	389	1.41	2.05
10	Acta Ecologica Sinica	386	0.21	0.55

Table 12.4— *Top 10 journals based on SDG12 publication output from 2007-2016. FWCI is mean FWCI for any SDG12 publications in the journal during the period; CiteScore is based on data for the journal as a whole. (Source: Scopus)*

12.4 Research efforts focused on SDG12

12.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 12.3, the United States leads in terms of research output related to SDG12. The China lags behind the US by approximately 5,000 publications while the United Kingdom, Germany, Italy and Brazil have followed a similar trend in publication output during the period with 3,000-6,000 per country. Among comparators, Colombia has the lowest scholarly output in this field, just below Mexico. However, as shown in Table 12.5, Colombia has seen the greatest growth in research output in this field with a Compound Annual Growth Rate (CAGR) of 40.4%. After Colombia, Italy, Brazil and China have the highest CAGR at 20-23%. All countries analysed have a CAGR above 11% in this field and the CAGR for all research on SDG12 is 9.6%.

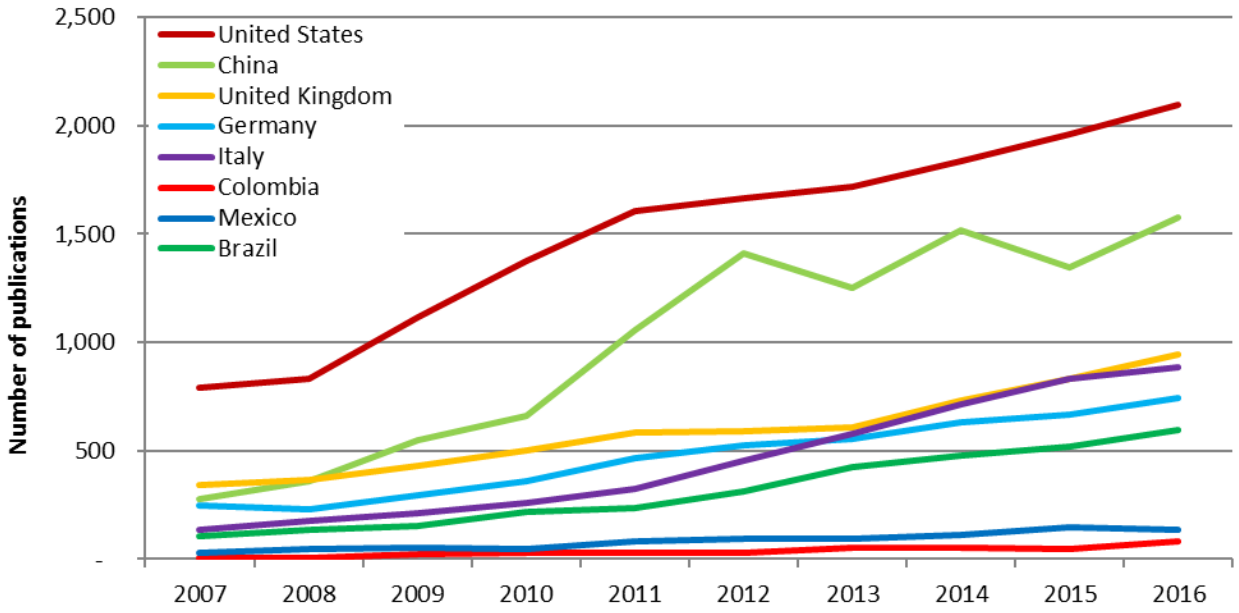


Figure 12.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	14,993	11.40%
China	10,023	21.20%
United Kingdom	5,936	11.90%
Germany	4,718	13.20%
Italy	4,572	23.30%
Colombia	363	40.40%
Mexico	839	17.20%
Brazil	3,179	21.50%
World	78,468	9.60%

Table 12.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

12.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG12 related research from 2006-2017 is 1.31.

Country	FWCI
United States	1.74
China	1.08
United Kingdom	1.99
Germany	1.73
Italy	1.71
Colombia	1.17
Mexico	1.12
Brazil	0.96
World	1.31

Comparing the FWCI of SDG12 publications from each of the eight countries included in this chapter reveals that the United Kingdom leads in terms of FWCI with an FWCI near 2.0 (Table 12.6). The United States, Germany and Italy all have an FWCI near 1.7. Among countries analysed, China, Brazil and Mexico have an FWCI below the world average for this subject.

Table 12.6— *FWCI per Comparator, 2007-2016. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

12.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 12.4 and Table 12.7, the United States leads in terms of SDG12 publications with close to 3,000 publications that are among the top 10% most cited. The other top 5 countries – China, United Kingdom, Germany, and Italy – have similar counts of top 10% papers. Colombia has 45 publications among the top 10% most cited during this time period. China has the highest CAGR for this metric, which combined with its large output, suggests it is on course to be on a par with the United States in the near future.

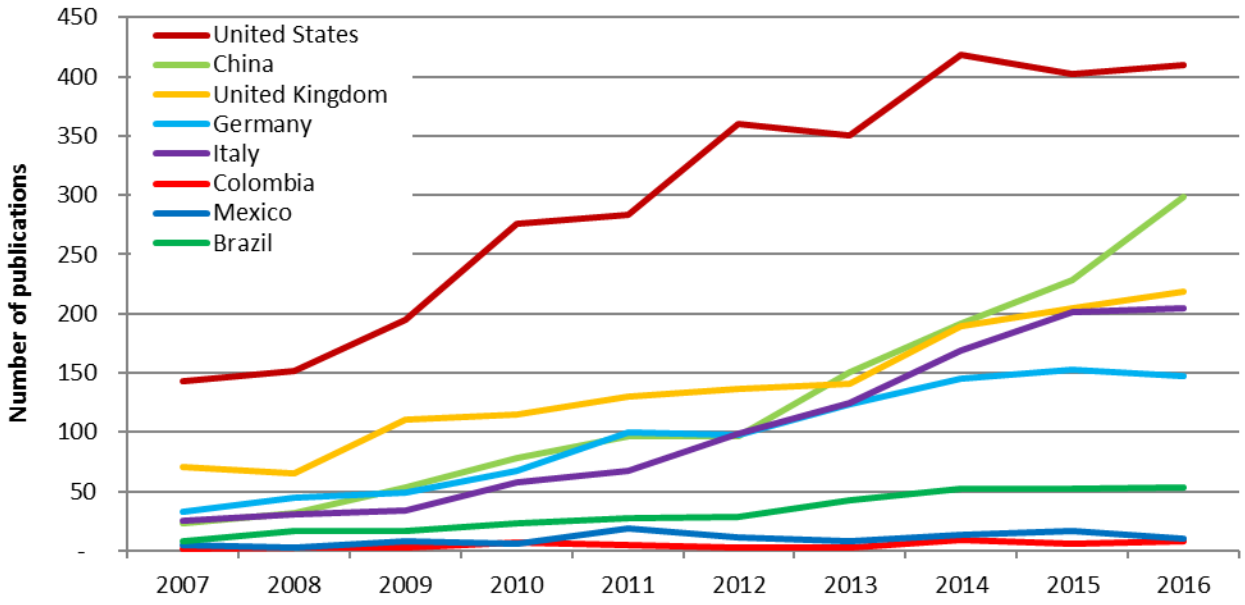


Figure 12.4— *Top 10% most cited publications on SDG12 from 2007-2016 per country. CAGR shown at top of each bar. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
United States	2,990	12.42%
China	1,246	32.93%
United Kingdom	1,381	13.33%
Germany	960	18.06%
Italy	1,013	26.27%
Colombia	45	25.99%
Mexico	98	8.01%
Brazil	318	23.38%
World	11,739	15.89%

Table 12.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG12 publications from 2007-2016. (Source: Scopus)*

12.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 12.8 provides the count of SDG12 publications from each country that have been cited in patents and the number of patents that have cited these publications. For the United States, 306 US publications on SDG12 have been cited in 1,232 patents. China, The United Kingdom and Germany follow with 80-90 publications cited in 200-300 patents. Three of Colombia's publications have been cited in 3 patents.

Country	Patent Cited Publications	Patents Citing Publications
United States	306	1,232
China	90	313
United Kingdom	81	202
Germany	83	201
Italy	34	68
Colombia	3	3
Mexico	7	17
Brazil	21	30
World	976	3,066

Table 12.8— *Number of publications cited in patent and patents citing publications on SDG12 from 2007 to 2016. (Source: Scopus)*

12.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG12. To identify patents relevant to SDG12, we retrieved all the patents citing any SDG12-related publication. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO. From 2006 to 2016, the United States had the highest number of SDG12-related patents (both applied for and granted) with 421 patent applications and 887 patents granted (Table 12.9). Germany, the United Kingdom and China account for 2-7% of patents in this field while Colombia has 1 patent application and 2 patents granted in this field. Note that China may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	421	887	1,308	57.27%
China	41	19	60	2.63%
United Kingdom	53	27	80	3.50%
Germany	122	41	163	7.14%
Italy	28	4	32	1.40%
Colombia	1	2	3	0.13%
Mexico	4	1	5	0.22%
Brazil	6	1	7	0.31%
World	1,098	1,186	2,284	

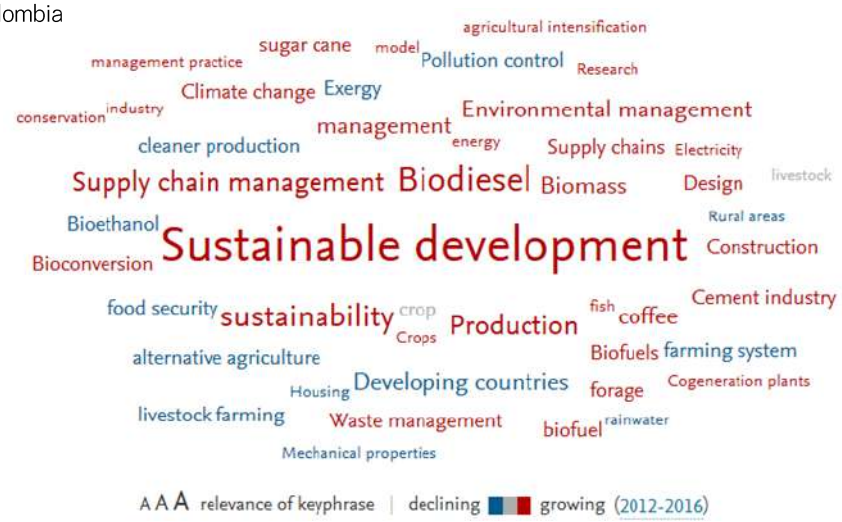
Table 12.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

12.4.6 **Research Focus**

Within the topic of SDG12-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG12-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG12 research is shown in Figure 12.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG12 research from Colombia, terms that stand out as unique to Colombia are 'Energy', and 'Cleaner Production'. Among the top 50 key phrases the terms 'Supply Chain Management', 'Environmental Management', 'Supply Chains', 'Industry', 'Production', 'Biomass', 'Alternative Agriculture', and 'Biofuels' were common among the countries analyzed. Figure 12.5 provides a visualization of the top 50 key phrases for SDG12 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

Colombia



Mexico

Figure 12.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Brazil

United States

China

United Kingdom

Germany

Italy

12.5 The reach of Colombia's SDG12 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

12.5.1 Downloads

As shown in the Figure 12.6, the mean count of downloads per ScienceDirect publication is similar across all countries. For Colombia, there is a peak in 2009 that results from five SD articles that were downloaded more than 60,000 times, resulting in a high 'mean' value. The United Kingdom's SD publications consistently receive more downloads per publication than other countries.

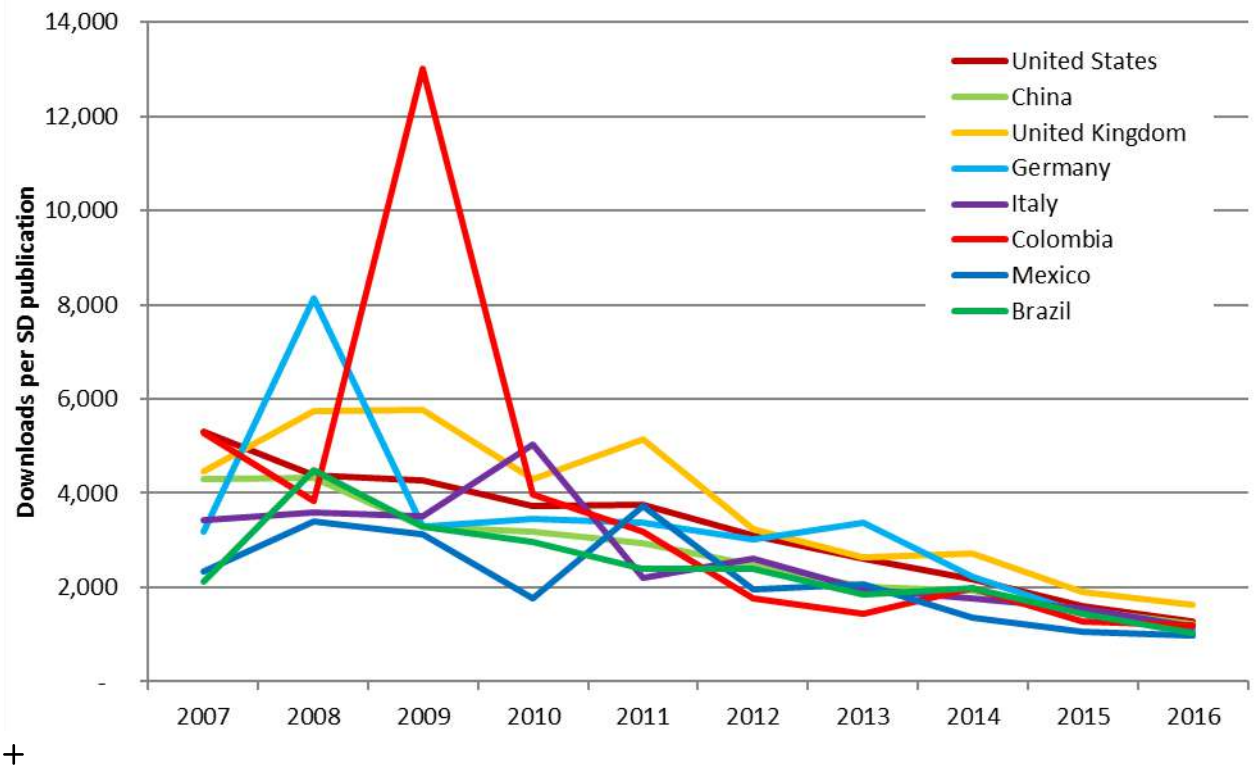


Figure 12.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

12.5.2 Field Weighted Download Impact (FWDI)

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. All countries analyzed have an FWDI above the world average for all research (10.) and near the world average for SDG12 research (world average FWDI = 1.5; Figure 12.7).

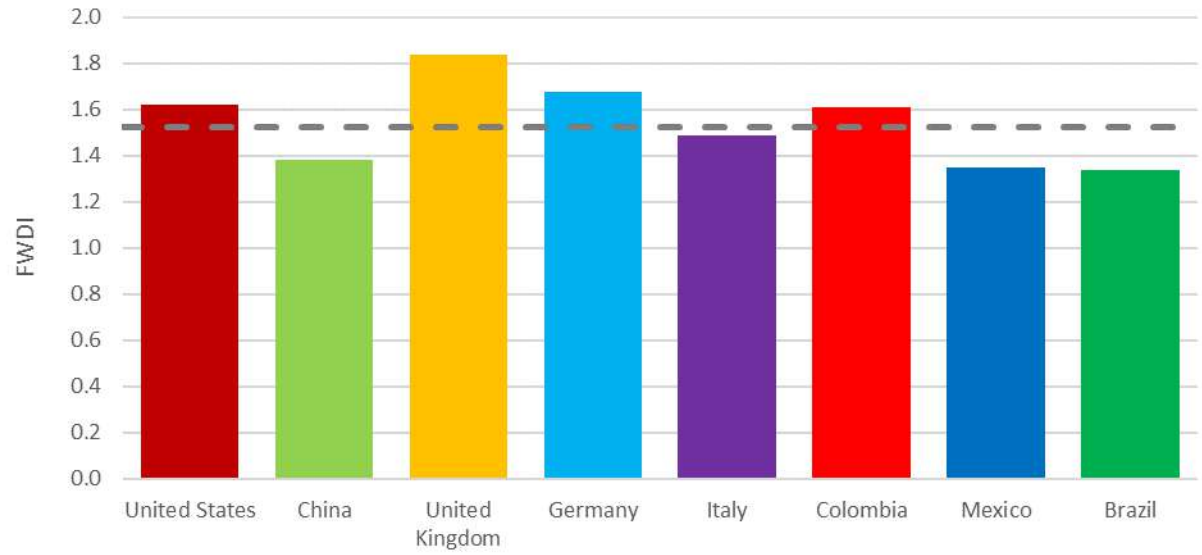


Figure 12.7 — *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. Grey dotted line indicates average for all SDG12 research. (Source: ScienceDirect)*

12.6 SDG12 collaboration network

12.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG12-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 12.10-12.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG12 publications with. Among partner institutes, Colombia has published the most SDG12 papers in collaboration with three institutes: International Crops Research Institute for the Semi-Arid Tropics (India); Wageningen University & Research (Netherlands); CSIC (Spain). The highest FWCI came from publications with INRA Institut National de La Recherche Agronomique (France) and the United Nations. Notably, publication on this subject with 12 of the 20 top partners yielded an FWCI above 3.0, which is more than double the world average for SDG12 research.

Country	Institution (Country)	Publication Count	FWCI
Colombia	International Crops Research Institute for the Semi-Arid Tropics (India)	7	4.76
	Wageningen University & Research (Netherlands)	7	4.32
	CSIC (Spain)	7	3.81
	IRD (France)	6	3.88
	KU Leuven (Belgium)	6	3.79
	Universidad Nacional Autonoma de Mexico (Mexico)	6	1.64
	Aarhus University (Denmark)	6	1.03
	INRA Institut National de La Recherche Agronomique (France)	5	7.91
	Universitat Rovira i Virgili (Spain)	5	4.33
	Universitat Politecnica de Catalunya (Spain)	5	2.28
	Universite Pierre et Marie Curie (France)	5	2.14
	Japan International Research Center for Agricultural Sciences (Japan)	5	1.87
	Universidade de Sao Paulo (Brazil)	5	1.73
	Universitat Autonoma de Barcelona (Spain)	5	1.43
	CIRAD (France)	5	1.42
	United Nations (United States)	4	7.34
	Chinese Academy of Agricultural Sciences (China)	4	6.67
	U.S. Department of Agriculture (United States)	4	5.98
	International Livestock Research Institute (Kenya)	4	5.73
	CNRS (France)	4	3.24

Table 12.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	Texas A and M University (United States)	35	2.09
	King Abdulaziz University (Saudi Arabia)	18	2.15
	Wageningen University & Research (Netherlands)	17	3.56
	KU Leuven (Belgium)	15	2.11
	U.S. Department of Agriculture (United States)	14	1.69
	INRA Institut National de La Recherche Agronomique (France)	10	3.83
	Clark University (United States)	9	0.70
	CSIC (Spain)	8	3.04
	Ghent University (Belgium)	8	1.57
	New Mexico State University (United States)	8	0.79
	SUNY Albany (United States)	8	0.71
	Universitat Politecnica de Catalunya (Spain)	8	0.48
	Cornell University (United States)	7	2.73
	University of California at Berkeley (United States)	7	2.07
	CNRS (France)	6	4.63
	International Crops Research Institute for the Semi-Arid Tropics (India)	6	3.48
	University of Massachusetts Lowell (United States)	6	1.48
	Universidad Nacional de Colombia (Colombia)	6	0.73
	Utrecht University (Netherlands)	5	4.36
	Yale University (United States)	5	2.73

Table 12.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	U.S. Department of Agriculture (United States)	32	3.49
	INRA Institut National de La Recherche Agronomique (France)	27	4.04
	CIRAD (France)	25	2.23
	University of Florida (United States)	24	1.56
	Wageningen University & Research (Netherlands)	22	1.51
	Universidade Nova de Lisboa (Portugal)	15	1.64
	CNRS (France)	14	3.89
	Universidad Politecnica de Valencia (Spain)	13	2.68
	University of East Anglia (United Kingdom)	12	6.51
	CSIRO (Australia)	11	2.46
	AgroParisTech (France)	10	4.61
	IRD (France)	10	2.48
	Universidade do Porto (Portugal)	10	1.81
	Colorado State University (United States)	9	4.84
	Yale University (United States)	8	4.79
	Swedish University of Agricultural Sciences (Sweden)	8	2.89
	University of Illinois at Urbana-Champaign (United States)	8	2.13
	University of Tennessee, Knoxville (United States)	8	1.71
	Florida State University (United States)	8	1.17
	Royal Institute of Technology (Sweden)	8	1.09

Table 12.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	Chinese Academy of Sciences (China)	125	2.77
	Wageningen University & Research (Netherlands)	81	4.10
	Universidade de Sao Paulo (Brazil)	52	1.90
	CSIRO (Australia)	51	3.88
	Tsinghua University (China)	49	2.73
	University of Queensland (Australia)	45	8.10
	University of Cambridge (United Kingdom)	45	7.86
	University of British Columbia (Canada)	45	6.46
	ETH Zurich (Switzerland)	45	3.83
	University of Toronto (Canada)	41	1.91
	China Agricultural University (China)	38	2.30
	Swedish University of Agricultural Sciences (Sweden)	37	3.87
	Ministry of Education China (China)	37	2.21
	McGill University (Canada)	36	7.77
	CNRS (France)	36	5.31
	INRA Institut National de La Recherche Agronomique (France)	36	4.68
	King Abdulaziz University (Saudi Arabia)	36	2.43
	Zhejiang University (China)	31	3.31
	Embrapa - Empresa Brasileira de Pesquisa Agropecuaria (Brazil)	31	2.23
	Ghent University (Belgium)	30	5.31

Table 12.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
China	Hong Kong Polytechnic University (Hong Kong)	75	1.81
	Wageningen University & Research (Netherlands)	57	2.06
	U.S. Department of Agriculture (United States)	46	2.54
	National Institute for Environmental Studies of Japan (Japan)	40	3.21
	City University of Hong Kong (Hong Kong)	38	1.27
	Arizona State University (United States)	33	2.34
	CSIRO (Australia)	30	2.11
	National University of Singapore (Singapore)	29	4.29
	AgriFood Canada (Canada)	29	1.48
	Nanyang Technological University (Singapore)	27	2.45
	Hong Kong University of Science and Technology (Hong Kong)	26	2.63
	University of Regina (Canada)	26	2.13
	International Institute for Applied Systems Analysis, Laxenburg (Austria)	25	4.06
	University of Michigan (United States)	25	2.19
	Purdue University (United States)	23	2.19
	University of Hong Kong (Hong Kong)	23	1.97
	Texas A and M University (United States)	23	1.96
	King Abdulaziz University (Saudi Arabia)	22	3.40
	University of Cambridge (United Kingdom)	21	4.87
	Georgia Institute of Technology (United States)	21	4.17

+

Table 12.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for China. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	Wageningen University & Research (Netherlands)	81	3.26
	INRA Institut National de La Recherche Agronomique (France)	58	3.13
	CNRS (France)	34	3.56
	CSIC (Spain)	32	2.18
	Ghent University (Belgium)	31	2.53
	Chinese Academy of Sciences (China)	29	3.71
	CSIRO (Australia)	28	3.95
	University of Copenhagen (Denmark)	28	2.45
	University of Sydney (Australia)	27	3.57
	Swedish University of Agricultural Sciences (Sweden)	27	3.25
	Aarhus University (Denmark)	26	3.40
	Universidade de Sao Paulo (Brazil)	25	2.50
	U.S. Department of Agriculture (United States)	24	3.86
	Delft University of Technology (Netherlands)	24	2.99
	European Commission Joint Research Centre Institute (Belgium)	23	6.34
	Technical University of Denmark (Denmark)	23	2.30
	Harvard University (United States)	22	6.83
	China Agricultural University (China)	22	3.31
	Utrecht University (Netherlands)	21	7.32
	University College Dublin (Ireland)	21	2.87

Table 12.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Germany	Wageningen University & Research (Netherlands)	87	2.76
	ETH Zurich (Switzerland)	67	3.05
	CNRS (France)	42	4.93
	INRA Institut National de La Recherche Agronomique (France)	40	4.30
	Chinese Academy of Sciences (China)	38	2.50
	European Commission Joint Research Centre Institute (Belgium)	35	2.36
	Swedish University of Agricultural Sciences (Sweden)	33	3.49
	Delft University of Technology (Netherlands)	33	1.86
	University of Helsinki (Finland)	26	2.86
	Technical University of Denmark (Denmark)	23	4.56
	Ghent University (Belgium)	23	4.52
	CNR (Italy)	23	2.97
	Aarhus University (Denmark)	22	3.44
	Utrecht University (Netherlands)	22	3.19
	University of Copenhagen (Denmark)	21	2.52
	Politecnico di Milano (Italy)	21	2.23
	Universite Paris Saclay (France)	20	5.69
	CEA (France)	20	4.20
	International Institute for Applied Systems Analysis, Laxenburg (Austria)	19	5.19
	Vrije Universiteit (Netherlands)	19	3.18

Table 12.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Germany. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Italy	European Commission Joint Research Centre Institute (Belgium)	127	3.44
	Wageningen University & Research (Netherlands)	66	3.51
	INRA Institut National de La Recherche Agronomique (France)	40	3.34
	CSIC (Spain)	34	2.13
	European Commission (Belgium)	23	2.64
	CNRS (France)	23	1.57
	University of Copenhagen (Denmark)	22	3.00
	Aarhus University (Denmark)	22	2.30
	Ghent University (Belgium)	21	2.92
	ETH Zurich (Switzerland)	20	2.37
	Beijing Normal University (China)	18	3.11
	Universidad Politecnica de Madrid (Spain)	17	6.76
	Swedish University of Agricultural Sciences (Sweden)	17	2.57
	Technical University of Denmark (Denmark)	17	1.79
	Vrije Universiteit (Netherlands)	15	1.92
	KU Leuven (Belgium)	14	3.65
	Chalmers University of Technology (Sweden)	14	3.26
	Aristotle University of Thessaloniki (Greece)	14	2.34
	U.S. Department of Agriculture (United States)	13	3.43
	CIRAD (France)	13	2.05

+

Table 12.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Germany. (Source: Scopus)*

12.6.2 **Collaboration impact analysis**

To visualize the citation impact of collaborations, the ratio of FWCI from SDG12 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG12 publications (x-axis) was plotted against the ratio of the FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG12 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. For SDG12 research from 2007-2016, the majority of Colombia's collaborations with top 20 academic partners were mutually beneficial to both Colombia and the collaboration partner in terms of citation impact (Figure 12.8). Collaborations with the United Nations, Chinese Academy of Agricultural Sciences, INRA, and ASDA were particularly beneficial to both parties (relative to the FWCI for international SDG12 publications for each respectively). Publications with CIRAD, Universitat Autonoma de Barcelona and Aarhus yielded a lower average FWCI than each partner's SDG12 FWCI for international publications.

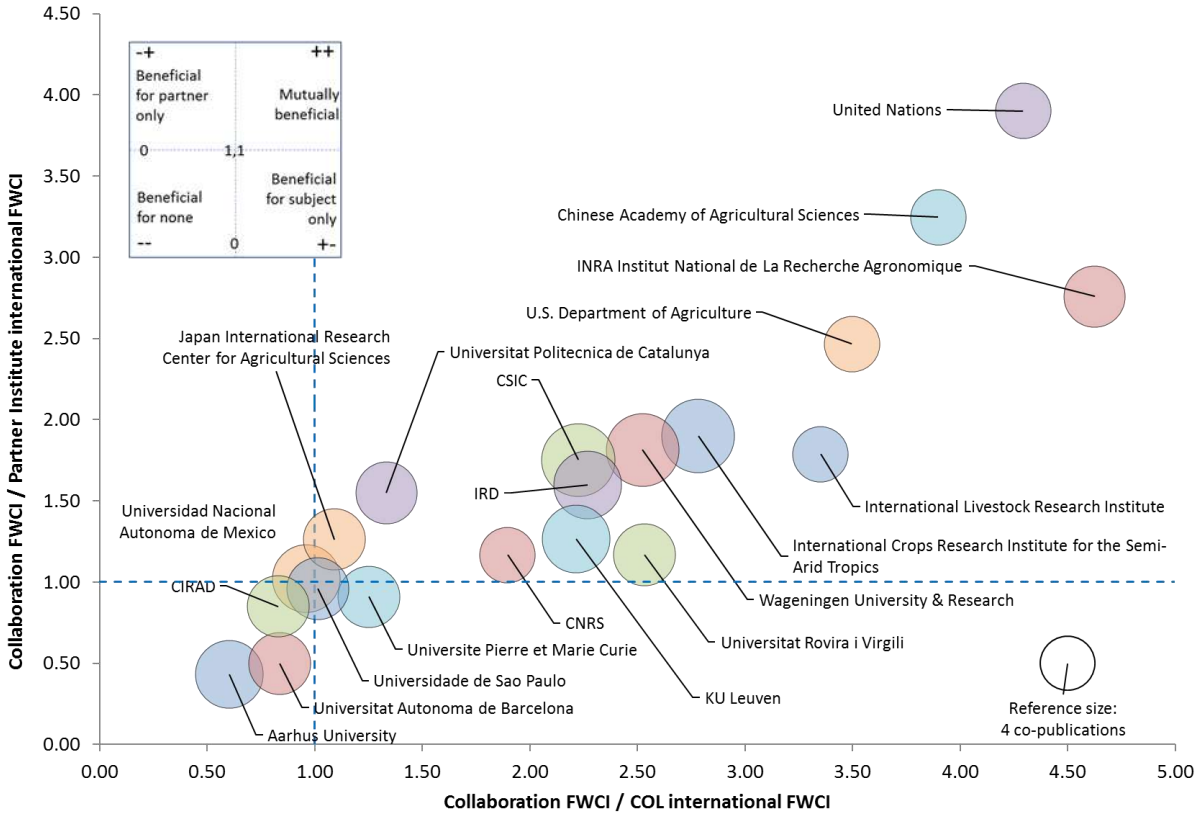


Figure 12.8— *Collaboration quadrant for Colombia and its top 20 collaborators on SDG1 from 2007-2016. (Source: Scopus).*

12.6.3 **Collaboration chart**

Figure 12.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG12. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 12.9 shows where there may be potential to improve output and impact through partnership. Colombia co-authored 4-7 publications with its top foreign partner institutes. Among Colombia's top 20 partners, Wageningen University & Research produces the highest number of SDG12 publications with 881 publications and International Livestock Research Institute has the highest FWCI for SDG12 research at 3.28. Colombia may want to leverage its existing relationships with these institutes to increase its publication output and impact in SDG12 research.

Figure 12.9— *Chart showing Colombia's top 20 collaborators on SDG12 from 2007-2016. Circle (node) size is proportional to the number of SDG12 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (3.28) and lightest shade of green indicating the lowest FWCI (1.09). (Source: Scopus).*

Chapter 13
Climate Action

In this Chapter, we assess research related to SDG13, which aims to take urgent action to combat climate change and its impacts. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

13.1 **Key Findings**

Goal 13: Take urgent action to combat climate change and its impacts

WORLD RESEARCH OUTPUT

136,651

Number of SDG13 publications, 2007-2016.

SDG13 PATENTS

2,489

Number of SDG13 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

620

Colombia's SDG13 publications, 2007-2016.

COLOMBIA'S RESEARCH OUTPUT CAGR

30%

Compound annual growth rate for Colombia's 2007-2016 SDG13 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

75

Colombia's SDG13 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

1.21

Average field-weighted citation impact for Colombia's SDG13 publications, 2007-2016.

13.2 SDG13 – Take urgent action to combat climate change and its impacts

According to the United Nations,

> *"Climate change is now affecting every country on every continent. It is disrupting national economies and affecting lives, costing people, communities and countries dearly today and even more tomorrow.*
> *People are experiencing the significant impacts of climate change, which include changing weather patterns, rising sea level, and more extreme weather events. The greenhouse gas emissions from human activities are driving climate change and continue to rise. They are now at their highest levels in history. Without action, the world's average surface temperature is projected to rise over the 21st century and is likely to surpass 3 degrees Celsius this century—with some areas of the world expected to warm even more. The poorest and most vulnerable people are being affected the most.*
> *Affordable, scalable solutions are now available to enable countries to leapfrog to cleaner, more resilient economies. The pace of change is quickening as more people are turning to renewable energy and a range of other measures that will reduce emissions and increase adaptation efforts.*
>
> *But climate change is a global challenge that does not respect national borders. Emissions anywhere affect people everywhere. It is an issue that requires solutions that need to be coordinated at the international level and it requires international cooperation to help developing countries move toward a low-carbon economy.*
>
> *To address climate change, countries adopted the Paris Agreement at the COP21 in Paris on 12 December 2015. The Agreement entered into force shortly thereafter, on 4 November 2016. In the agreement, all countries agreed to work to limit global temperature rise to well below 2 degrees Celsius, and given the grave risks, to strive for 1.5 degrees Celsius. You can learn more about the agreement here.*
>
> *Implementation of the Paris Agreement is essential for the achievement of the Sustainable Development Goals, and provides a roadmap for climate actions that will reduce emissions and build climate resilience."*[18]

The targets for SDG 13, according to the United Nations are:

- *"Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.*
- *Integrate climate change measures into national policies, strategies and planning.*
- *Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.*
- *Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible.*
- *Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities."*[18]

[18] http://www.un.org/sustainabledevelopment/climate-change-2/

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG13 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

13.3 SDG13: Leaders in the field

13.3.1 Top 5 countries conducting SDG13 research

The top 5 countries publishing on SDG13 based on cumulative publication output from 2007-2016 are shown in Table 13.1 and Figure 13.1. The United States ranks 1st according to Publication Count, Percentage of Global Output, and Citation Count. The United Kingdom ranks 1st in FWCI with 1.83. The world average for SDG13 research is above the world average for all research, at 1.21. Except for China, all other countries' FWCI exceeds the average for SDG13 research.

Table 13.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	27,423	20.07%	446,992	1.64
China	16,939	12.40%	146,310	1.02
United Kingdom	12,382	9.06%	220,869	1.83
Germany	7,953	5.82%	121,851	1.64
Australia	7,666	5.61%	132,485	1.76
World	136,651	100.00%	623,539	1.21

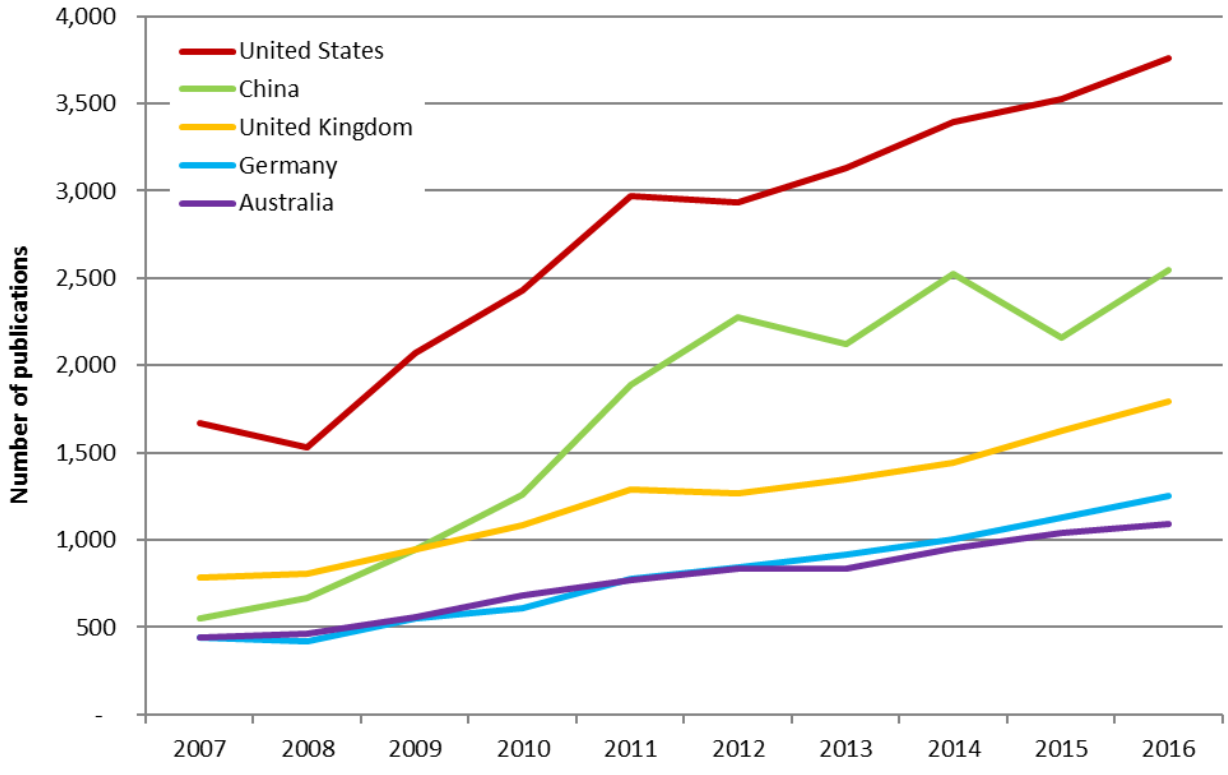


Figure 13.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG13 research. (Source: Scopus)*

13.3.2 Top 20 institutes conducting SDG13 research

A list of the top 20 research institutes publishing SDG13-related research is shown in Table 13.2. The Chinese Academy of Sciences (China) ranks 1st in Publication Count and surpasses the next ranked institute by nearly 900 publications. It is interesting to note that, the second highest ranked institute, Wageningen University & Research has the highest citation count, despite 900 fewer publications. Among the top 20 institutes, University of California at Berkeley (United States) has the highest FWCI at close to 3.0, more than double the world average for SDG13. The trends in publication output from 2007-2016 are shown in Figure 13.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Chinese Academy of Sciences (China)	2,284	30,599	1.32
2	Wageningen University & Research (Netherlands)	1,394	38,016	2.59
3	U.S. Department of Agriculture (United States)	1,167	25,754	1.88
4	CNRS (France)	912	20,076	2.10
5	INRA Institut National de La Recherche Agronomique (France)	877	21,315	2.20
6	CSIRO (Australia)	756	28,487	2.52
7	University of Queensland (Australia)	715	17,506	2.31
8	Universidade de Sao Paulo (Brazil)	714	7,649	1.32
9	Ministry of Education China (China)	664	8,252	1.36
10	University of British Columbia (Canada)	656	19,711	2.51
11	Arizona State University (United States)	616	21,844	2.78
12	Delft University of Technology (Netherlands)	614	10,344	1.95
13	Tsinghua University (China)	601	9,908	1.65
14	CSIC (Spain)	588	14,283	1.85
15	Beijing Normal University (China)	566	6,315	1.40
16	CNR (Italy)	554	6,986	1.53
17	ETH Zurich (Switzerland)	537	13,220	2.42
18	Texas A and M University (United States)	531	8,590	1.62
19	University of Florida (United States)	524	9,488	1.68
20	University of California at Berkeley (United States)	519	15,119	2.99

Table 13.2— *Top 20 research Institutes ranked based on SDG13 publication output and FWCI from 2007-2016. (Source: Scopus)*

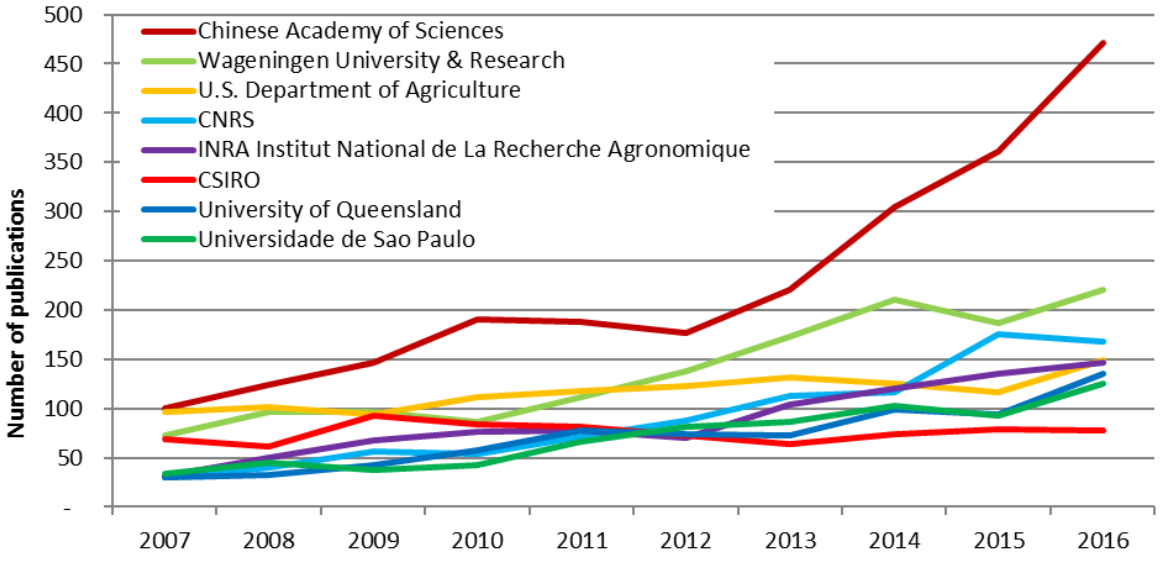


Figure 13.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG13. (Source: Scopus)*

13.3.3 Top 20 researchers conducting SDG13 research

A list of the top 20 researchers publishing in the SDG13 field based on publication output from 2007-2016 is shown in Table 13.3. Lal R. ranks 1st in Publication Count followed by Dinçer I. and Salvati L.
Antonietti M. has the highest h-index at 141 and Lal R., Dinçer I., Zhang F., Smith P. have the next highest h-index with an h-index near 70.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Lal R.	Ohio State University (United States)	85	1,966	1.96	76
2	Dinçer I.	University of Ontario Institute of Technology (Canada)	71	2,319	3.83	73
3	Salvati L.	Council for Agricultural Research and Economics (CREA) (Italy)	65	450	1.35	27
4	Geng Y.	Shanghai Jiaotong University (China)	59	1,267	2.45	41
5	YANG Z.	Beijing Normal University (China)	57	996	1.49	50
6	Chen B.	Beijing Normal University (China)	55	1,265	2.02	46
7	Faaij A.	University of Groningen (Netherlands)	49	2,518	4.00	61
8	Huang G.	Beijing Normal University (China)	49	930	1.93	50
9	Ulgiati S.	Universita degli Studi di Napoli Parthenope (Italy)	48	1,042	2.09	38
10	Zuo J.	Shenzhen University (China)	46	707	2.06	23
11	Zhang F.	China Agricultural University (China)	44	1,346	2.69	72
12	Ouyang Z.	Research Center for Eco-Environmental Sciences Chinese Academy of Sciences (China)	44	1,310	1.77	43
13	Webber M.	University of Texas at Austin (United States)	44	293	1.20	29
14	El-Halwagi M.	Texas A and M University (United States)	43	622	1.73	40
15	Štreimikiene D.	Lithuanian Energy Institute (Lithuania)	43	477	0.76	17
16	Smith P.	University of Aberdeen (United Kingdom)	41	1,867	3.89	71
17	Azapagic A.	University of Manchester (United Kingdom)	41	593	1.84	32
18	Antonietti M.	Max Planck Institut fur Kolloid Und Grenzflachenforschung Potsdam (Germany)	40	4,815	4.71	141
19	Scholz M.	University of Salford (United Kingdom)	39	385	0.80	26
20	Huisingh D.	University of Tennessee, Knoxville (United States)	38	1,265	5.22	26

Table 13.3— *Top 20 researchers publishing SDG13 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG13 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

13.3.4 Top 10 journals publishing SDG13 research

A list of the top 10 journals publishing SDG13-related research from 2007-2016 is shown in Table 13.4. *Advanced Materials Research* published 2,326 SDG13 related publications, making it the highest ranked journal in terms of SDG13 publications. *Journal of Cleaner Production* ranks 1st in terms of average FWCI from SDG13 publications and 2nd in terms of publication count. Given that reviews attract a higher count of citations, it is not surprising that *Renewable and Sustainable Energy Reviews* is in 1st place in terms of CiteScore. *Renewable and Sustainable Energy Reviews* is 4th in terms of publication count. Over half of the journals publishing the most SDG13 research have an FWCI above the world average.

Rank	Journal	Publication count	FWCI	CiteScore
1	Advanced Materials Research	2,326	0.51	0.17
2	Journal of Cleaner Production	1,623	3.06	3.70
3	Sustainability	1,430	1.04	0.92
4	Renewable and Sustainable Energy Reviews	1,292	1.21	7.66
5	Acta Horticulturae	971	1.09	0.20
6	Energy Policy	823	1.76	3.52
7	WIT Transactions on Ecology and the Environment	810	0.08	0.08
8	Applied Mechanics and Materials	791	0.47	0.11
9	Acta Ecologica Sinica	712	0.22	0.55
10	PLoS ONE	633	1.54	4.29

Table 13.4— *Top 10 journals based on SDG13 publication output from 2007-2016. FWCI is mean FWCI for any SDG13 publications in the journal during the period; CiteScore is based on data for the journal as a whole. (Source: Scopus)*

13.4 Research efforts focused on SDG13

13.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 13.3, the United States leads in terms of research output related to SDG13, followed by China, which surpassed the output of the United Kingdom in 2008. Germany and Australia follow the United Kingdom. Among comparators, Colombia has the lowest output in this field, just below Mexico. However, as shown in Table 1.5, Colombia has seen the greatest growth in research output in this field with a Compound Annual Growth Rate (CAGR) near 30%. All countries analysed have a CAGR above 9% in this field and the CAGR for SDG13 research globally was 8.4%.

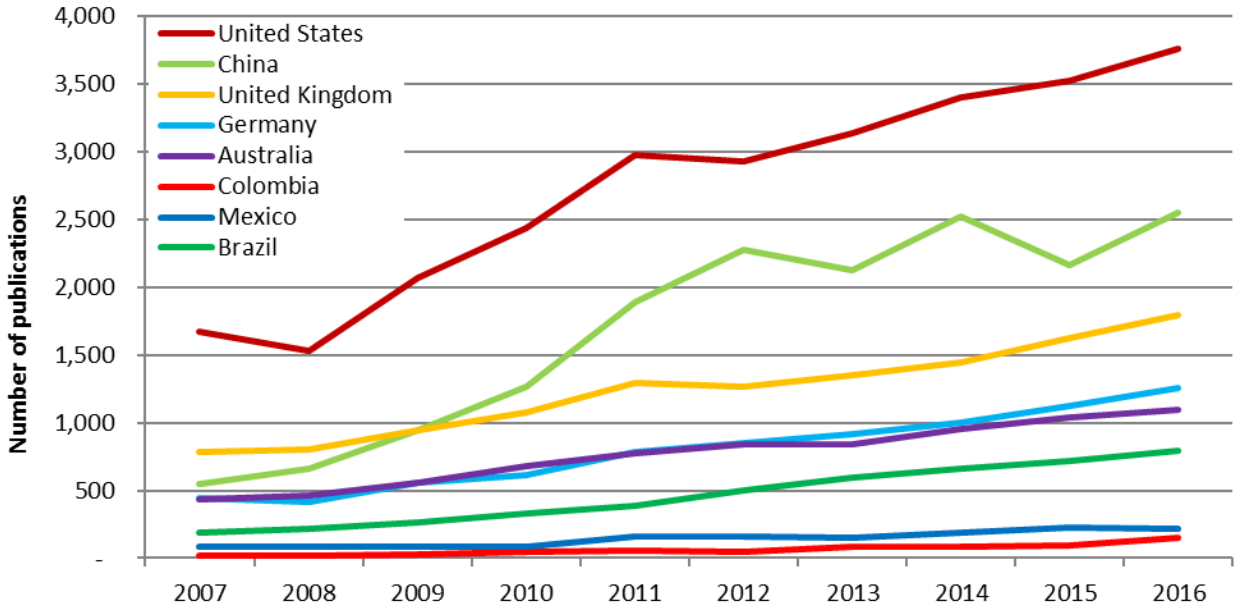


Figure 13.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	27,423	9.40%
China	16,939	18.50%
United Kingdom	12,382	9.60%
Germany	7,953	12.20%
Australia	7,666	10.70%
Colombia	620	29.90%
Mexico	1,453	10.80%
Brazil	4,650	17.30%
World	136,651	8.40%

Table 13.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

13.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG13 related research from 2006-2017 is 1.21.

Country	FWCI
United States	1.64
China	1.02
United Kingdom	1.83
Germany	1.64
Australia	1.76
Colombia	1.21
Mexico	1.18
Brazil	1.02
World	1.21

Comparing the FWCI of SDG13 publications from each of the eight countries included in this chapter reveals that the United Kingdom leads in terms of FWCI (Table 13.6). Along with the United Kingdom, the United States, Australia, Germany, and Colombia all have an FWCI at or above the world average for SDG13 research.

Table 13.6— *FWCI for SDG13 research from 2007-2016 per country and world. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

13.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 13.4 and Table 13.7, the United States leads in terms of SDG13 publications with 5,079 publications that are among the top 10% most cited. The United Kingdom comes in second in terms of total number of top 10% papers during the period. China recently surpassed the United Kingdom in this metric and has the highest CAGR for top 10% papers, suggesting that China may overtake the United States in this field in the near future.

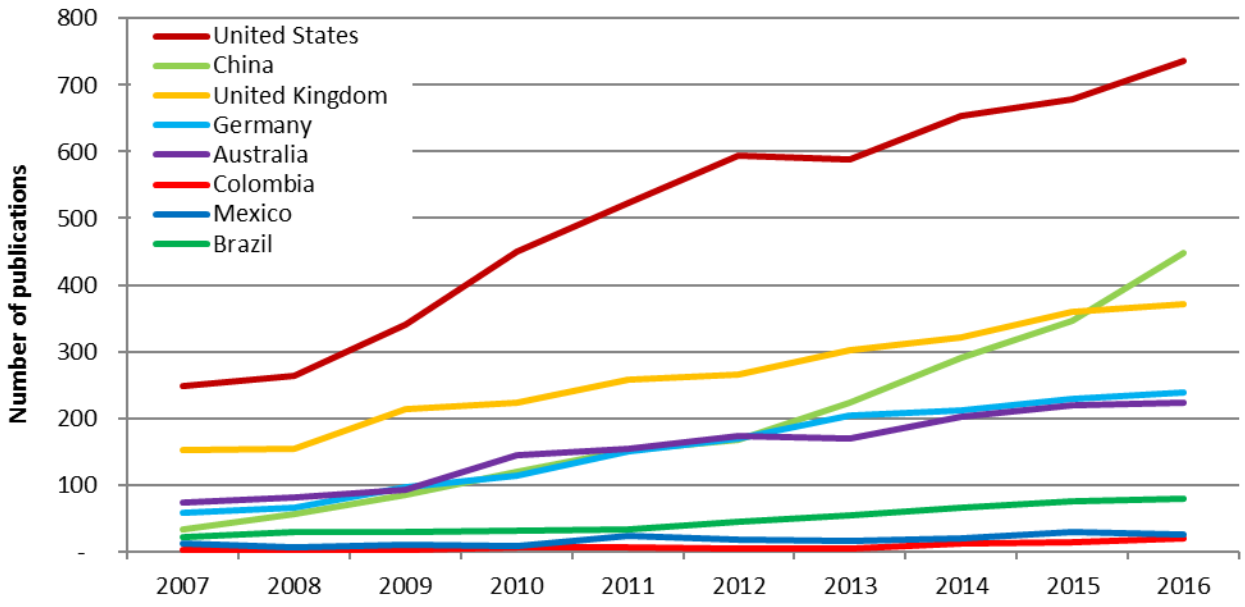


Figure 13.4— *Top 10% most cited publications on SDG13 from 2007-2016 per country. CAGR shown at top of each bar. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
United States	5,079	12.81%
China	1,922	33.17%
United Kingdom	2,622	10.46%
Germany	1,538	16.82%
Australia	1,532	13.04%
Colombia	75	22.76%
Mexico	170	7.54%
Brazil	467	15.26%
World	18,316	14.81%

Table 13.7— *Top 10% most cited publication count per Comparator and Compound Annual Growth Rate, 2007-2016. (Source: Scopus)*

13.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 13.8 provides the count of SDG13 publications from each country that have been cited in patents and the number of patents that have cited these publications. For the United States, 351 US publications on SDG13 have been cited in 1,361 patents. China, the United Kingdom, Germany and Australia also had 50 - 100 publications cited in 100-350 patents. Colombia had 3 publications cited in 3 patents.

Country	Patent Cited Publications	Patents Citing Publications
United States	351	1,361
China	98	351
United Kingdom	88	192
Germany	86	224
Australia	57	114
Colombia	3	3
Mexico	9	20
Brazil	20	29

Table 13.8— *Number of publications cited in patent and patents citing publications on SDG13 from 2007 to 2016. (Source: Scopus)*

13.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG13. To identify patents relevant to SDG13, we retrieved all the patents citing any SDG13-related publication. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO. From 2006 to 2016, the United States had the highest number of SDG13-related patents (both applied for and granted) with 445 patent applications and 1,041 patents granted (Table 13.9). Germany accounted for approximately 6% of the total patents in this field while China, Australia and the United Kingdom account for 2-4% of the patents in this field. Colombia applied for one patent and had two granted during the period. Note that China and Australia may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	445	1,041	1,486	59.70%
China	48	20	68	2.73%
United Kingdom	53	25	78	3.13%
Germany	118	40	158	6.35%
Australia	15	38	53	2.13%
Colombia	1	2	3	0.12%
Mexico	4	1	5	0.20%
Brazil	6	1	7	0.28%
World	1,150	1,339	2,489	

Table 13.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

13.4.6 **Research Focus**

Within the topic of SDG13-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG13-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG13 research is shown in Figure 13.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG13 research from Colombia, the term that stands out as unique to Colombia is 'Electricity'. Among the top 50 key phrases the terms 'Greenhouse Gases', 'Public Policy'; 'Economics', 'Conservation', 'Climate Change', 'Production', 'Ecosystem Service', 'Energy Efficiency', and 'Alternative Agriculture' were common among the countries analyzed. The term 'Agriculture' and 'Protected Area' stand out as unique to the Latin American countries. Figure 13.5 provides a visualization of the top 50 key phrases for SDG13 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

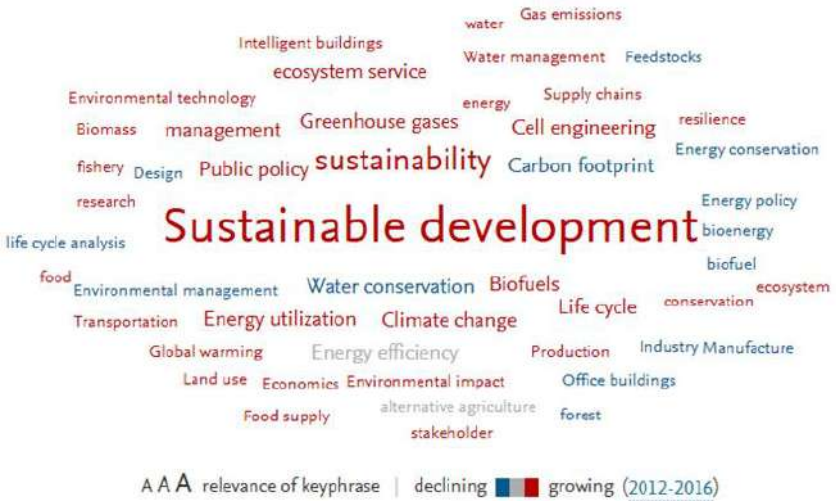
Colombia

Mexico

Figure 13.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Brazil

United States



China

United Kingdom

Germany

Australia

13.5 The reach of Colombia's SDG13 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

13.5.1 Downloads

As shown in the Figure 13.6, the mean count of downloads per ScienceDirect publication varies across all countries with the United Kingdom most consistently receiving a high count of downloads per SD publications. Mexico and Colombia receive the fewest downloads on average relative to the other countries analysed.

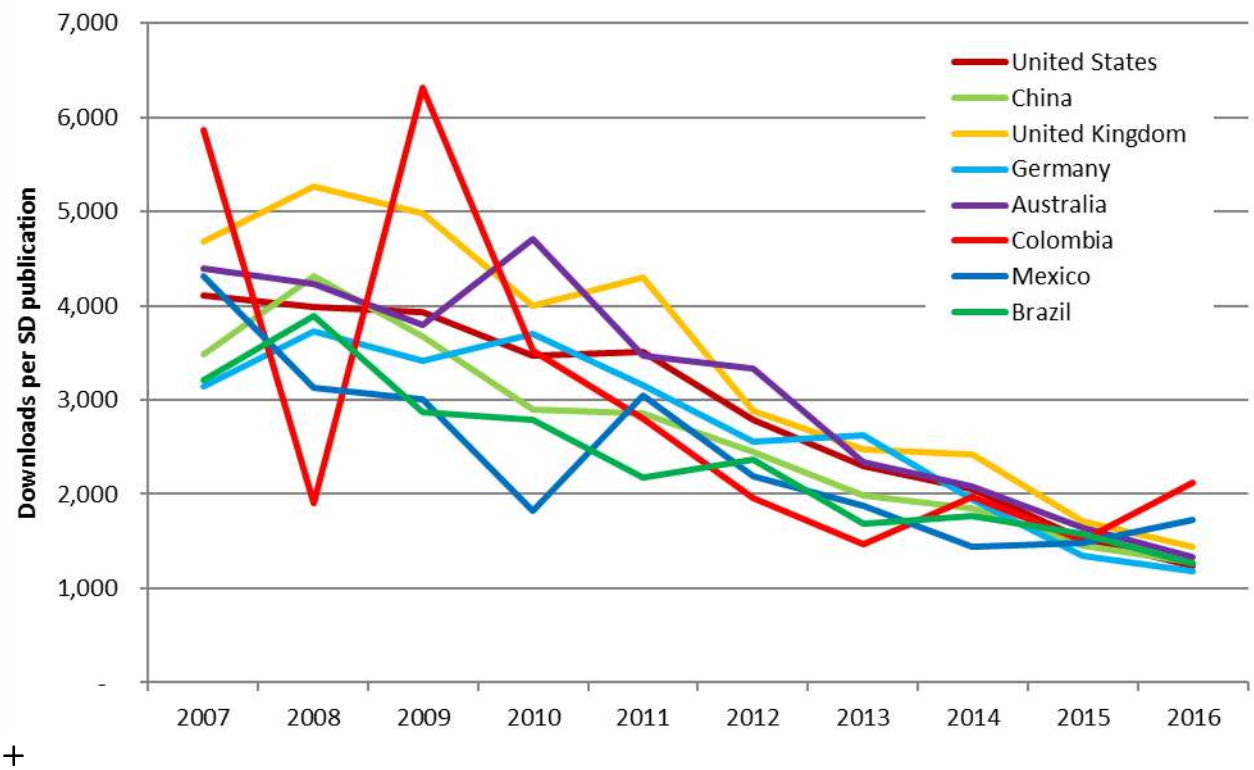


Figure 13.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

13.5.2 **Field Weighted Download Impact (FWDI)**

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. Colombia has the highest mean FWDI for the period of 2007-2016 (Figure 13.7). However, it is important to note that the FWDI for Colombia is based on only 150 SD publications and therefore, outliers may sway the mean significantly. Therefore, interpretation of this metric should focus on the top 5 countries only. All top 5 countries had an FWDI near the average for all SDG13 research (1.43).

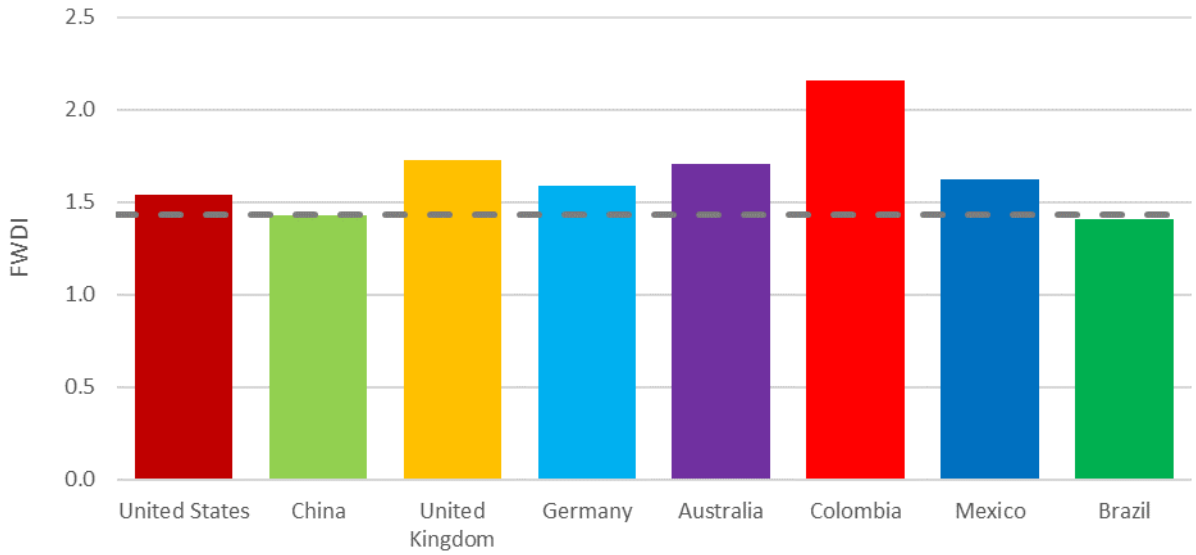


Figure 13.7 — *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. Grey dotted line indicates average for all SDG13 research. (Source: ScienceDirect)*

13.6 SDG13 collaboration network

13.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG13-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 13.10-13.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG13 publications with. Among academic partner institutes, Colombia has published the most SDG13 papers in collaboration with **Wageningen University & Research (Netherlands;** 17 publications from 2007-2016). The FWCI for these publications was very high at more than 5 times the world average for SDG13 research. Colombia's collaborated publications with each of the top 20 partners resulted in an FWCI greater than the world average for SDG13 research.

Country	Institution (Country)	Publication Count	FWCI
Colombia	Wageningen University & Research (Netherlands)	17	6.11
	Universidade de Sao Paulo (Brazil)	13	6.76
	Columbia University (United States)	12	6.22
	Aarhus University (Denmark)	11	6.87
	CSIC (Spain)	11	2.39
	Universidad Nacional Autonoma de Mexico (Mexico)	10	4.25
	International Crops Research Institute for the Semi-Arid Tropics (India)	9	4.22
	IRD (France)	9	2.29
	Imperial College London (United Kingdom)	8	10.50
	University of Cambridge (United Kingdom)	8	8.72
	Stanford University (United States)	8	8.12
	University of Leeds (United Kingdom)	8	2.63
	United Nations (United States)	7	12.82
	Yale University (United States)	7	11.27
	INRA Institut National de La Recherche Agronomique (France)	7	8.21
	University of California at Davis (United States)	7	3.79
	CIRAD (France)	7	2.24
	Universitat Politecnica de Catalunya (Spain)	7	2.21
	Universite Pierre et Marie Curie (France)	7	1.78
	University of British Columbia (Canada)	6	13.11

Table 13.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	Texas A and M University (United States)	39	2.20
	Wageningen University & Research (Netherlands)	37	4.95
	University of Arizona (United States)	23	3.75
	KU Leuven (Belgium)	21	2.48
	King Abdulaziz University (Saudi Arabia)	18	2.25
	U.S. Department of Agriculture (United States)	18	1.54
	INRA Institut National de La Recherche Agronomique (France)	15	3.59
	CSIC (Spain)	14	2.42
	Ghent University (Belgium)	13	6.70
	Stanford University (United States)	13	6.59
	Arizona State University (United States)	13	3.01
	University of British Columbia (Canada)	12	8.08
	Yale University (United States)	12	7.14
	CSIRO (Australia)	12	5.39
	SUNY Albany (United States)	11	6.46
	Universidad Nacional de Colombia (Colombia)	11	6.26
	University of California at Berkeley (United States)	11	1.59
	World Health Organization (Switzerland)	10	11.89
	Imperial College London (United Kingdom)	10	10.13
	University of Toronto (Canada)	10	9.61

Table 13.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	University of Florida (United States)	62	1.90
	Wageningen University & Research (Netherlands)	50	4.06
	U.S. Department of Agriculture (United States)	49	3.32
	CIRAD (France)	46	1.98
	INRA Institut National de La Recherche Agronomique (France)	42	4.26
	IRD (France)	28	3.55
	Harvard University (United States)	27	8.23
	University of East Anglia (United Kingdom)	27	6.13
	University of Oxford (United Kingdom)	26	6.55
	Yale University (United States)	24	5.41
	CNRS (France)	23	4.46
	World Health Organization (Switzerland)	21	5.12
	CSIRO (Australia)	21	3.91
	Universidad Nacional Autonoma de Mexico (Mexico)	21	3.74
	Universidade Nova de Lisboa (Portugal)	20	2.00
	United Nations (United States)	19	5.26
	Colorado State University (United States)	19	4.73
	Stanford University (United States)	18	8.92
	Universidade de Lisboa (Portugal)	18	2.55
	Imperial College London (United Kingdom)	17	9.56

Table 13.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	Chinese Academy of Sciences (China)	320	2.12
	Wageningen University & Research (Netherlands)	156	4.74
	University of British Columbia (Canada)	148	5.31
	CSIRO (Australia)	118	5.32
	University of Cambridge (United Kingdom)	110	5.47
	CNRS (France)	107	4.73
	University of Queensland (Australia)	101	6.04
	University of Oxford (United Kingdom)	101	4.61
	Universidade de Sao Paulo (Brazil)	100	3.05
	World Health Organization (Switzerland)	95	4.41
	University of Toronto (Canada)	94	2.61
	Tsinghua University (China)	87	2.56
	McGill University (Canada)	82	6.27
	Stockholm University (Sweden)	80	7.47
	Imperial College London (United Kingdom)	79	5.29
	Beijing Normal University (China)	79	2.22
	Ministry of Education China (China)	77	1.63
	Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences (China)	77	1.46
	Swedish University of Agricultural Sciences (Sweden)	75	5.08
	University of Cape Town (South Africa)	75	4.12

Table 13.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
China	Hong Kong Polytechnic University (Hong Kong)	132	1.79
	U.S. Department of Agriculture (United States)	97	2.61
	University of Hong Kong (Hong Kong)	85	2.48
	Wageningen University & Research (Netherlands)	77	3.11
	Colorado State University (United States)	75	0.72
	City University of Hong Kong (Hong Kong)	73	1.94
	Arizona State University (United States)	66	2.62
	CSIRO (Australia)	59	2.47
	National Institute for Environmental Studies of Japan (Japan)	51	3.01
	National University of Singapore (Singapore)	49	3.61
	University of Regina (Canada)	48	2.02
	University of British Columbia (Canada)	46	3.89
	AgriFood Canada (Canada)	43	1.74
	Chinese University of Hong Kong (Hong Kong)	42	1.83
	University of Cambridge (United Kingdom)	41	4.53
	University of Maryland (United States)	40	3.17
	Texas A and M University (United States)	40	1.98
	Purdue University (United States)	40	1.95
	University of Adelaide (Australia)	39	3.85
	University of Western Australia (Australia)	39	3.40

Table 13.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for China. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	Wageningen University & Research (Netherlands)	188	4.26
	CNRS (France)	97	3.61
	INRA Institut National de La Recherche Agronomique (France)	92	3.58
	CSIC (Spain)	78	2.20
	University of Copenhagen (Denmark)	71	4.50
	European Commission Joint Research Centre Institute (Belgium)	71	4.19
	Harvard University (United States)	66	7.32
	CSIRO (Australia)	66	6.42
	Chinese Academy of Sciences (China)	66	2.63
	Aarhus University (Denmark)	65	3.70
	University of Cape Town (South Africa)	63	4.28
	Ghent University (Belgium)	63	3.30
	University of British Columbia (Canada)	60	8.58
	Swedish University of Agricultural Sciences (Sweden)	59	4.72
	University of Queensland (Australia)	55	6.70
	University of Sydney (Australia)	55	4.12
	United Nations (United States)	53	4.56
	World Health Organization (Switzerland)	52	5.64
	Stockholm University (Sweden)	52	5.64
	CNR (Italy)	51	2.84

Table 13.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Germany	Wageningen University & Research (Netherlands)	180	3.56
	CNRS (France)	90	4.11
	ETH Zurich (Switzerland)	88	3.28
	European Commission Joint Research Centre Institute (Belgium)	75	2.54
	INRA Institut National de La Recherche Agronomique (France)	73	4.95
	Chinese Academy of Sciences (China)	73	2.49
	Swedish University of Agricultural Sciences (Sweden)	61	4.22
	University of Copenhagen (Denmark)	60	5.39
	Lund University (Sweden)	53	5.91
	CNR (Italy)	52	2.47
	Ghent University (Belgium)	51	4.15
	Utrecht University (Netherlands)	46	3.09
	Vrije Universiteit (Netherlands)	44	3.81
	University of Helsinki (Finland)	43	4.13
	Universite Paris Saclay (France)	43	4.04
	University of Bern (Switzerland)	43	3.75
	Delft University of Technology (Netherlands)	43	2.47
	Stockholm University (Sweden)	41	7.98
	University of Zurich (Switzerland)	41	5.15
	University of Oxford (United Kingdom)	41	4.88

Table 13.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Germany. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Australia	Chinese Academy of Sciences (China)	100	2.17
	Wageningen University & Research (Netherlands)	83	5.80
	University of British Columbia (Canada)	54	6.91
	University of Washington (United States)	45	7.26
	University of Cambridge (United Kingdom)	42	7.22
	National University of Singapore (Singapore)	42	5.10
	U.S. Department of Agriculture (United States)	41	4.82
	University of Cape Town (South Africa)	41	4.49
	Stanford University (United States)	39	9.04
	University of Oxford (United Kingdom)	38	7.48
	Imperial College London (United Kingdom)	37	6.42
	Harvard University (United States)	34	9.16
	NOAA (United States)	34	6.12
	University of Leeds (United Kingdom)	33	4.15
	University of Auckland (New Zealand)	32	4.37
	University College London (United Kingdom)	31	4.33
	CNRS (France)	31	3.85
	INRA Institut National de La Recherche Agronomique (France)	30	4.87
	University of Copenhagen (Denmark)	29	4.83
	Stockholm University (Sweden)	28	7.94

Table 13.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Australia. (Source: Scopus)*

13.6.2 **Collaboration impact analysis**

To visualize the citation impact of collaborations, the ratio of FWCI from SDG13 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG13 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG13 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. For SDG13 research from 2007-2016, the majority of Colombia's collaborations with top 20 academic partners were mutually beneficial to both Colombia and the collaboration partner (Figure 13.8). The publications resulting from collaboration with the United Nations, University of British Columbia, Yale University and Imperial College London stand out for being highly mutually beneficial in terms of citation impact.

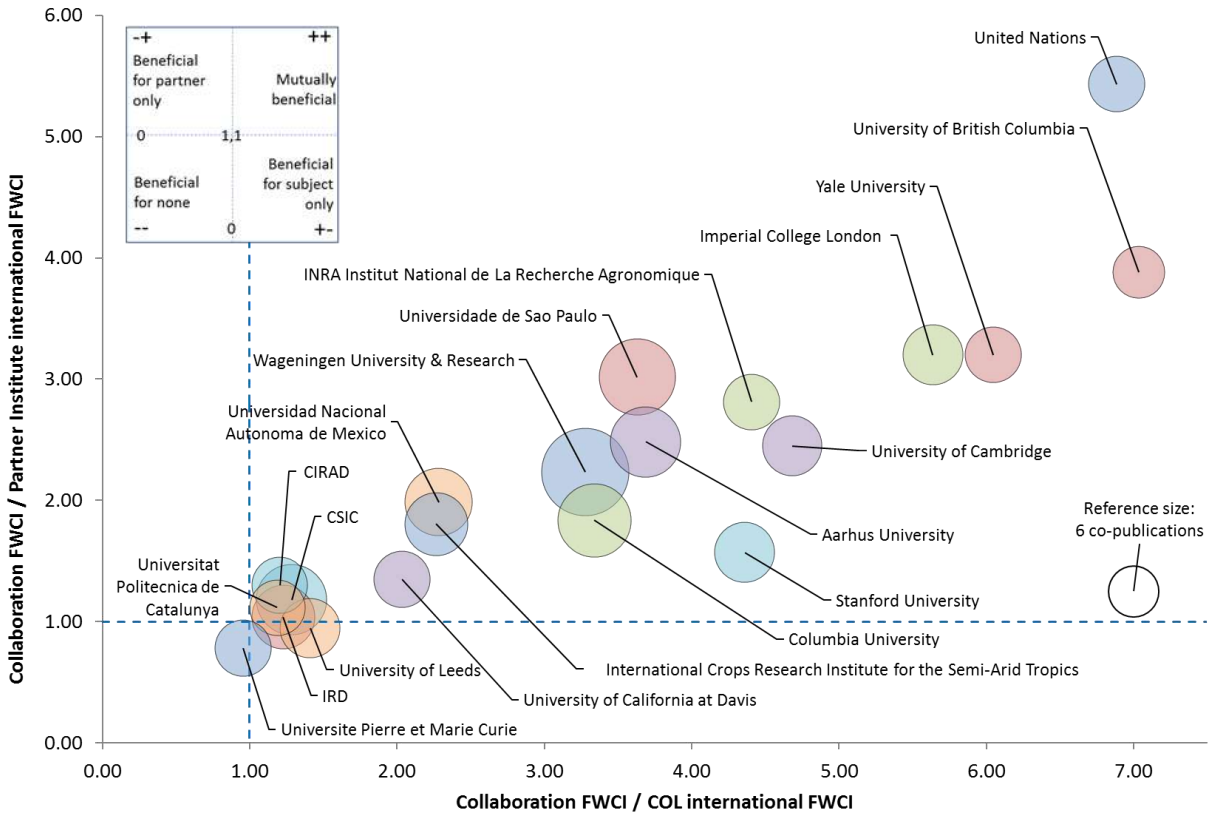


Figure 13.8— *Collaboration quadrant of Colombia's Top 20 collaborations in SDG13-related research with other institutions. Collaboration FWCI refers to the FWCI of all SDG13-related research co-authored by Colombia and the partner institute during the period 2007-2016. Bubble size corresponds to number of co-authored publications (reference bubble depicted at top left of chart). Impact of collaboration between partners can be interpreted based on quadrant position as described in legend on top left. (Source: Scopus).*

13.6.3 **Collaboration chart**

Figure 13.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG13. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 13.9 shows where there may be potential to improve output and impact through partnership. Colombia co-authored 6-17 publications with its top foreign partner institutes. Currently, Colombia produces the most co-authored papers with Wageningen University & Research, which produces the highest number of publications (among Colombia's top 20 partners) with 1,394 SDG13 publications. INRA Institut National de La Recherche Agronomique is the second most prolific among Colombia's top 20, with 877 publications, 7 of which were in co-authored with Colombia. Among Colombia's top 20 partners, Stanford University has the highest FWCI for SDG13 research at 3.87. Colombia may want to leverage its existing relationship with INRA Institut National de La Recherche Agronomique and Stanford University to increase its publication output and impact on SDG13 research.

Figure 13.9— *Chart showing Colombia's top 20 collaborators on SDG13 from 2007-2016. Circle (node) size is proportional to the number of SDG13 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (3.87) and lightest shade of green indicating the lowest FWCI (1.33). (Source: Scopus).*

Chapter 14
Life Below Water

In this Chapter, we assess research related to SDG14, which aims to conserve and sustainably use the oceans, seas, and marine resources. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

14.1 Key Findings

Goal 14: Conserve and sustainably use the oceans, seas and marine resources

WORLD RESEARCH OUTPUT

104,312

Number of SDG14 publications, 2007-2016.

SDG14 PATENTS

1,118

Number of SDG14 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

498

Colombia's SDG14 publications, 2007-2016.

COLOMBIA'S RESEARCH OUTPUT CAGR

33%

Compound annual growth rate for Colombia's 2007-2016 SDG14 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

52

Colombia's SDG14 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

1.01

Average field-weighted citation impact for Colombia's SDG14 publications, 2007-2016.

14.2 SDG14 – Conserve and sustainably use the oceans, seas and marine resources

According to the United Nations,

> *"The world's oceans – their temperature, chemistry, currents and life – drive global systems that make the Earth habitable for humankind.*
> *Our rainwater, drinking water, weather, climate, coastlines, much of our food, and even the oxygen in the air we breathe, are all ultimately provided and regulated by the sea. Throughout history, oceans and seas have been vital conduits for trade and transportation."* [19]

The targets for SDG 1, according to the United Nations are:

- *"By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.*
- *By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.*
- *Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels.*
- *By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics.*
- *By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information.*
- *By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the world Trade Organization fisheries subsidies negotiation.*
- *By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism.*
- *Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries.*
- *Provide access for small-scale artisanal fishers to marine resources and markets.*
- *Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of The Future We Want."* [19]

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG1 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a

[19] http://www.un.org/sustainabledevelopment/oceans/

query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

14.3 SDG14: Leaders in the field

14.3.1 Top 5 countries conducting SDG14 research

The top 5 countries publishing on SDG14 based on cumulative publication output from 2007-2016 are shown in Table 14.1 and Figure 14.1. The United States ranks 1st according to Publication Count, Percentage of Global Output, and Citation Count. The United Kingdom ranks 1st in FWCI with 1.22, which is much higher than the world average. Except for China, all other countries' FWCI also exceed the average.

Table 14.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	24,572	23.56%	358,044	1.56
United Kingdom	10,727	10.28%	173,983	1.79
Australia	7,123	6.83%	111,100	1.64
China	6,856	6.57%	67,218	1.19
Germany	5,753	5.52%	82,457	1.67
World	104,312	100.00%	440,296	1.22

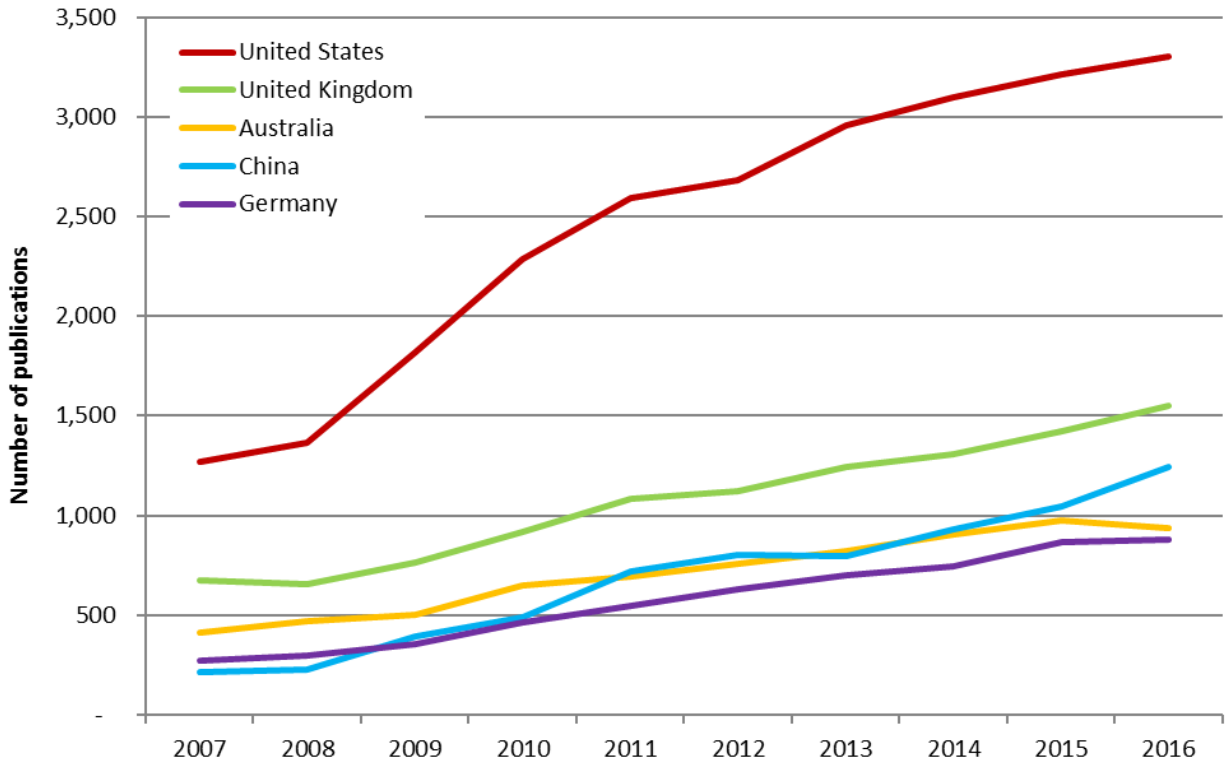


Figure 14.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG14 research. (Source: Scopus)*

14.3.2 Top 20 institutes conducting SDG14 research

A list of the top 20 research institutes publishing SDG14-related research is shown in Table 14.2. The Chinese Academy of Sciences ranks first in terms of Publication Count but ranks fairly low among the top 20 institutes in terms of FWCI. Wageningen University & Research ranks just behind the Chinese Academy of Sciences with 91 fewer publications but has 10,000 more citations. Arizona State University (United States) has the highest FWCI among comparators. Among the top 20 institutes, the University of Minnesota has the highest FWCI at over three times the world average. Except for Universidade de Sao Paulo (Brazil), all top 20 institutes have a mean FWCI above world average in this research field. The trends in publication output from 2007-2016 are shown in Figure 14.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Chinese Academy of Sciences (China)	1,059	15,187	1.49
2	Wageningen University & Research (Netherlands)	968	25,091	2.49
3	U.S. Department of Agriculture (United States)	748	18,097	1.94
4	University of British Columbia (Canada)	667	16,501	2.22
5	Arizona State University (United States)	635	21,564	2.84
6	Universidade de Sao Paulo (Brazil)	597	5,665	1.11
7	CNRS (France)	594	11,723	2.04
8	INRA Institut National de La Recherche Agronomique (France)	572	13,069	2.06
9	University of Queensland (Australia)	570	12,683	2.00
10	CSIRO (Australia)	562	22,802	2.74
11	Delft University of Technology (Netherlands)	523	8,736	2.01
12	University of Washington (United States)	482	13,254	2.46
13	University of Toronto (Canada)	451	8,627	1.68
14	Texas A and M University (United States)	438	6,797	1.60
15	CSIC (Spain)	413	9,090	1.76
16	University of California at Berkeley (United States)	411	9,243	2.44
17	Monash University (Australia)	407	8,576	1.89
18	University of Florida (United States)	407	5,458	1.50
19	Universiti Teknologi Malaysia (Malaysia)	404	2,438	1.54
20	University of Cambridge (United Kingdom)	403	8,318	2.65

Table 14.2— *Top 20 research Institutes ranked based on SDG14 publication output and FWCI from 2007-2016. (Source: Scopus)*

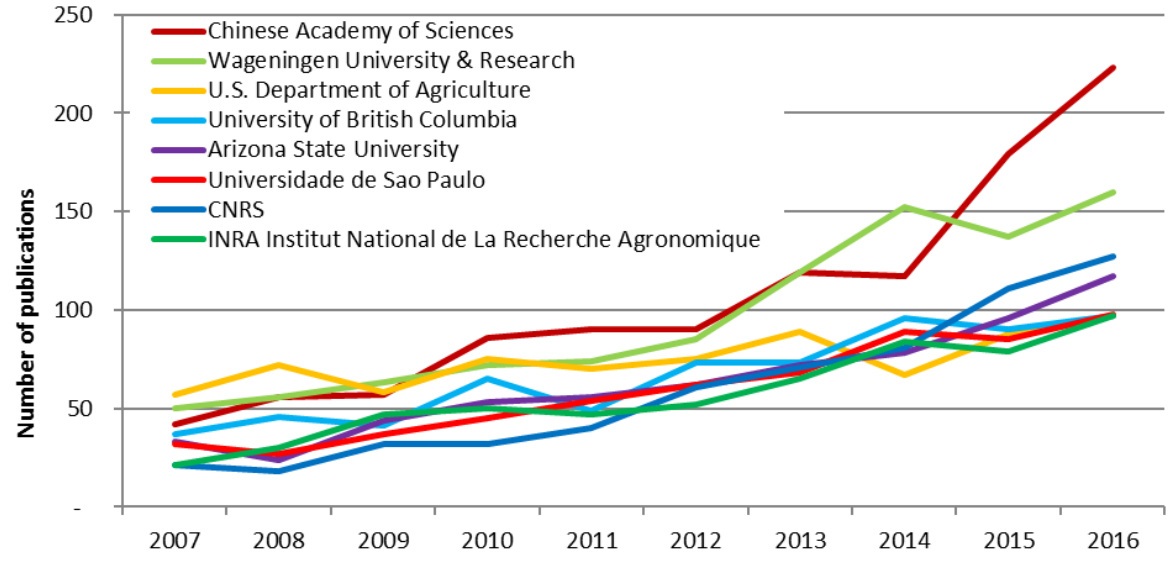


Figure 14.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG1. (Source: Scopus)*

14.3.3 Top 20 researchers conducting SDG14 research

A list of the top 20 researchers publishing in the SDG14 field based on publication output from 2007-2016 is shown in Table 14.3. Dinçer I. ranks 1st in Publication Count followed by Rashid Sumaila U. and Sarkis J.
Lal R., Dinçer I., and **Pauly D.** are the top 3 researchers in this list in terms of H-index.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Dinçer I.	University of Ontario Institute of Technology (Canada)	62	2,166	3.82	73
2	Rashid Sumaila U.	Institute for the Oceans and Fisheries (Canada)	48	1,588	2.98	42
3	Sarkis J.	Worcester Polytechnic Institute (United States)	47	2,511	5.57	62
4	Chen B.	Beijing Normal University (China)	46	895	1.76	46
5	Lal R.	Ohio State University (United States)	45	860	2.06	76
6	Wiek A.	Leuphana Universitat Luneburg (Germany)	44	1,633	4.00	30
7	Blevis E.	Indiana University (United States)	43	726	2.32	15
8	Germani M.	Universita Politecnica delle Marche (Italy)	42	147	1.57	12
9	YANG Z.	Beijing Normal University (China)	41	627	1.07	50
10	Huisingh D.	University of Tennessee, Knoxville (United States)	40	1,526	8.38	26
11	Vinodh S.	National Institute of Technology Tiruchirappalli (India)	40	375	1.16	22
12	Shah A.	Hewlett Packard Laboratories (United States)	39	359	2.31	17
13	Haapala K.	Oregon State University (United States)	39	199	1.86	12
14	Hepbaşli A.	Yasar Universitesi (Turkey)	38	1,219	2.28	48
15	Wu J.	Arizona State University (United States)	37	2,613	3.81	50
16	Pauly D.	The University of British Columbia (Canada)	37	1,584	3.71	64
17	Ulgiati S.	Universita degli Studi di Napoli Parthenope (Italy)	37	821	2.27	38
18	Azapagic A.	University of Manchester (United Kingdom)	36	681	2.58	32
19	Rosen M.	University of Ontario Institute of Technology (Canada)	36	845	2.50	53
20	Taisch M.	Politecnico di Milano (Italy)	36	349	2.48	15

Table 14.3— *Top 20 researchers publishing SDG14 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG14 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

14.3.4 Top 10 journals publishing SDG14 research

A list of the top 10 journals publishing SDG14-related research from 2007-2016 is shown in Table 14.4. *Sustainability* published 1,507 SDG14 related publications, making it the highest ranked journal in terms of SDG1 publications. *Journal of Cleaner Production* ranks 1st in terms of FWCI and second in terms of publication count while *Renewable and Sustainable Energy Reviews* sits in the 1st place in terms of CiteScore and third in terms of publication count. Six of the top 10 journals publishing SDG14 research have an FWCI above the world average for SDG14 research.

Rank	Journal	Publication count	FWCI	CiteScore
1	Sustainability	1,507	1.00	0.92
2	Journal of Cleaner Production	1,412	3.46	3.70
3	WIT Transactions on Ecology and the Environment	788	0.09	0.08
4	Advanced Materials Research	566	0.69	0.17
5	Renewable and Sustainable Energy Reviews	555	1.17	7.66
6	Ecological Economics	475	2.57	3.42
7	Marine Policy	465	2.12	2.27
8	PLoS ONE	450	1.57	4.29
9	Energy Policy	435	1.79	3.52
10	Journal of Environmental Management	434	1.51	3.75

Table 14.4— *Top 10 journals based on SDG14 publication output from 2007-2016. FWCI is mean FWCI for any SDG1 publications in the journal during the period; CiteScore is based on data for the journal as a whole. (Source: Scopus)*

14.4 Research efforts focused on SDG14

14.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 14.3, the United States is by far the leader in terms of research output related to SDG14. The United Kingdom follows, along with Australia, China, and Germany. Among comparators, Colombia has the lowest output in this field, just below Mexico. However, as shown in Table 14.5, Colombia has seen the greatest growth in research output in this field with a Compound Annual Growth Rate (CAGR) of 33.1%. All countries analysed have a CAGR above the world average in this field. Following Colombia, China and Brazil have the highest CAGR at 21% and 17% respectively.

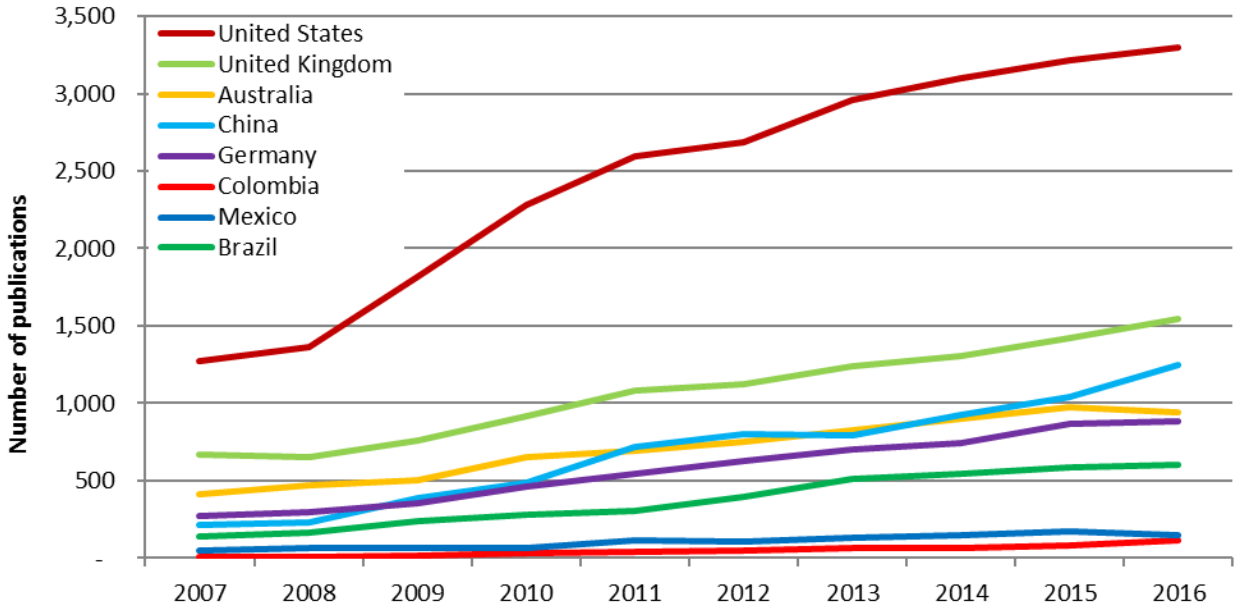


Figure 14.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	24,572	11.20%
United Kingdom	10,727	9.70%
Australia	7,123	9.50%
China	6,856	21.70%
Germany	5,753	13.90%
Colombia	498	33.10%
Mexico	1,061	13.70%
Brazil	3,768	17.40%
World	104,312	9.30%

Table 14.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

14.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG14 related research from 2006-2017 is 1.22.

Country	FWCI
United States	1.56
United Kingdom	1.79
Australia	1.64
China	1.19
Germany	1.67
Colombia	1.01
Mexico	1.26
Brazil	0.89
World	1.22

Comparing the FWCI of SDG14 publications from each of the eight countries included in this chapter reveals that the United Kingdom leads in terms of FWCI, followed by Germany and Australia (Table 14.6). The United States, though it leads in publication output comes in fourth among the top 5 countries. Among countries analysed, China has an FWCI just below the world average for this subject and Brazil has an FWCI below the world average for all research.

Table 14.6— *FWCI for SDG14 research from 2007-2016 per country and world. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

14.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 14.4 and Table 14.7, the United States leads in terms of SDG14 publications with 4,264 publications that are among the top 10% most cited. The United Kingdom follows with approximately half the count of top 10% papers. Colombia has 52 publications among the top 10% most cited during this time period. Although China has the lowest count of highly cited publications among the top 5 countries, China has the highest CAGR and surpassed Australia and Germany in 2016. Colombia also has a high CAGR for this metric.

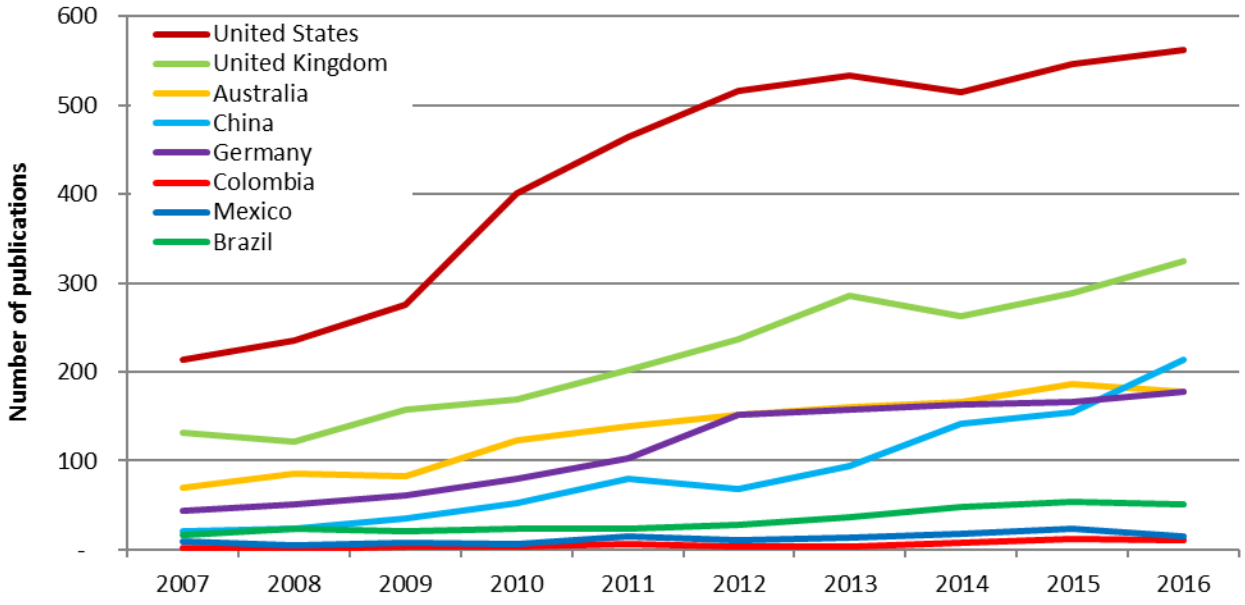


Figure 14.4— *Top 10% most cited publications on SDG14 from 2007-2016 per country. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
United States	4,264	11.38%
United Kingdom	2,178	10.59%
Australia	1,340	11.10%
China	881	29.43%
Germany	1,151	17.02%
Colombia	52	20.85%
Mexico	122	5.84%
Brazil	324	13.75%
World	14,058	13.70%

Table 14.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG14 publications from 2007-2016. (Source: Scopus)*

14.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 14.8 provides the count of SDG14 publications from each country that have been cited in patents and the number of patents that have cited these publications. For the United States, 183 US publications on SDG14 were cited in 482 patents. The other top 5 countries had 25-50 publications cited in 70-120 patents. Colombia, had a single publication cited in one patent.

Country	Patent Cited Publications	Patents Citing Publications
United States	183	482
United Kingdom	49	117
Australia	37	83
China	29	71
Germany	38	94
Colombia	1	1
Mexico	2	2
Brazil	9	11
World	525	1,436

Table 14.8— *Number of publications cited in patent and patents citing publications on SDG14 from 2007 to 2016. (Source: Scopus)*

14.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG14. To identify patents relevant to SDG14, we retrieved all the patents citing any SDG14-related publication. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO. From 2006 to 2016, the United States had the highest number of SDG14-related patents (both applied for and granted) with 210 patent applications and 490 patents granted accounting for 62% of the total (Table 14.9). The United Kingdom, Australia and Germany together account for 13% of all patents in this field, while Colombia applied for one patent and had one granted during the period. Note that China and Australia may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	210	490	700	62.61%
United Kingdom	21	6	27	2.42%
Australia	12	31	43	3.85%
China	11	7	18	1.61%
Germany	59	6	65	5.81%
Colombia	1	1	2	0.18%
Mexico	2	1	3	0.27%
Brazil	2	-	2	0.18%
World	517	601	1,118	

Table 14.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

14.4.6 **Research Focus**

Within the topic of SDG14-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG14-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG14 research is shown in Figure 14.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG14 research from Colombia, terms that stand out as unique to Colombia are 'Architecture', 'Biomass', and 'Concretes'. Among the top 50 key phrases the terms 'Environmental Management', 'Economics', 'Climate Change', and 'Ecosystem Service' were common among the countries analyzed. Figure 14.5 provides a visualization of the top 50 key phrases for SDG14 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

Colombia

Mexico

Figure 14.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Brazil

United States

United Kingdom

Australia

China

Germany

14.5 The reach of Colombia's SDG14 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

14.5.1 Downloads

As shown in the Figure 14.6, the mean count of downloads per ScienceDirect publication is similar across all countries. For Colombia, there is a prominent peak in 2009 resulting from four SD articles in 2009. Except for this anomaly, all countries had a similar downloads per SD publication rate.

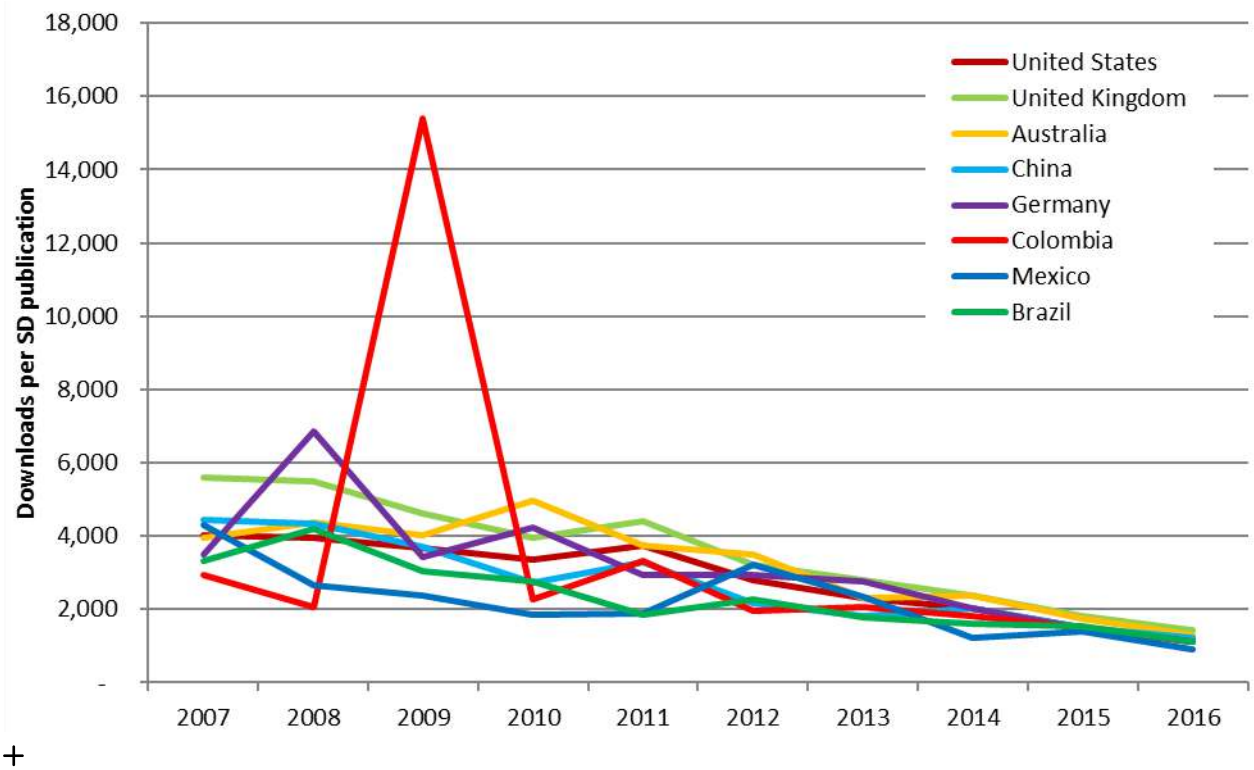


Figure 14.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

14.5.2 **Field Weighted Download Impact (FWDI)**

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. The United Kingdom has the highest mean FWDI for the period of 2007-2016 (Figure 14.7). It is important to note that given the very low count of SD publications from Colombia, and Mexico (i.e. under 50 SD publications for the full period) interpretation of this metric should focus on the top 5 countries only. All top 5 countries had an FWDI near the average for all SDG1 research of 1.45.

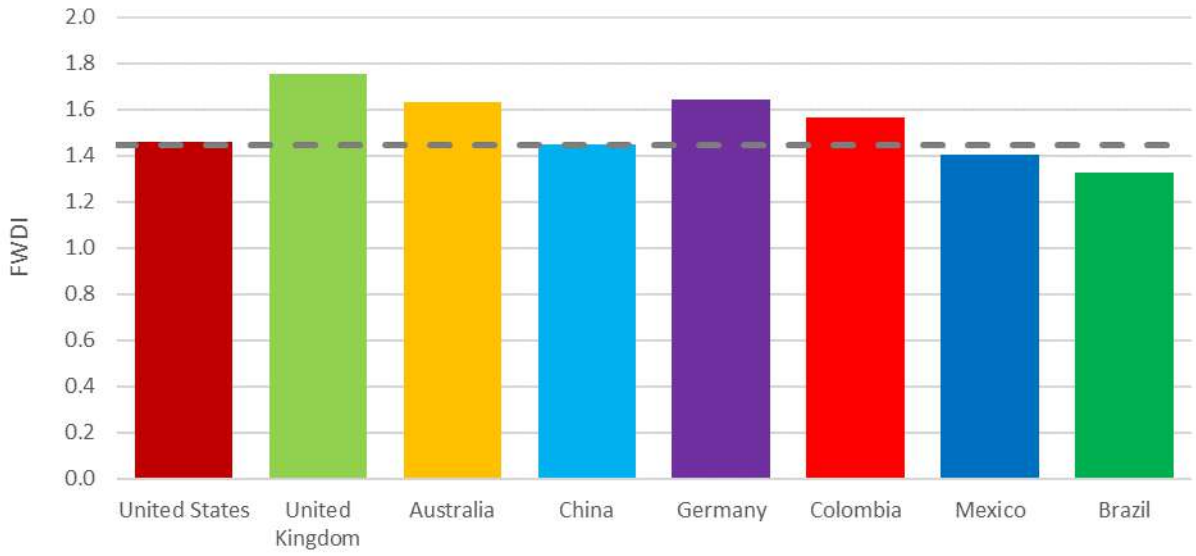


Figure 14.7 — *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. Grey dotted line indicates average for all SDG14 research. (Source: ScienceDirect)*

14.6 SDG14 collaboration network

14.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG14-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 14.10-14.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG14 publications with. Among academic partner institutes, Colombia has published the most SDG14 papers in collaboration with Universitat Politecnica de Catalunya (Spain; 10 publications from 2007-2016). The FWCI for these publications was near the world average for SDG14 research. The highest FWCI resulted from the 5 publications Colombia did in collaboration with the Chinese Academy of Agricultural Sciences (China).

Country	Institution (Country)	Publication Count	FWCI
Colombia	Universitat Politecnica de Catalunya (Spain)	10	1.24
	Universidade de Sao Paulo (Brazil)	9	3.36
	Universitat Autonoma de Barcelona (Spain)	9	2.27
	Wageningen University & Research (Netherlands)	8	3.78
	Columbia University (United States)	8	1.48
	Universidad Nacional Autonoma de Mexico (Mexico)	7	1.71
	Stanford University (United States)	6	4.16
	KU Leuven (Belgium)	6	3.61
	Chinese Academy of Agricultural Sciences (China)	5	8.78
	University of Cambridge (United Kingdom)	5	5.96
	Universitat Rovira i Virgili (Spain)	5	4.56
	University of Leeds (United Kingdom)	5	3.48
	CSIC (Spain)	5	2.98
	IRTA - Institute of Agrifood Research and Technology (Spain)	5	2.03
	Universite Pierre et Marie Curie (France)	5	1.40
	IRD (France)	5	1.32
	Georgia Institute of Technology (United States)	5	0.81
	Universidade Nova de Lisboa (Portugal)	4	7.89
	U.S. Department of Agriculture (United States)	4	6.80
	Embrapa - Empresa Brasileira de Pesquisa Agropecuaria (Brazil)	4	6.18

Table 14.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	Texas A and M University (United States)	33	2.13
	Wageningen University & Research (Netherlands)	19	3.47
	University of California at San Diego (United States)	18	2.81
	KU Leuven (Belgium)	16	2.41
	University of Arizona (United States)	16	1.39
	Arizona State University (United States)	14	2.79
	King Abdulaziz University (Saudi Arabia)	13	2.46
	U.S. Department of Agriculture (United States)	11	3.57
	University of British Columbia (Canada)	11	3.43
	Cornell University (United States)	10	5.98
	CSIC (Spain)	10	2.66
	Stanford University (United States)	9	4.84
	Clark University (United States)	9	4.65
	SUNY Albany (United States)	9	2.79
	CSIRO (Australia)	8	7.08
	University of Wisconsin (United States)	8	6.21
	Louisiana State University (United States)	8	1.76
	Universitat Politecnica de Catalunya (Spain)	8	0.74
	Utrecht University (Netherlands)	7	9.27
	Imperial College London (United Kingdom)	7	5.76

Table 14.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	University of Florida (United States)	38	1.47
	INRA Institut National de La Recherche Agronomique (France)	34	3.22
	CIRAD (France)	30	1.53
	Wageningen University & Research (Netherlands)	26	2.86
	U.S. Department of Agriculture (United States)	26	2.56
	IRD (France)	18	2.94
	Universidade Nova de Lisboa (Portugal)	18	1.95
	University of East Anglia (United Kingdom)	16	3.57
	CNRS (France)	16	2.72
	Harvard University (United States)	15	3.89
	CSIRO (Australia)	15	3.64
	University of Minho (Portugal)	15	0.95
	Colorado State University (United States)	14	2.77
	Stanford University (United States)	13	5.73
	University of Oxford (United Kingdom)	13	3.33
	Universidad Nacional Autonoma de Mexico (Mexico)	12	3.54
	United Nations (United States)	12	2.12
	University of Coimbra (Portugal)	12	1.15
	Universidade do Porto (Portugal)	12	0.93
	Universidade de Lisboa (Portugal)	11	3.55

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Table 14.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	Chinese Academy of Sciences (China)	190	2.76
	University of British Columbia (Canada)	162	3.85
	Wageningen University & Research (Netherlands)	100	4.62
	University of Toronto (Canada)	98	2.23
	CSIRO (Australia)	96	5.81
	University of Queensland (Australia)	81	3.91
	CNRS (France)	74	4.05
	Universidade de Sao Paulo (Brazil)	74	2.10
	University of Cambridge (United Kingdom)	73	4.77
	Stockholm University (Sweden)	71	7.73
	McGill University (Canada)	67	6.97
	University of Oxford (United Kingdom)	61	4.20
	Beijing Normal University (China)	60	3.48
	World Health Organization (Switzerland)	60	2.03
	Swedish University of Agricultural Sciences (Sweden)	54	5.41
	James Cook University Queensland (Australia)	53	4.55
	Tsinghua University (China)	53	2.70
	University of Cape Town (South Africa)	53	2.40
	University of Alberta (Canada)	51	2.15
	Imperial College London (United Kingdom)	50	3.81

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Table 14.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	Wageningen University & Research (Netherlands)	135	4.06
	CNRS (France)	62	3.72
	University of British Columbia (Canada)	61	5.28
	CSIRO (Australia)	55	7.05
	European Commission Joint Research Centre Institute (Belgium)	54	2.80
	CSIC (Spain)	54	1.95
	Stockholm University (Sweden)	51	5.37
	Harvard University (United States)	51	4.88
	INRA Institut National de La Recherche Agronomique (France)	51	4.01
	Swedish University of Agricultural Sciences (Sweden)	45	4.39
	University of Copenhagen (Denmark)	44	4.50
	Technical University of Denmark (Denmark)	44	2.91
	Utrecht University (Netherlands)	43	5.37
	University of Queensland (Australia)	42	4.23
	University of Toronto (Canada)	42	3.03
	Stanford University (United States)	41	8.57
	James Cook University Queensland (Australia)	40	4.00
	CNR (Italy)	40	3.37
	University of Cape Town (South Africa)	38	2.37
	ETH Zurich (Switzerland)	37	4.25

Table 14.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Australia	Chinese Academy of Sciences (China)	70	2.50
	Wageningen University & Research (Netherlands)	55	4.86
	University of British Columbia (Canada)	50	4.03
	University of Washington (United States)	46	5.46
	U.S. Department of Agriculture (United States)	39	4.57
	NOAA (United States)	37	5.62
	Stanford University (United States)	34	6.89
	National University of Singapore (Singapore)	33	4.01
	University of Auckland (New Zealand)	32	2.44
	Imperial College London (United Kingdom)	31	3.54
	University of Cape Town (South Africa)	29	2.58
	CNRS (France)	28	3.17
	Stockholm University (Sweden)	27	7.78
	INRA Institut National de La Recherche Agronomique (France)	25	4.65
	University of Cambridge (United Kingdom)	24	2.90
	Hong Kong Polytechnic University (Hong Kong)	24	1.57
	University College London (United Kingdom)	23	2.61
	Delft University of Technology (Netherlands)	23	2.06
	University of Leeds (United Kingdom)	22	3.79
	Harvard University (United States)	21	6.10

Table 14.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Australia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
China	Hong Kong Polytechnic University (Hong Kong)	95	1.74
	Arizona State University (United States)	61	3.02
	University of Hong Kong (Hong Kong)	58	1.66
	U.S. Department of Agriculture (United States)	47	3.29
	Wageningen University & Research (Netherlands)	41	2.32
	CSIRO (Australia)	40	2.96
	City University of Hong Kong (Hong Kong)	39	1.92
	National University of Singapore (Singapore)	33	3.55
	AgriFood Canada (Canada)	30	1.86
	Texas A and M University (United States)	30	1.76
	University of Maryland (United States)	29	3.37
	National Institute for Environmental Studies of Japan (Japan)	26	2.54
	Purdue University (United States)	26	2.48
	University of Michigan (United States)	24	2.76
	University of South Australia (Australia)	24	2.48
	Michigan State University (United States)	24	2.07
	Stanford University (United States)	23	2.97
	Chinese University of Hong Kong (Hong Kong)	23	0.91
	Delft University of Technology (Netherlands)	22	2.61
	Georgia Institute of Technology (United States)	21	3.65

Table 14.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for China. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Germany	Wageningen University & Research (Netherlands)	106	3.34
	ETH Zurich (Switzerland)	68	3.73
	CNRS (France)	58	3.92
	European Commission Joint Research Centre Institute (Belgium)	46	2.50
	University of Copenhagen (Denmark)	45	5.87
	Swedish University of Agricultural Sciences (Sweden)	43	4.27
	INRA Institut National de La Recherche Agronomique (France)	41	5.23
	Technical University of Denmark (Denmark)	40	3.01
	Vrije Universiteit (Netherlands)	39	4.31
	Lund University (Sweden)	38	5.21
	Chinese Academy of Sciences (China)	35	3.03
	Stockholm University (Sweden)	32	9.40
	Ghent University (Belgium)	32	3.65
	Utrecht University (Netherlands)	32	3.65
	CSIRO (Australia)	31	5.40
	Universite Paris Saclay (France)	31	3.40
	Arizona State University (United States)	30	9.86
	Universitat Autonoma de Barcelona (Spain)	30	3.17
	University of Zurich (Switzerland)	29	4.38
	CNR (Italy)	29	2.64

Table 14.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Germany. (Source: Scopus)*

14.6.2 Collaboration impact analysis

To visualize the citation impact of collaborations, the ratio of FWCI from SDG14 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG14 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG14 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. For SDG14 research from 2007-2016, about half of Colombia's collaborations with top 20 academic partners were mutually beneficial to both Colombia and the collaboration partner in terms of citation impact (Figure 14.8). Publications with Universidade Nova de Lisboa, the Chinese Academy of Agricultural Sciences, the United States Department of Agriculture, and Empraba stand out as being especially mutually beneficial to both parties in terms of citation impact.

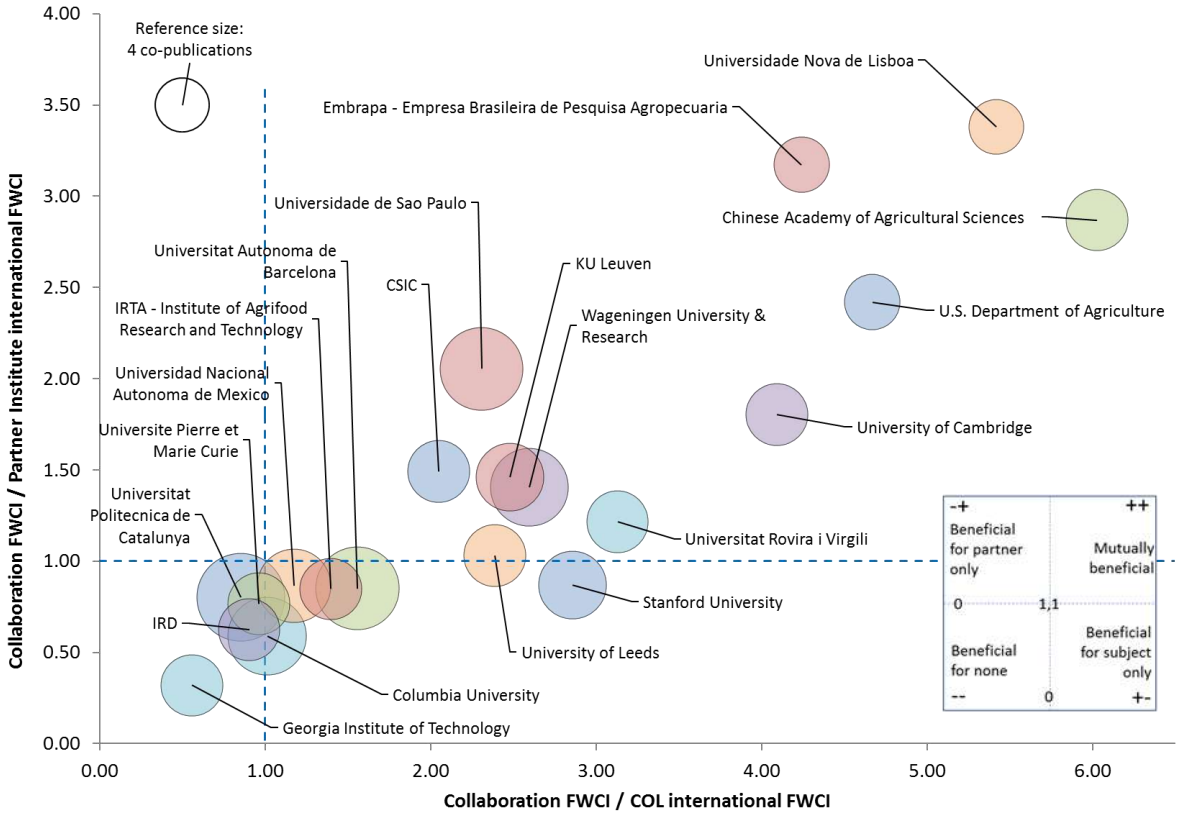

Figure 14.8— *Collaboration quadrant of Colombia's Top 20 collaborations in SDG14-related research with other institutions. Collaboration FWCI refers to the FWCI of all SDG14-related research co-authored by Colombia and the partner institute during the period 2007-2016. Bubble size corresponds to number of co-authored publications (reference bubble depicted at top left of chart). Impact of collaboration between partners can be interpreted based on quadrant position as described in legend on right. (Source: Scopus).*

14.6.3 **Collaboration chart**

Figure 14.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG14. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 14.9 shows where there may be potential to improve output and impact through partnership. Colombia co-authored 4-10 publications with its top foreign partner institutes. Wageningen University & Research publishes the most SDG14 research (among Colombia's top 20 partners) with 968 publications. U.S. Department of Agriculture is the second most prolific among Colombia's top 20, with 748 publications, 4 of which were in co-authored with Colombia. Among Colombia's top 20 partners, Stanford University has the highest FWCI for SDG14 research at 3.54. Colombia may want to leverage its existing relationship with U.S. Department of Agriculture and Stanford University to increase its publication output and impact on SDG14 research.

Figure 14.9— *Chart showing Colombia's top 20 collaborators on SDG14 from 2007-2016. Circle (node) size is proportional to the number of SDG14 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (3.54) and lightest shade of green indicating the lowest FWCI (1.11). (Source: Scopus).*

Chapter 15
Life on Land

In this Chapter, we assess research related to SDG15, which aims to sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

15.1 **Key Findings**

Goal 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss

WORLD RESEARCH OUTPUT

170,280

Number of SDG15 publications, 2007-2016.

SDG15 PATENTS

1,663

Number of SDG15 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

171

Colombia's SDG15 publications, 2007-2016.

COLOMBIA'S RESEARCH OUTPUT CAGR

29%

Compound annual growth rate for Colombia's 2007-2016 SDG15 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

82

Colombia's SDG15 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

1.10

Average field-weighted citation impact for Colombia's SDG15 publications, 2007-2016.

15.2 SDG15 – Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss

According to the United Nations,

> *"Forests cover 30 per cent of the Earth's surface and in addition to providing food security and shelter, forests are key to combating climate change, protecting biodiversity and the homes of the indigenous population. Thirteen million hectares of forests are being lost every year while the persistent degradation of drylands has led to the desertification of 3.6 billion hectares.*
> *Deforestation and desertification – caused by human activities and climate change – pose major challenges to sustainable development and have affected the lives and livelihoods of millions of people in the fight against poverty. Efforts are being made to manage forests and combat desertification."*[20]

The targets for SDG15, according to the United Nations are:

- *"By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, especially forests, wetlands, mountains and drylands, in line with obligations under international agreements.*
- *By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.*
- *By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.*
- *By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development.*
- *Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species.*
- *Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed.*
- *Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products.*
- *By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species.*
- *By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.*
- *Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems.*
- *Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation.*
- *Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities."*[20]

[20] http://www.un.org/sustainabledevelopment/biodiversity/

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG1 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

15.3 SDG15: Leaders in the field

15.3.1 Top 5 countries conducting SDG15 research

The top 5 countries publishing on SDG15 based on cumulative publication output from 2007-2016 are shown in Table 15.1 and Figure 15.1. The United States ranks 1st according to Publication Count, Percentage of Global Output, and Citation Count. The United Kingdom ranks 1st in FWCI with 1.73, which is much higher than the world average for SDG15 (1.07). Except for China, all other countries' FWCI exceed the global average as well.

Table 15.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	33,006	19.38%	448,029	1.47
China	25,541	15.00%	131,692	0.70
United Kingdom	13,856	8.14%	222,478	1.73
Australia	8,909	5.23%	136,151	1.64
Germany	8,498	4.99%	116,658	1.63
World	170,280	100.00%	592,675	1.07

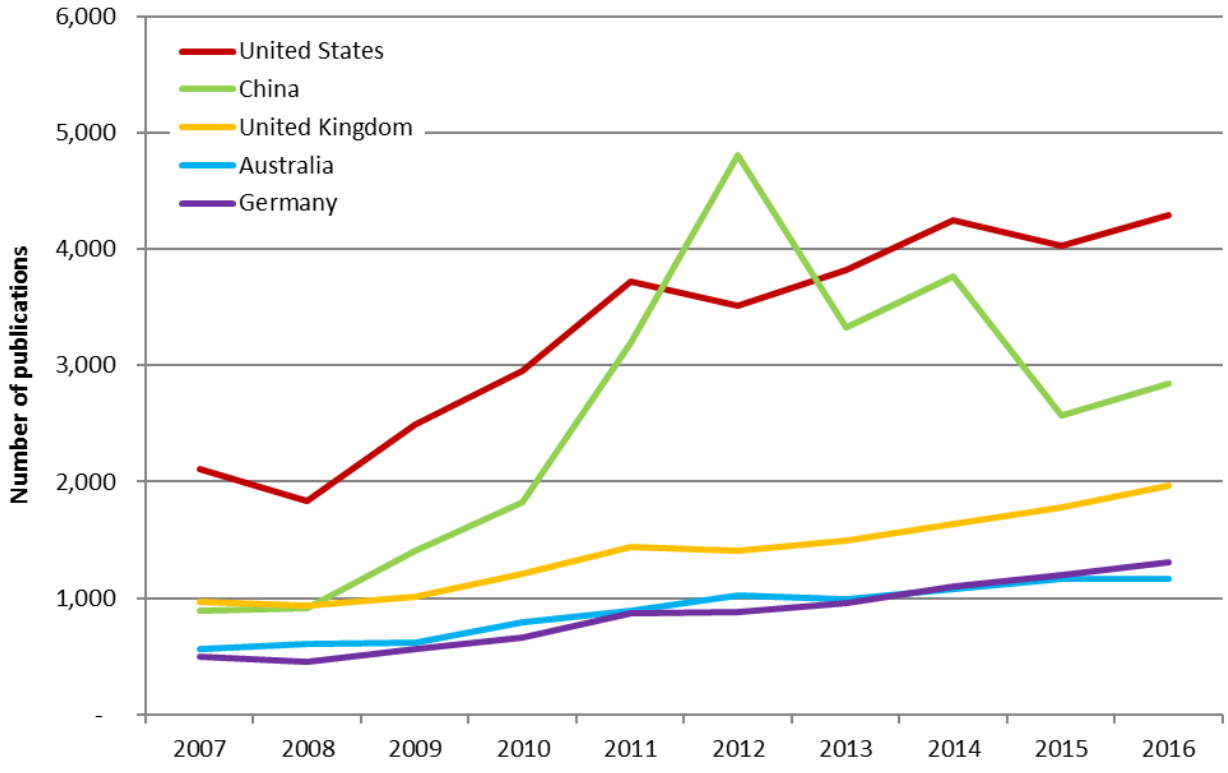

Figure 15.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG15 research. (Source: Scopus)*

15.3.2 Top 20 institutes conducting SDG15 research

A list of the top 20 research institutes publishing SDG15-related research is shown in Table 15.2. The Chinese Academy of Sciences (China) ranks 1st in Publication Count and surpasses Wageningen University & Research, the next ranked institute by approximately 1,200 publications. However, Wageningen University & Research has the highest citation count and is among the top 4 for FWCI. Among the top 20 institutes, the University of Cambridge (United Kingdom) has the highest FWCI. The trends in publication output from 2007-2016 are shown in Figure 15.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Chinese Academy of Sciences (China)	2,512	27,718	1.16
2	Wageningen University & Research (Netherlands)	1,366	36,441	2.54
3	U.S. Department of Agriculture (United States)	1,142	26,730	1.92
4	CNRS (France)	973	19,448	1.94
5	Ministry of Education China (China)	900	6,869	0.84
6	Arizona State University (United States)	827	24,879	2.58
7	Universidade de Sao Paulo (Brazil)	819	7,451	1.17
8	INRA Institut National de La Recherche Agronomique (France)	814	19,919	2.15
9	University of British Columbia (Canada)	808	20,861	2.32
10	CSIRO (Australia)	768	28,846	2.63
11	University of Queensland (Australia)	752	17,101	2.10
12	Delft University of Technology (Netherlands)	726	11,728	1.92
13	Beijing Normal University (China)	667	7,687	1.38
14	Tsinghua University (China)	666	7,452	1.29
15	Universiti Teknologi Malaysia (Malaysia)	628	3,662	1.32
16	Texas A and M University (United States)	585	8,164	1.51
17	University of Florida (United States)	578	9,141	1.60
18	ETH Zurich (Switzerland)	576	12,884	2.24
19	CSIC (Spain)	575	13,174	1.80
20	University of Cambridge (United Kingdom)	557	13,475	2.72

Table 15.2— *Top 20 research Institutes ranked based on SDG15 publication output and FWCI from 2007-2016. (Source: Scopus)*

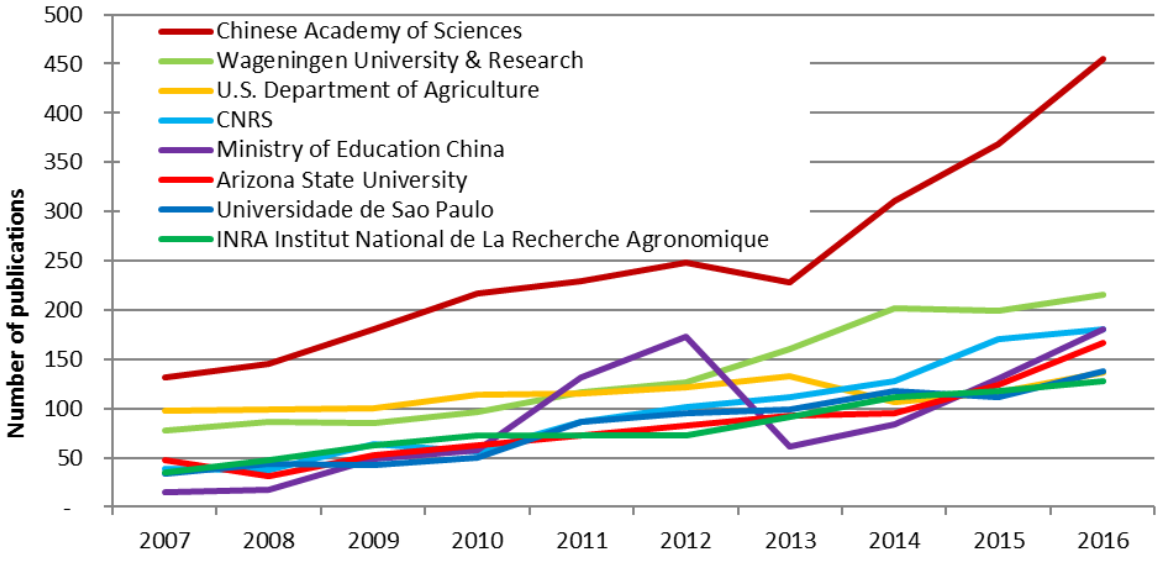

Figure 15.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG15. (Source: Scopus)*

15.3.3 Top 20 researchers conducting SDG15 research

A list of the top 20 researchers publishing in the SDG15 field based on publication output from 2007-2016 is shown in Table 15.3. Lal R. ranks 1st in Publication Count followed by Dinçer I. and Yang Z.
Lal R. and Dinçer I. are also the top 2 researchers in terms of H-index.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Lal R.	Ohio State University (United States)	79	1,820	1.98	76
2	Dinçer I.	University of Ontario Institute of Technology (Canada)	78	2,311	3.24	73
3	YANG Z.	Beijing Normal University (China)	71	1,128	1.38	50
4	Chen B.	Beijing Normal University (China)	69	1,569	1.93	46
5	Salvati L.	Council for Agricultural Research and Economics (CREA) (Italy)	69	509	1.40	27
6	Zuo J.	Shenzhen University (China)	59	1,012	2.33	23
7	Geng Y.	Shanghai Jiaotong University (China)	59	1,180	2.17	41
8	Hepbaşli A.	Yasar Universitesi (Turkey)	56	1,882	2.12	48
9	Sarkis J.	Worcester Polytechnic Institute (United States)	55	2,673	5.27	62
10	Shi R.	East China Normal University (China)	54	13	0.10	7
11	Shen L.	Chongqing University (China)	53	1,321	2.53	38
12	Wiek A.	Leuphana Universitat Luneburg (Germany)	49	1,735	3.75	30
13	Huang G.	Beijing Normal University (China)	49	822	1.68	50
14	Ulgiati S.	Universita degli Studi di Napoli Parthenope (Italy)	48	1,036	2.10	38
15	Liu C.	East China Normal University (China)	48	33	0.17	5
16	Huisingh D.	University of Tennessee, Knoxville (United States)	47	1,708	7.64	26
17	Jabbour C.	Montpellier Research in Management (France)	47	536	1.75	22
18	Ouyang Z.	Research Center for Eco-Environmental Sciences Chinese Academy of Sciences (China)	46	1,319	1.72	43
19	Scholz M.	University of Salford (United Kingdom)	46	577	0.92	26
20	Taisch M.	Politecnico di Milano (Italy)	45	382	2.38	15

Table 15.3— *Top 20 researchers publishing SDG15 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG15 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

15.3.4 Top 10 journals publishing SDG15 research

A list of the top 10 journals publishing SDG15-related research from 2007-2016 is shown in Table 1.4. *Advanced Materials Research* publishes the most SDG15 publications by 3,600 publications. *Journal of Cleaner Production* had the highest FWCI for SDG15 publications. Given that review articles attract citations at a higher rate, it is not surprising that *Renewable and Sustainable Energy Reviews* has the highest CiteScore.

Rank	Journal	Publication count	FWCI	CiteScore
1	Advanced Materials Research	5,629	0.43	0.17
2	Sustainability	1,927	1.02	0.92
3	Journal of Cleaner Production	1,874	3.26	3.70
4	Applied Mechanics and Materials	1,664	0.39	0.11
5	Renewable and Sustainable Energy Reviews	1,084	1.13	7.66
6	WIT Transactions on Ecology and the Environment	1,069	0.08	0.08
7	Procedia Engineering	1,063	1.87	0.48
8	Acta Ecologica Sinica	817	0.22	0.55
9	Energy Policy	779	1.75	3.52
10	Energy Procedia	762	1.23	2.05

Table 15.4— *Top 10 journals based on SDG15 publication output from 2007-2016. FWCI is mean FWCI for any SDG15 publications in the journal during the period; CiteScore is based on data for the journal as a whole. (Source: Scopus)*

15.4 Research efforts focused on SDG15

15.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 15.3, the United States is the leader in terms of research output related to SDG15 but is closely followed by China. The United Kingdom follows, along with Australia, Germany, and Brazil. Among comparators, Colombia has the lowest output in this field, just below Mexico. However, as shown in Table 15.5, Colombia has seen the greatest growth in research output in this field with a Compound Annual Growth Rate (CAGR) of 29%. All countries analysed have a CAGR above 8% in this field, well above the global CAGR (4.9%).

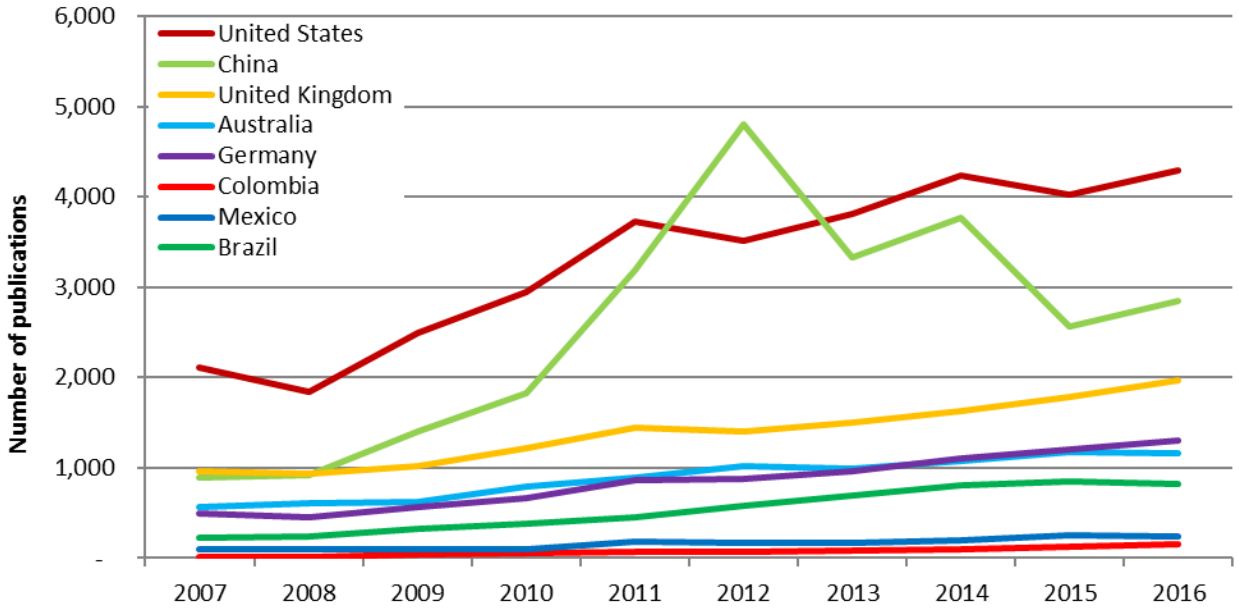

Figure 15.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	33,006	8.20%
China	25,541	13.70%
United Kingdom	13,856	8.20%
Australia	8,909	8.50%
Germany	8,498	11.30%
Colombia	717	29.00%
Mexico	1,607	10.50%
Brazil	5,368	15.80%
World	170,280	4.90%

Table 15.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

15.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG15 related research from 2006-2017 is 1.07.

Country	FWCI
United States	1.47
China	0.70
United Kingdom	1.73
Australia	1.64
Germany	1.63
Colombia	1.10
Mexico	1.11
Brazil	0.92
World	1.07

Comparing the FWCI of SDG15 publications from each of the eight countries included in this chapter reveals that the United Kingdom leads in terms of FWCI (Table 15.6). The United States, Australia, and Germany have an FWCI near 1.5. Among countries analysed, China and Brazil have an FWCI below the world average for this subject.

Table 15.6— *FWCI for SDG13 research from 2007-2016 per country and world. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

15.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI more than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 15.4 and Table 15.7, the United States leads in terms of SDG15 publications with 5,484 publications that are among the top 10% most cited. The United Kingdom follows with 1,892 publications. China, Australia, and Germany follow although China has a very high CAGR and is on track to surpass the United Kingdom in the future, having overtaken Australia and Germany in 2011. Colombia has 82 publications among the top 10% most cited during this time period.

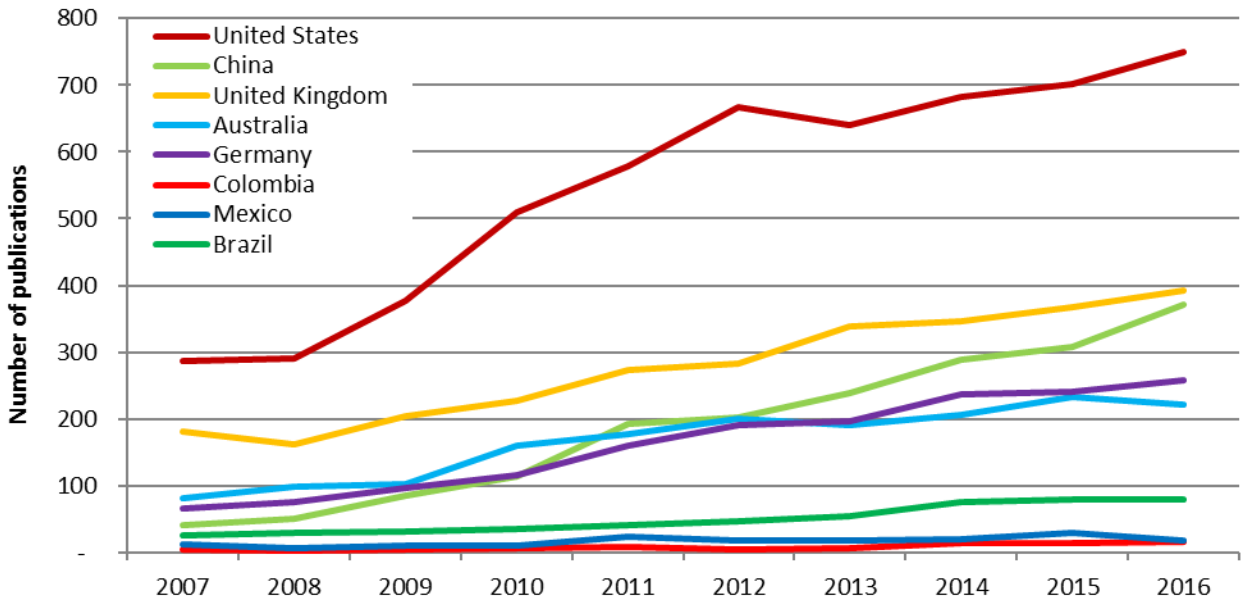

Figure 15.4— *Top 10% most cited publications on SDG15 from 2007-2016 per country. CAGR shown at top of each bar. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
United States	5,484	11.29%
China	1,892	27.73%
United Kingdom	2,775	8.93%
Australia	1,671	11.85%
Germany	1,636	16.36%
Colombia	82	16.65%
Mexico	164	4.61%
Brazil	498	13.64%
World	20,141	13.54%

Table 15.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG15 publications from 2007-2016. (Source: Scopus)*

15.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 15.8 provides the count of SDG15 publications from each country that have been cited in patents and the number of patents that have cited these publications. For the United States, 250 US publications on SDG15 were cited in769 patents. The other top 5 countries had approximately 40-65 publications cited in 80-200 patents. Colombia had 2 publications cited in 2 patents.

Country	Patent Cited Publications	Patents Citing Publications
United States	250	769
China	65	202
United Kingdom	65	149
Australia	44	79
Germany	54	141
Colombia	2	2
Mexico	5	20
Brazil	11	13

Table 15.8— *Number of publications cited in patent and patents citing publications on SDG15 from 2007 to 2016. (Source: Scopus)*

15.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG15. To identify patents relevant to SDG15, we retrieved all the patents citing any SDG15-related publication. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO. From 2006 to 2016, the United States had the highest number of SDG15-related patents (both applied for and granted) with 276 patent applications and 711 patents granted, accounting for nearly 60% of all patents related to SDG15 (Table 15.9). Colombia applied for one patent and had none granted during the period. Note that China and Australia may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	276	711	987	59.35%
China	22	13	35	2.10%
United Kingdom	39	17	56	3.37%
Australia	15	32	47	2.83%
Germany	89	22	111	6.67%
Colombia	1	-	1	0.06%
Mexico	2	1	3	0.18%
Brazil	4	2	6	0.36%
World	749	914	1,663	

Table 15.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

15.4.6 **Research Focus**

Within the topic of SDG15-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG15-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG15 research is shown in Figure 15.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG15 research from Colombia, the term that stands out as unique to Colombia is 'Bamboo'. Among the top 50 key phrases the terms 'Environmental Management'; 'Innovation', 'Industry', 'Economics', 'Climate Change', 'Planning', and 'Societies and Institutions' were common among the countries analyzed. The term 'Biofuels' stands out as unique to the Latin American countries. Figure 15.5 provides a visualization of the top 50 key phrases for SDG15 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

Colombia

Figure 15.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Mexico

Brazil

United States

China

United Kingdom

Australia

Germany

15.5 The reach of Colombia's SDG15 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

15.5.1 Downloads

As shown in the Figure 15.6, the mean count of downloads per ScienceDirect publication is similar across all countries. The United Kingdom had the highest count of downloads per SD publication. Although there is a prominent peak in 2009 for Colombia, this peak is the result of six SD articles in 2009 that were downloaded more than 70,000 times, resulting in a high 'mean' value. It should be noted that for Colombia, the results shown for all years are based on very small counts of SD articles and should be interpreted with caution.

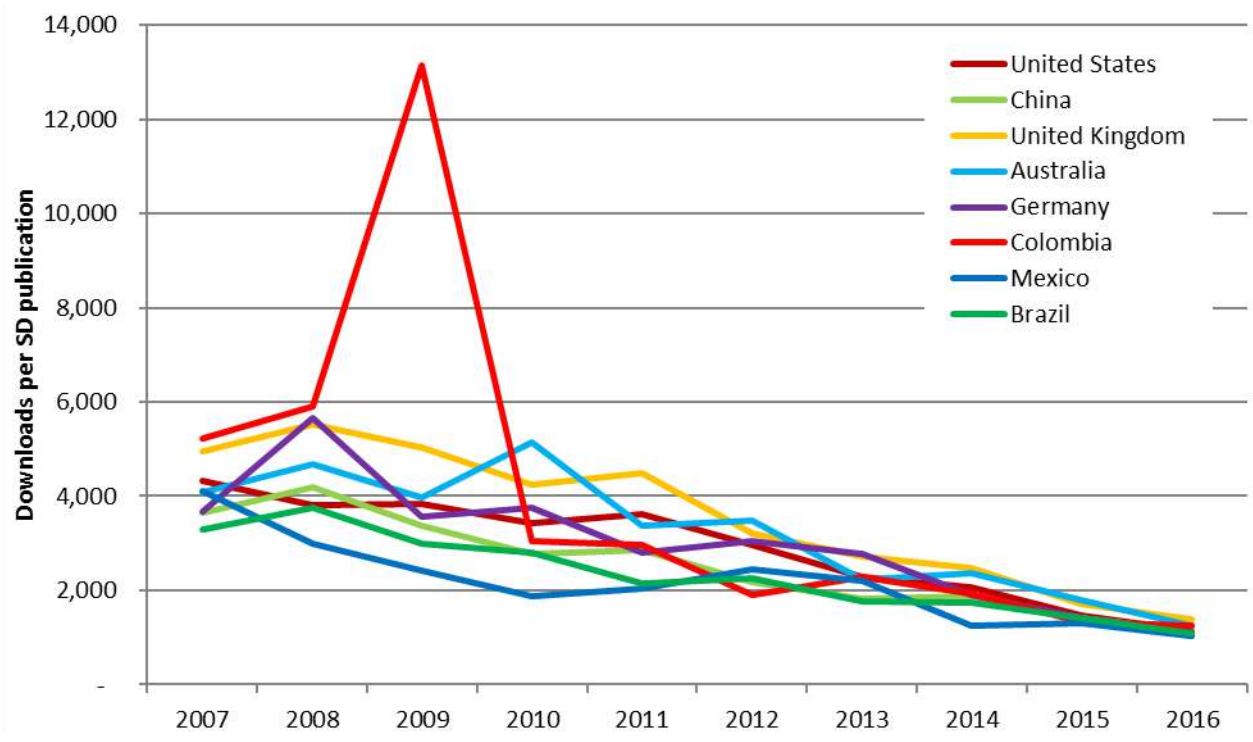

Figure 15.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

15.5.2 **Field Weighted Download Impact (FWDI)**

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. The mean FWDI for the period of 2007-2016 is shown for each country in Figure 15.7. All countries had an FWCI near the world average for SDG15 research (1.43).

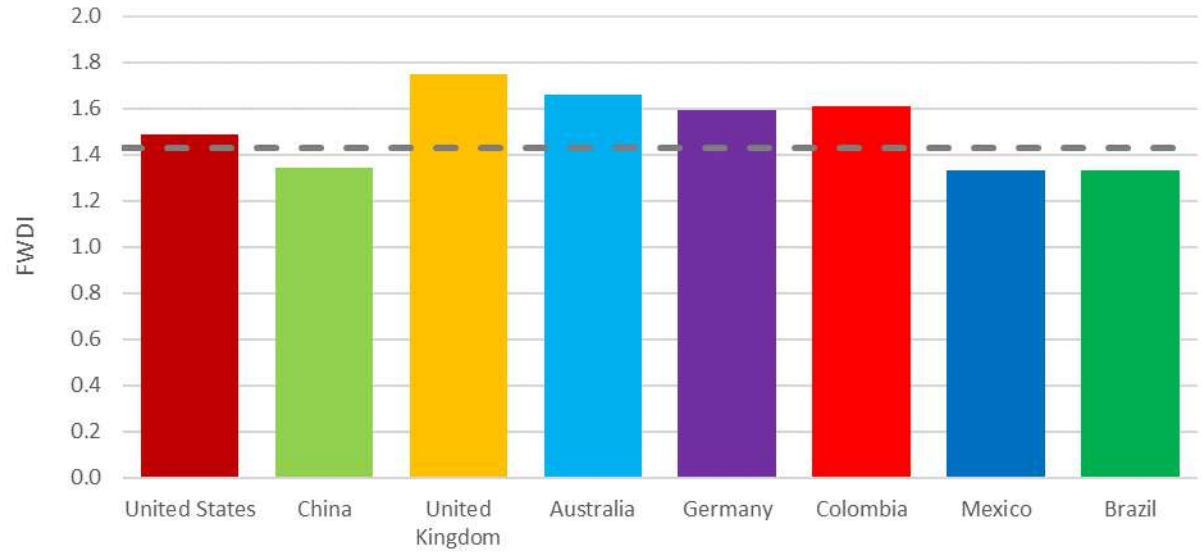

Figure 15.7 — *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. Grey dotted line indicates average for all SDG15 research. (Source: ScienceDirect)*

15.6 SDG15 collaboration network

15.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG15-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 15.10-15.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG15 publications with. Among academic partner institutes, Colombia has published the most SDG15 papers in collaboration with Wageningen University & Research (Netherlands; 14 co-authored publications). The FWCI for Colombia's publications with each of the top 20 partners exceeds the world average for SDG15 research. Publications with INRA Institut National de La Recherche Agronomique yield the highest FWCI with an average of 9.5.

Country	Institution (Country)	Publication Count	FWCI
Colombia	Wageningen University & Research (Netherlands)	14	4.39
	Universitat Politecnica de Catalunya (Spain)	13	1.40
	CSIC (Spain)	12	2.53
	Universidad Nacional Autonoma de Mexico (Mexico)	11	1.77
	Universidade de Sao Paulo (Brazil)	10	4.90
	Columbia University (United States)	10	3.47
	IRD (France)	10	2.29
	Universitat Autonoma de Barcelona (Spain)	9	2.27
	Aarhus University (Denmark)	8	4.37
	University of Leeds (United Kingdom)	8	2.77
	International Crops Research Institute for the Semi-Arid Tropics (India)	7	5.36
	University of Cambridge (United Kingdom)	7	4.56
	University of California at Davis (United States)	7	3.79
	Stanford University (United States)	7	3.64
	KU Leuven (Belgium)	7	3.45
	Georgia Institute of Technology (United States)	7	1.55
	INRA Institut National de La Recherche Agronomique (France)	6	9.50
	Imperial College London (United Kingdom)	6	7.34
	Yale University (United States)	6	6.48
	International Food Policy Research Institute (United States)	6	4.48

Table 15.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	Texas A and M University (United States)	42	2.19
	Wageningen University & Research (Netherlands)	31	4.06
	University of Arizona (United States)	20	2.32
	KU Leuven (Belgium)	20	2.27
	U.S. Department of Agriculture (United States)	19	2.96
	King Abdulaziz University (Saudi Arabia)	19	2.26
	Arizona State University (United States)	18	2.49
	University of California at San Diego (United States)	15	3.12
	CSIC (Spain)	15	2.17
	University of British Columbia (Canada)	12	4.85
	CSIRO (Australia)	11	5.67
	Cornell University (United States)	11	4.96
	Stanford University (United States)	11	4.15
	INRA Institut National de La Recherche Agronomique (France)	11	2.89
	University of California at Berkeley (United States)	11	1.63
	Utrecht University (Netherlands)	10	8.49
	CNRS (France)	10	5.28
	Yale University (United States)	10	4.57
	SUNY Albany (United States)	10	4.55
	Universidad Nacional de Colombia (Colombia)	10	2.89

+

Table 15.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	University of Florida (United States)	67	1.81
	CIRAD (France)	48	1.97
	U.S. Department of Agriculture (United States)	47	3.04
	Wageningen University & Research (Netherlands)	45	3.51
	INRA Institut National de La Recherche Agronomique (France)	42	4.24
	IRD (France)	30	3.36
	University of East Anglia (United Kingdom)	28	5.32
	CNRS (France)	28	3.70
	Yale University (United States)	24	3.91
	CSIRO (Australia)	21	3.86
	University of Oxford (United Kingdom)	21	3.68
	Universidade de Lisboa (Portugal)	21	2.43
	Colorado State University (United States)	20	4.55
	Universidade Nova de Lisboa (Portugal)	20	1.90
	Universidad Nacional Autonoma de Mexico (Mexico)	19	3.01
	Harvard University (United States)	17	4.90
	University of Queensland (Australia)	17	4.30
	University of Minho (Portugal)	17	0.91
	Virginia Polytechnic Institute and State University (United States)	16	3.54
	Universidad de la Republica (Uruguay)	16	2.27

+

Table 15.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	Chinese Academy of Sciences (China)	350	2.27
	University of British Columbia (Canada)	172	4.82
	Wageningen University & Research (Netherlands)	158	4.44
	CSIRO (Australia)	119	5.53
	University of Cambridge (United Kingdom)	110	5.33
	CNRS (France)	104	4.38
	Universidade de Sao Paulo (Brazil)	104	2.27
	Beijing Normal University (China)	97	2.61
	University of Queensland (Australia)	95	5.02
	University of Oxford (United Kingdom)	91	3.70
	Ministry of Education China (China)	85	0.92
	University of Toronto (Canada)	84	2.34
	Tsinghua University (China)	84	2.25
	Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences (China)	84	1.40
	East China Normal University (China)	83	1.03
	McGill University (Canada)	82	6.20
	Stockholm University (Sweden)	78	7.26
	ETH Zurich (Switzerland)	78	4.37
	Peking University (China)	76	2.28
	Swedish University of Agricultural Sciences (Sweden)	75	5.02

+

Table 15.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
China	Hong Kong Polytechnic University (Hong Kong)	179	1.72
	Colorado State University (United States)	109	0.61
	University of Hong Kong (Hong Kong)	95	1.78
	U.S. Department of Agriculture (United States)	90	2.48
	City University of Hong Kong (Hong Kong)	86	1.62
	Arizona State University (United States)	76	2.78
	Wageningen University & Research (Netherlands)	68	2.58
	CSIRO (Australia)	53	2.99
	National University of Singapore (Singapore)	52	2.77
	University of South Australia (Australia)	50	2.34
	Texas A and M University (United States)	50	1.51
	University of Maryland (United States)	49	2.86
	University of Regina (Canada)	49	1.92
	University of British Columbia (Canada)	43	2.61
	Purdue University (United States)	43	2.01
	Chinese University of Hong Kong (Hong Kong)	43	1.45
	National Institute for Environmental Studies of Japan (Japan)	42	2.99
	Delft University of Technology (Netherlands)	41	2.29
	AgriFood Canada (Canada)	41	1.81
	Georgia Institute of Technology (United States)	40	4.31

Table 15.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for China. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	Wageningen University & Research (Netherlands)	190	4.29
	CNRS (France)	93	3.56
	INRA Institut National de La Recherche Agronomique (France)	84	3.80
	CSIRO (Australia)	75	6.21
	CSIC (Spain)	73	2.24
	European Commission Joint Research Centre Institute (Belgium)	70	4.19
	Swedish University of Agricultural Sciences (Sweden)	68	4.20
	University of Copenhagen (Denmark)	67	4.44
	University of British Columbia (Canada)	64	7.14
	Chinese Academy of Sciences (China)	64	2.75
	Stockholm University (Sweden)	59	4.96
	University of Queensland (Australia)	57	5.43
	ETH Zurich (Switzerland)	55	4.18
	James Cook University Queensland (Australia)	53	4.64
	Aarhus University (Denmark)	53	3.03
	Technical University of Denmark (Denmark)	52	3.38
	CNR (Italy)	51	3.24
	Utrecht University (Netherlands)	50	5.37
	Stanford University (United States)	48	8.39
	Harvard University (United States)	48	4.73

Table 15.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Australia	Chinese Academy of Sciences (China)	94	2.45
	Wageningen University & Research (Netherlands)	81	5.50
	University of British Columbia (Canada)	52	6.24
	U.S. Department of Agriculture (United States)	50	4.61
	National University of Singapore (Singapore)	48	3.97
	University of Washington (United States)	46	5.61
	Stanford University (United States)	42	5.75
	NOAA (United States)	38	5.47
	University of Cape Town (South Africa)	37	2.98
	Imperial College London (United Kingdom)	36	3.86
	Hong Kong Polytechnic University (Hong Kong)	36	1.56
	University of Cambridge (United Kingdom)	35	7.04
	CNRS (France)	35	3.48
	University of Leeds (United Kingdom)	34	4.04
	University of Auckland (New Zealand)	34	3.81
	Stockholm University (Sweden)	33	7.30
	INRA Institut National de La Recherche Agronomique (France)	31	4.98
	University of Oxford (United Kingdom)	29	6.13
	University College London (United Kingdom)	27	3.66
	Food and Agriculture Organization of the United Nations (Italy)	26	7.12

Table 15.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Australia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Germany	Wageningen University & Research (Netherlands)	173	3.44
	ETH Zurich (Switzerland)	91	3.44
	CNRS (France)	88	4.25
	European Commission Joint Research Centre Institute (Belgium)	70	2.55
	Swedish University of Agricultural Sciences (Sweden)	67	3.90
	INRA Institut National de La Recherche Agronomique (France)	66	5.29
	Chinese Academy of Sciences (China)	65	2.39
	University of Copenhagen (Denmark)	56	5.14
	Lund University (Sweden)	50	5.23
	Universite Paris Saclay (France)	49	3.00
	Utrecht University (Netherlands)	47	3.80
	CNR (Italy)	47	2.48
	Vrije Universiteit (Netherlands)	45	4.29
	Stockholm University (Sweden)	44	7.59
	Delft University of Technology (Netherlands)	44	2.88
	Technical University of Denmark (Denmark)	43	4.65
	CSIRO (Australia)	42	4.74
	University of Bern (Switzerland)	42	3.90
	Ghent University (Belgium)	41	4.23
	University of Natural Resources and Applied Life Sciences (Austria)	41	2.92

Table 15.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Germany. (Source: Scopus)*

15.6.2 **Collaboration impact analysis**

To visualize the citation impact of collaborations, the ratio of FWCI from SDG15 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG15 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG15 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. For SDG15 research from 2007-2016, the majority of Colombia's collaborations with top 20 academic partners were mutually beneficial to both Colombia and the collaboration partner (Figure 15.8). The publications resulting from collaboration with INRA and Imperial College stand out as highly mutually beneficial for both parties relative to the international SDG15 collaborations of each.

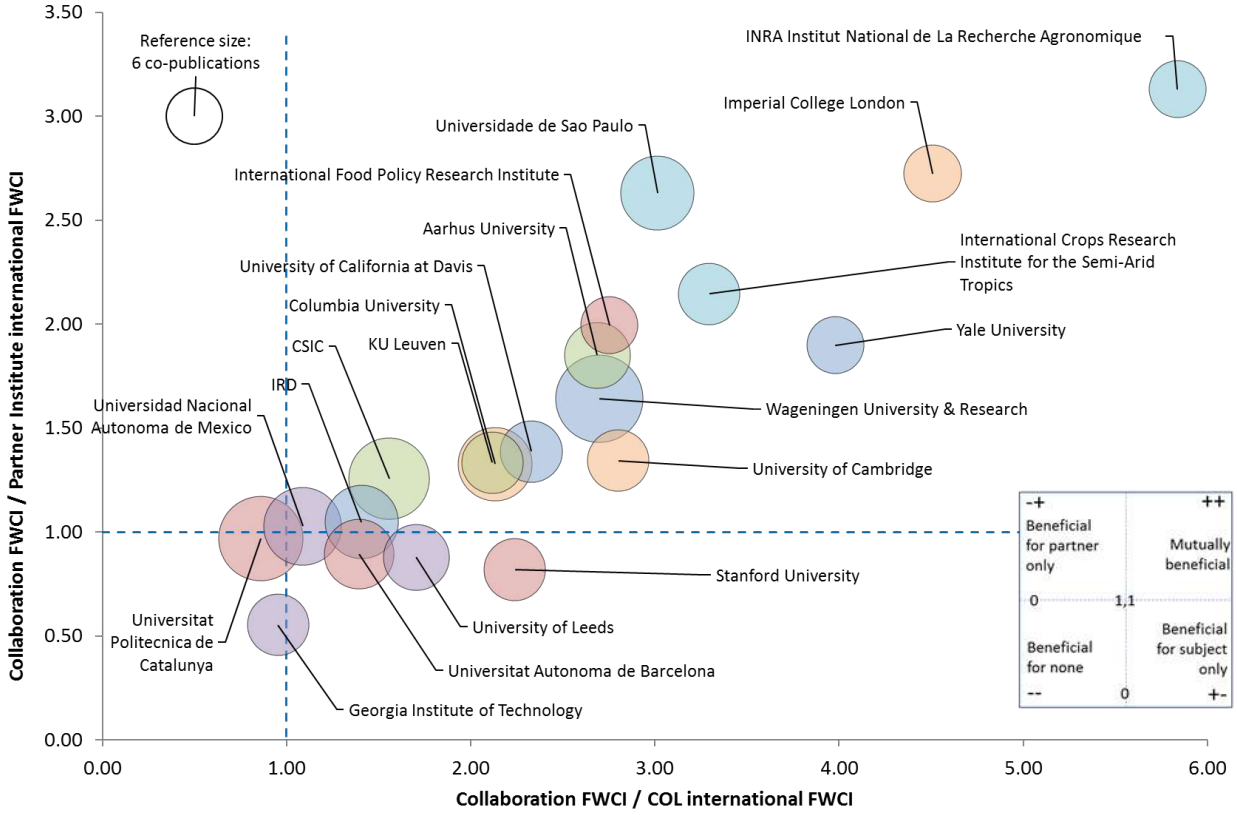

Figure 15.8— *Collaboration quadrant of Colombia's Top 20 collaborations in SDG15-related research with other institutions. Collaboration FWCI refers to the FWCI of all SDG15-related research co-authored by Colombia and the partner institute during the period 2007-2016. Bubble size corresponds to number of co-authored publications (reference bubble depicted at top left of chart). Impact of collaboration between partners can be interpreted based on quadrant position as described in legend on right. (Source: Scopus).*

15.6.3 **Collaboration chart**

Figure 15.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG15. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 15.9 shows where there may be potential to improve output and impact through partnership. Colombia co-authored 6-14 publications with its top foreign partner institutes. Wageningen University & Research publishes the most SDG15 research (among Colombia's top 20 partners) with 1,366 publications. Universidade de Sao Paulo is the second most prolific among Colombia's top 20, with 819 publications, 10 of which were in co-authored with Colombia. Among Colombia's top 20 partners, Stanford University has the highest FWCI for SDG15 research at 3.33. Colombia may want to leverage its existing relationship with these institutions to increase its publication output and impact on SDG15 research.

Figure 15.9— *Chart showing Colombia's top 20 collaborators on SDG15 from 2007-2016. Circle (node) size is proportional to the number of SDG15 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (3.33) and lightest shade of green indicating the lowest FWCI (1.12). (Source: Scopus).*

Chapter 16
Peace, Justice and Strong Institutions

In this Chapter, we assess research related to SDG16, which aims to promote just, peaceful, and inclusive societies. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

16.1 **Key Findings**

Goal 16: Promote just, peaceful and inclusive societies

WORLD RESEARCH OUTPUT

9,219

Number of SDG16 publications, 2007-2016.

SDG16 PATENTS

49

Number of SDG16 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

70

Colombia's SDG16 publications, 2007-2016.

COLOMBIA'S RESEARCH OUTPUT CAGR

26%

Compound annual growth rate for Colombia's 2007-2016 SDG16 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

11

Colombia's SDG16 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

1.40

Average field-weighted citation impact for Colombia's SDG16 publications, 2007-2016.

16.2 SDG16 – Promote just, peaceful and inclusive societies

According to the United Nations, the aim of this goal is to:

> *"dedicated to the promotion of peaceful and inclusive societies for sustainable development, the provision of access to justice for all, and building effective, accountable institutions at all levels."*[21]

The targets for SDG16, according to the United Nations are:

- *"Significantly reduce all forms of violence and related death rates everywhere.*
- *End abuse, exploitation, trafficking and all forms of violence against and torture of children.*
- *Promote the rule of law at the national and international levels and ensure equal access to justice for all*
- *By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organized crime.*
- *Substantially reduce corruption and bribery in all their forms.*
- *Develop effective, accountable and transparent institutions at all levels.*
- *Ensure responsive, inclusive, participatory and representative decision-making at all levels.*
- *Broaden and strengthen the participation of developing countries in the institutions of global governance.*
- *By 2030, provide legal identity for all, including birth registration.*
- *Ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements.*
- *Strengthen relevant national institutions, including through international cooperation, for building capacity at all levels, in particular in developing countries, to prevent violence and combat terrorism and crime.*
- *Promote and enforce non-discriminatory laws and policies for sustainable development."*[21]

Research can play a huge role in supporting the above goals. To identify research that aims to support the above goals and SDG1 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

[21] http://www.un.org/sustainabledevelopment/peace-justice/

16.3 SDG16: Leaders in the field

16.3.1 Top 5 countries conducting SDG16 research

The top 5 countries publishing on SDG16 based on cumulative publication output from 2007-2016 are shown in Table 16.1 and Figure 16.1. The United States ranks 1st according to Publication Count, Percentage of Global Output, and Citation Count. The United Kingdom ranks 1st in FWCI with 1.72, which is much higher than the world average of 1.09 for SDG16 research. Except for China, all other countries' FWCI exceed the global average as well.

Table 16.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	2,003	21.73%	21,882	1.35
United Kingdom	1,128	12.24%	16,042	1.72
China	619	6.71%	4,346	0.88
Australia	577	6.26%	10,563	1.66
Canada	463	5.02%	4,788	1.48
World	9,219	100.00%	29,474	1.09

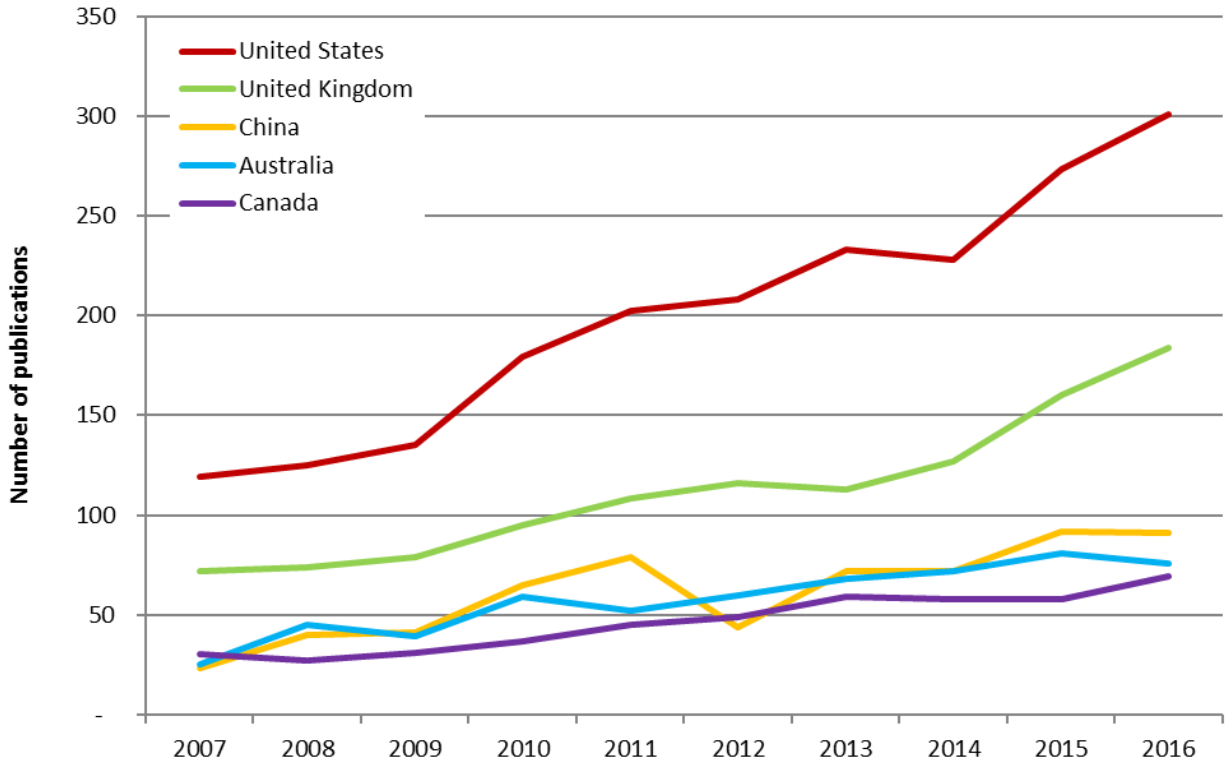

Figure 16.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG16 research (Source: Scopus)*

16.3.2 Top 20 institutes conducting SDG16 research

A list of the top 20 research institutes publishing SDG16-related research is shown in Table 16.2. The Chinese Academy of Sciences (China) ranks 1st in Publication Count with 89 publications in this field. Institutes among the top 20 publishing SDG16 research published 36-89 publications. For all institutes except Universidade de Sao Paulo (Brazil), the FWCi surpassed the world average for SDG16 research, ranging from 1.41-4.35. The highest FWCI comes from University of Sussex research on SDG16. The trends in publication output from 2007-2016 are shown in Figure 16.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Chinese Academy of Sciences (China)	89	1,072	1.41
2	Wageningen University & Research (Netherlands)	68	1,214	2.40
3	U.S. Department of Agriculture (United States)	57	876	1.49
4	University of Queensland (Australia)	56	771	1.89
5	INRA Institut National de La Recherche Agronomique (France)	51	906	1.89
6	University of British Columbia (Canada)	47	547	1.66
7	University of Toronto (Canada)	46	536	1.55
8	University College London (United Kingdom)	45	488	2.09
9	University of Sussex (United Kingdom)	44	1,905	4.35
10	University of East Anglia (United Kingdom)	43	1,399	3.45
11	University of Oxford (United Kingdom)	42	708	2.46
12	Arizona State University (United States)	41	1,477	3.24
13	Australian National University (Australia)	40	959	3.45
14	University of Melbourne (Australia)	39	514	1.99
15	National University of Singapore (Singapore)	39	405	1.42
16	CNRS (France)	39	417	1.47
17	Texas A and M University (United States)	39	524	1.78
18	University of Sydney (Australia)	38	447	1.80
19	University of Leeds (United Kingdom)	37	410	2.61
20	Universidade de Sao Paulo (Brazil)	36	214	0.84

Table 16.2— *Top 20 research Institutes ranked based on SDG16 publication output and FWCI from 2007-2016. (Source: Scopus)*

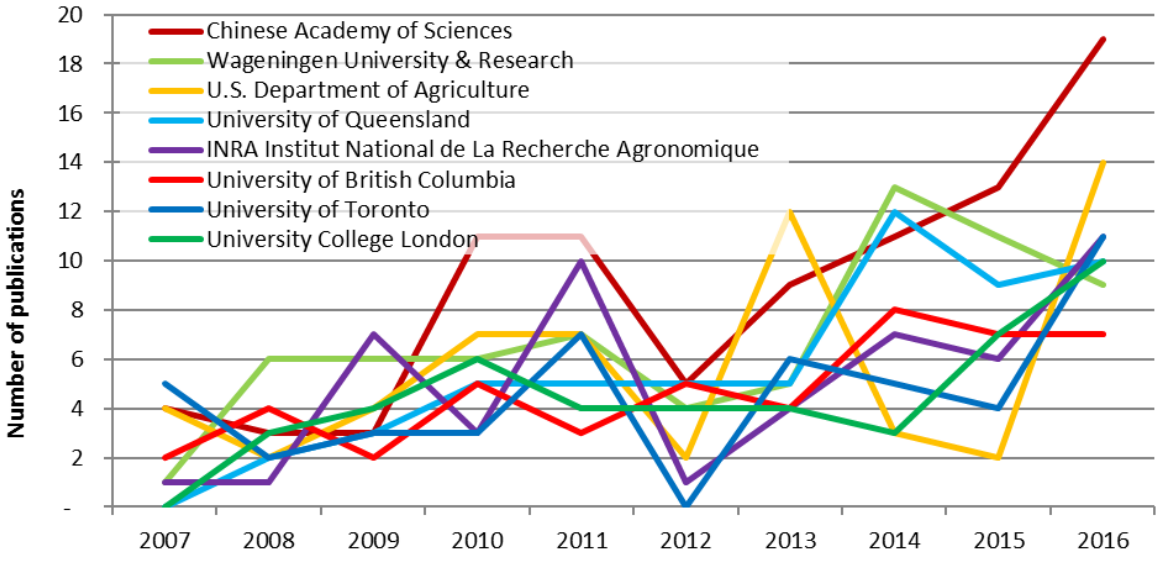

Figure 16.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG16. (Source: Scopus)*

16.3.3 Top 20 researchers conducting SDG16 research

A list of the top 20 researchers publishing in the SDG16 field based on publication output from 2007-2016 is shown in Table 16.3. Seyfang G. ranks 1st in Publication Count followed by Lee B. and Smith A.
Tuteja N., Farooq M., and Sovacool B. are the top 3 researchers in this list in terms of H-index.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Seyfang G.	University of East Anglia (United Kingdom)	15	838	5.11	25
2	Lee B.	Yale University (United States)	11	25	0.58	8
3	Smith A.	University of Sussex (United Kingdom)	10	736	6.14	31
4	Tuteja N.	Amity University, Uttar Pradesh (India)	8	217	1.33	42
5	Cozens P.	Curtin University (Australia)	7	131	1.93	14
6	Byrne S.	University of Manitoba (Canada)	7	18	0.40	7
7	Gupta J.	University of Amsterdam (Netherlands)	6	55	4.56	23
8	Anguelovski I.	Institut de Ciencia i Tecnologia Ambientals (ICTA)-UAB (Spain)	6	81	4.30	11
9	Goeminne G.	Universiteit Gent (Belgium)	6	55	2.43	9
10	Jamal T.	Texas A and M University (United States)	6	81	2.31	21
11	Annicchiarico P.	Research Centre for Fodder Crops and Dairy Productions (Italy)	6	107	2.31	19
12	Frías-Aceituno J.	Universidad de Granada (Spain)	6	69	2.01	8
13	Sovacool B.	Aarhus Universitet (Denmark)	6	67	1.76	36
14	Volaire F.	Universite de Montpellier (France)	6	140	1.58	17
15	Esteves A.	Community Insights Group (Singapore)	5	320	5.66	9
16	Longhurst N.	University of East Anglia (United Kingdom)	5	131	4.88	9
17	Raco M.	UCL (United Kingdom)	5	111	3.23	23
18	Kalfagianni A.	Utrecht University (Netherlands)	5	108	2.83	8
19	Stirling A.	University of Sussex (United Kingdom)	5	151	2.70	32
20	Farooq M.	University of Agriculture, Faisalabad (Pakistan)	5	252	2.60	40

Table 16.3— *Top 20 researchers publishing SDG16 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG16 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

16.3.4 Top 10 journals publishing SDG16 research

A list of the top 10 journals publishing SDG16-related research from 2007-2016 is shown in Table 16.4. *Sustainability* published 126 SDG16 related publications, making it the top journal in terms of SDG16 publications. The FWCI and CiteScore for *Sustainability* is just below one. *Ecological Economics* ranks 1st in terms of FWCI and 10th in terms of publication count while *PLoS ONE* sits in 1st place in terms of CiteScore. Six of the top 10 journals publishing the most SDG16 research have an FWCI above the world average.

Rank	Journal	Publication count	FWCI	CiteScore
1	Sustainability	126	0.99	0.92
2	Acta Ecologica Sinica	69	0.18	0.55
3	Local Environment	66	1.16	1.06
4	Acta Horticulturae	64	1.12	0.20
5	Development	57	0.29	0.32
6	Mediterranean Journal of Social Sciences	56	0.90	0.00
7	PLoS ONE	55	1.33	4.29
8	Journal of Cleaner Production	53	2.70	3.70
9	Land Use Policy	47	1.61	2.89
10	Ecological Economics	45	2.84	3.42

Table 16.4— *Top 10 journals based on SDG16 publication output from 2007-2016. FWCI is mean FWCI for any SDG16 publications in the journal during the period; CiteScore is based on data for the journal as a whole. (Source: Scopus)*

16.4 Research efforts focused on SDG16

16.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 16.3, the United States leads in terms of research output related to SDG16. The United Kingdom follows with just over half the publications of United States. China, Australia, and Canada have 450-650 publications. Among comparators, Colombia has the lowest output in this field, just below Mexico. However, as shown in Table 16.5, Colombia has seen the greatest growth in research output in this field with a Compound Annual Growth Rate (CAGR) of 26.0%. All countries analysed have a CAGR above 9% in this field.

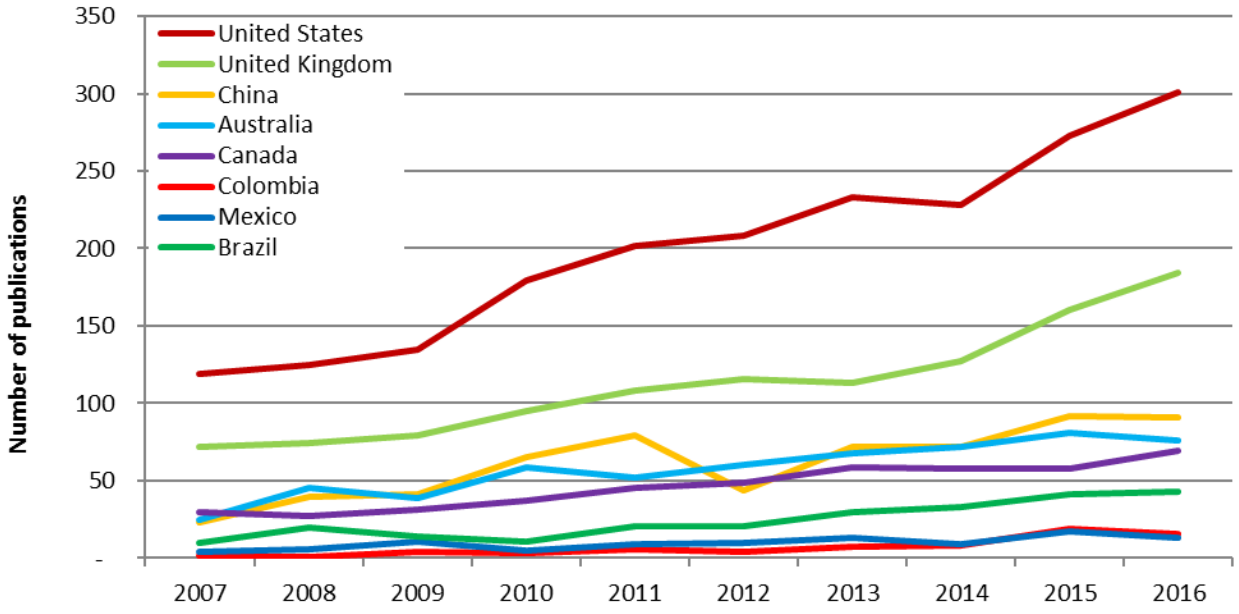

Figure 16.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	2,003	10.90%
United Kingdom	1,128	11.00%
China	619	16.50%
Australia	577	13.10%
Canada	463	9.70%
Colombia	70	26.00%
Mexico	97	14.00%
Brazil	244	17.60%
World	9,219	13.90%

Table 16.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

16.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG16 related research from 2006-2017 is 1.09.

Country	FWCI
United States	1.35
United Kingdom	1.72
China	0.88
Australia	1.66
Canada	1.48
Colombia	1.40
Mexico	1.21
Brazil	0.76
World	1.09

Comparing the FWCI of SDG16 publications from each of the eight countries included in this chapter reveals that the United Kingdom leads in terms of FWCI (Table 16.6). The United States, Australia, Canada, Mexico, and Colombia all have an FWCI above 1.2. Among the countries analysed, China and Brazil have an FWCI below the world average for this subject.

Table 16.6— *FWCI for SDG16 research from 2007-2016 per country and world. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

16.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 16.4 and Table 16.7, the United States leads in terms of SDG16 publications with 298 publications that are among the top 10% highest FWCI and has the highest CAGR for these publications. The United Kingdom follows closely with 237 publications. Australia and Canada have a similar count of top 10% publications. Colombia has 11 publications among the top 10% most cited during this time period.

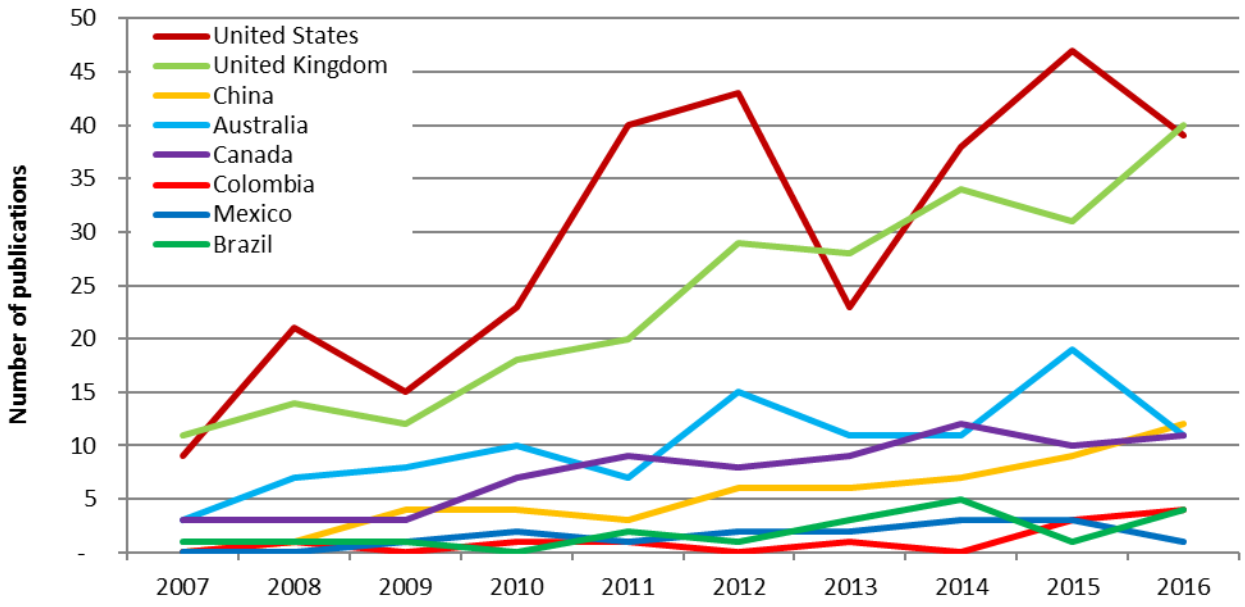

Figure 16.4— *Top 10% most cited publications on SDG16 from 2007-2016 per country. CAGR shown at top of each bar. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
United States	298	17.69%
United Kingdom	237	15.42%
China	52	-
Australia	102	15.53%
Canada	75	15.53%
Colombia	11	-
Mexico	15	-
Brazil	19	16.65%
World	1,078	16.65%

Table 16.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG16 publications from 2007-2016. (Source: Scopus)*

16.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 16.8 provides the count of SDG16 publications from each country that have been cited in patents and the number of patents that have cited these publications. For the United States, 12 US publications on SDG1 have been cited in 31 patents. The United Kingdom and Australia also had at least one publication cited in patents. Most countries, including Colombia, have no patent citations for SDG16 related research. This is not surprising given that SDG16 does not particularly led itself to patentable activities per se.

Country	Patent Cited Publications	Patents Citing Publications
United States	12	23
United Kingdom	3	4
China	-	-
Australia	1	1
Canada	-	-
Colombia	-	-
Mexico	-	-
Brazil	-	-
World	31	57

Table 16.8— *Number of publications cited in patent and patents citing publications on SDG16 from 2007 to 2016. (Source: Scopus)*

16.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG16. To identify patents relevant to SDG16, we retrieved all the patents citing any SDG16-related publication. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO. From 2006 to 2016, the United States had the highest number of SDG16-related patents (both applied for and granted) with 17 patent applications and 11 patents granted (Table 16.9). The United Kingdom, China, and Canada applied for a small number of patents and Australia had one patent granted. Colombia applied for no patents, nor had any granted during the period. Note that China and Australia may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	17	11	28	57.14%
United Kingdom	1	-	1	2.04%
China	1	-	1	2.04%
Australia	-	1	1	2.04%
Canada	2	-	2	4.08%
Colombia	-	-	-	0.00%
Mexico	-	-	-	0.00%
Brazil	-	-	-	0.00%
World	35	14	49	

Table 16.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

16.4.6 **Research Focus**

Within the topic of SDG16-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG16-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG16 research is shown in Figure 16.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG16 research from Colombia, the term that stands out as unique to Colombia is 'Silvopastoral Systems', 'Valuation', 'Agroforestry', 'Parks', 'Strategy', 'Communication', and 'Project'. Among the top 50 key phrases the terms 'Sustainable Development, and 'Human Rights' were common among the countries analyzed. Figure 16.5 provides a visualization of the top 50 key phrases for SDG16 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

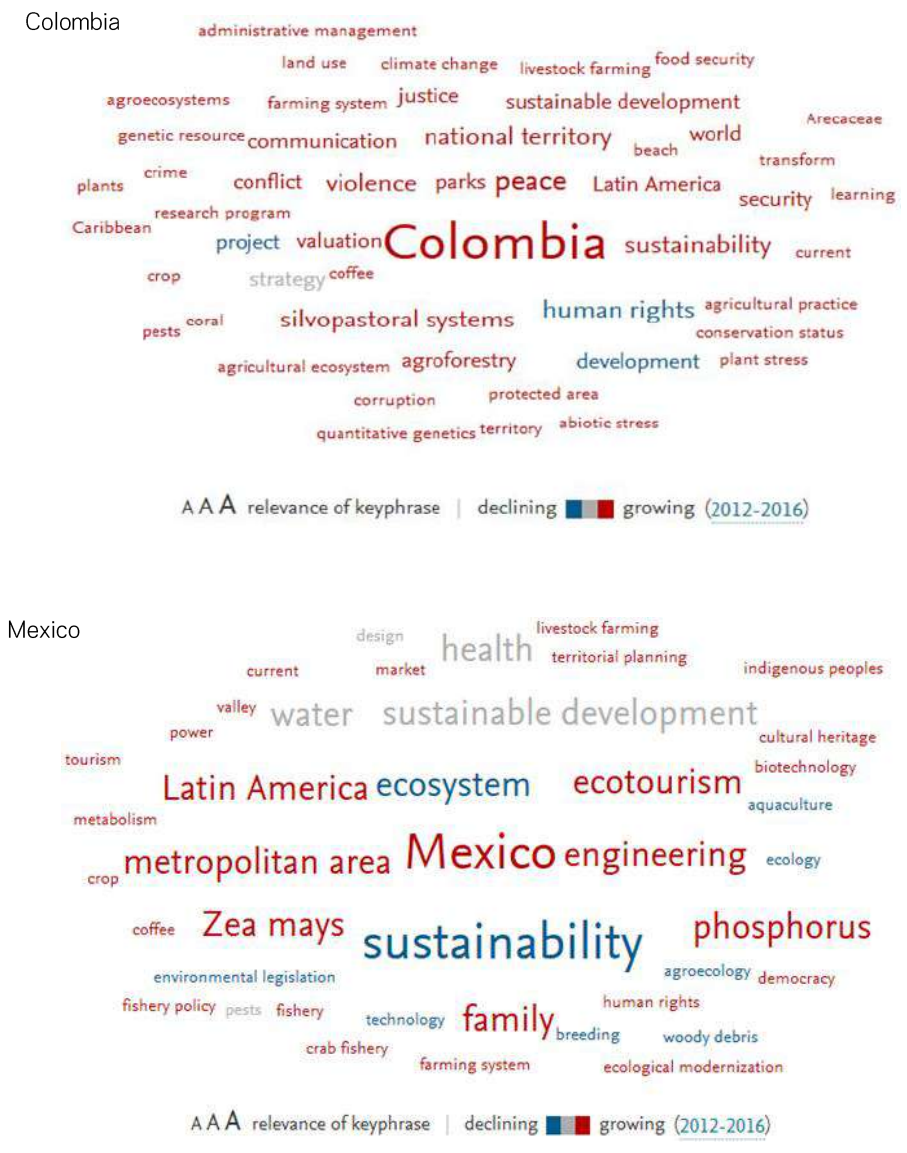

Figure 16.5— *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Brazil

United States

United Kingdom

China

Australia

Canada

16.5 The reach of Colombia's SDG16 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

16.5.1 Downloads

As shown in the Figure 16.6, the mean count of downloads per ScienceDirect publication fluctuates considerably across the period for all countries. This is because the count of SD publications per country was very small for the period (11-288 publications). Therefore, this metric is not a useful indicator of usage data for SDG16.

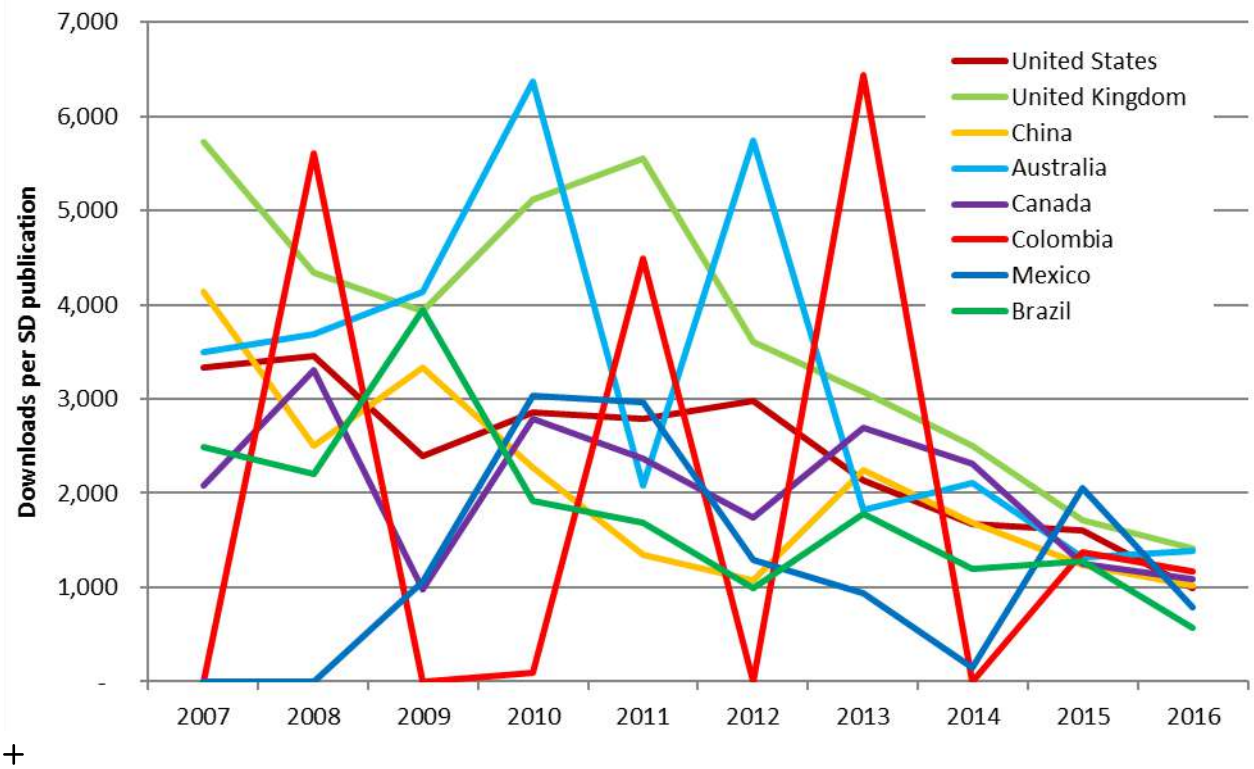

Figure 16.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

16.5.2 **Field Weighted Download Impact (FWDI)**

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. As indicated in section 16.5.1, the count of SD publications for each country was quite low and therefore, FWDI is not an ideal indicator. However, it is notable that the average FWDI for all SDG16 research, at 1.3, is above the average of all research (i.e. 1.0).

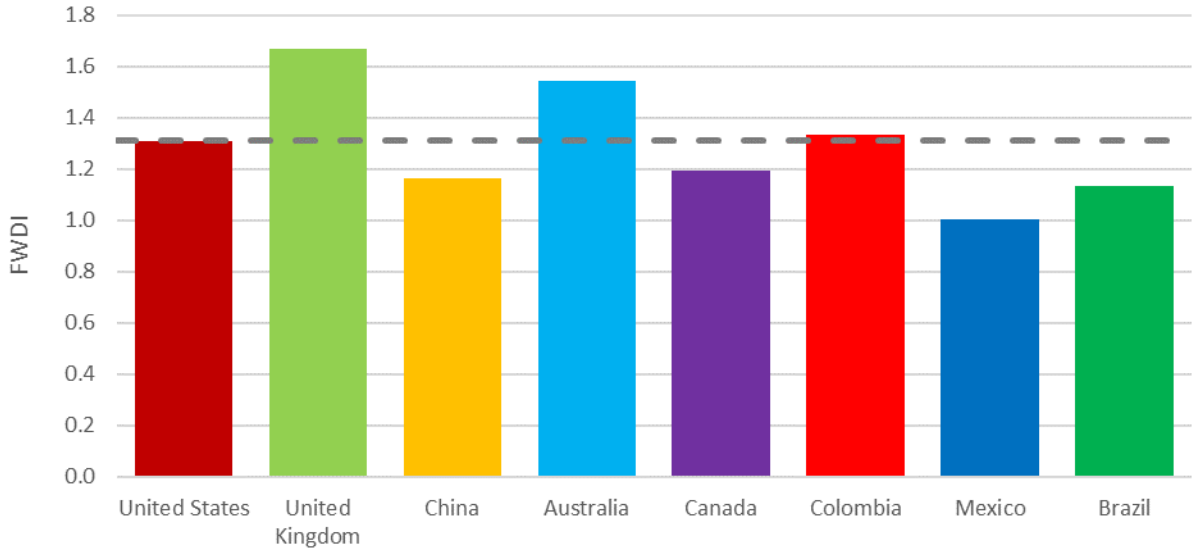

Figure 16.7 — *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. Grey dotted line indicates average for all SDG16 research. (Source: ScienceDirect)*

16.6 SDG16 collaboration network

16.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG16-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 16.10-16.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG16 publications with. As shown in Table 16.10, Colombia has published only 1-4 publications with top partners on SDG16. The FWCI for these collaborations has on average, exceeded the world average. A single publication[22] done in collaboration with several partners resulted in a very high FWCI (18.12).

Country	Institution (Country)	Publication Count	FWCI
Colombia	Wageningen University & Research (Netherlands)	4	7.07
	University of Cambridge (United Kingdom)	3	8.02
	International Crops Research Institute for the Semi-Arid Tropics (India)	3	3.64
	University of Essex (United Kingdom)	2	10.77
	The Ohio State University (United States)	2	10.20
	Universidade Nova de Lisboa (Portugal)	2	6.63
	Yale University (United States)	2	4.99
	University of Leeds (United Kingdom)	2	3.54
	University of Queensland (Australia)	2	2.40
	Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias (Mexico)	2	1.37
	Bangor University (United Kingdom)	1	18.12
	University of Colorado Boulder (United States)	1	18.12
	Chinese Academy of Agricultural Sciences (China)	1	18.12
	University of the Philippines (Philippines)	1	18.12
	Imperial College London (United Kingdom)	1	18.12
	University of Oxford (United Kingdom)	1	18.12
	University College Cork (Ireland)	1	18.12
	U.S. Department of Agriculture (United States)	1	18.12
	World Agroforestry Centre (Kenya)	1	18.12
	Indian Institute of Science Bangalore (India)	1	18.12

Table 16.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

[22] The top 100 questions of importance to the future of global agriculture. *International Journal of Agricultural Sustainability.* Volume 8, Issue 4, 2010, Pages 219-236.

Country	Institution (Country)	Publication Count	FWCI
Mexico	Texas A and M University (United States)	4	2.90
	Wageningen University & Research (Netherlands)	3	2.84
	Universidade de Sao Paulo (Brazil)	3	0.92
	McGill University (Canada)	2	7.74
	Yale University (United States)	2	7.42
	Helmholtz Center for Environmental Research (UFZ) (Germany)	2	5.18
	Pontificia Universidad Catolica del Peru (Peru)	2	2.23
	Chinese Academy of Agricultural Sciences (China)	2	1.92
	University of California at Berkeley (United States)	2	1.91
	U.S. Department of Agriculture (United States)	2	1.25
	University of Stellenbosch (South Africa)	1	10.36
	Stockholm University (Sweden)	1	10.36
	Universitat Bayreuth (Germany)	1	10.36
	Leuphana Universitat Luneburg (Germany)	1	10.36
	CSIRO (Australia)	1	10.36
	University of Wisconsin (United States)	1	10.36
	Vrije Universiteit (Netherlands)	1	10.36
	James Cook University Queensland (Australia)	1	10.36
	Stockholm Environment Institute (Sweden)	1	10.36
	KU Leuven (Belgium)	1	7.48

Table 16.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	U.S. Department of Agriculture (United States)	5	0.82
	Universidade de Lisboa (Portugal)	3	2.16
	Australian National University (Australia)	3	0.87
	Universidade Nova de Lisboa (Portugal)	2	2.74
	Rutgers - The State University of New Jersey, New Brunswick (United States)	2	2.35
	Columbia University (United States)	2	1.94
	Universite d'Angers (France)	2	1.76
	Swedish University of Agricultural Sciences (Sweden)	2	1.66
	United Nations (United States)	2	1.45
	University of Victoria BC (Canada)	2	1.30
	University College London (United Kingdom)	2	1.30
	University of Michigan (United States)	2	1.12
	University of Aberdeen (United Kingdom)	2	1.01
	Yale University (United States)	2	0.85
	University of Florida (United States)	2	0.43
	Max Planck Institute for Chemistry (Germany)	2	0.30
	University of Oslo (Norway)	1	12.92
	University of Melbourne (Australia)	1	12.92
	University of Botswana (Botswana)	1	12.92
	Universidad de Chile (Chile)	1	12.92

+

Table 16.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	Chinese Academy of Sciences (China)	14	1.68
	Wageningen University & Research (Netherlands)	11	3.34
	University of British Columbia (Canada)	9	1.03
	Australian National University (Australia)	8	8.81
	University of Cambridge (United Kingdom)	7	4.83
	University of Queensland (Australia)	7	2.66
	Utrecht University (Netherlands)	7	1.87
	Embrapa - Empresa Brasileira de Pesquisa Agropecuaria (Brazil)	7	1.63
	Vrije Universiteit (Netherlands)	6	4.63
	INRA Institut National de La Recherche Agronomique (France)	6	4.09
	University of Oxford (United Kingdom)	6	4.01
	James Cook University Queensland (Australia)	6	3.49
	University of Stellenbosch (South Africa)	6	2.88
	National University of Singapore (Singapore)	6	2.37
	University College London (United Kingdom)	6	1.83
	Lund University (Sweden)	6	1.73
	University of Victoria BC (Canada)	5	6.86
	McGill University (Canada)	5	5.94
	Universite Paris Saclay (France)	5	5.88
	University of Zurich (Switzerland)	5	5.83

+

Table 16.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	Wageningen University & Research (Netherlands)	9	5.51
	University of Amsterdam (Netherlands)	6	4.28
	Norwegian University of Life Sciences (Norway)	6	3.18
	Curtin University of Technology (Australia)	6	2.30
	Aalborg University (Denmark)	6	1.83
	University of Cape Town (South Africa)	6	1.31
	University of Gothenburg (Sweden)	5	2.51
	York University Toronto (Canada)	5	1.96
	University of Coimbra (Portugal)	5	1.48
	University of Victoria BC (Canada)	4	6.51
	University of Zurich (Switzerland)	4	6.45
	United Nations (United States)	4	6.27
	University of Otago (New Zealand)	4	6.08
	U.S. Department of Agriculture (United States)	4	5.80
	INRA Institut National de La Recherche Agronomique (France)	4	3.95
	Australian National University (Australia)	4	3.92
	James Cook University Queensland (Australia)	4	3.87
	Universitat Autonoma de Barcelona (Spain)	4	3.48
	Stanford University (United States)	4	3.12
	Ghent University (Belgium)	4	2.82

+

Table 16.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
China	Hong Kong Polytechnic University (Hong Kong)	7	1.94
	City University of Hong Kong (Hong Kong)	7	1.90
	Wageningen University & Research (Netherlands)	6	3.32
	Chinese University of Hong Kong (Hong Kong)	6	1.58
	University of Hong Kong (Hong Kong)	5	1.72
	U.S. Department of Agriculture (United States)	4	6.68
	University of California at Davis (United States)	4	6.66
	University of Zurich (Switzerland)	4	6.60
	University of Oxford (United Kingdom)	4	5.51
	University of Western Australia (Australia)	4	3.12
	University of Tokyo (Japan)	4	1.53
	National University of Singapore (Singapore)	4	1.19
	University College London (United Kingdom)	3	5.40
	Hong Kong Baptist University (Hong Kong)	3	1.64
	University of Michigan (United States)	3	1.60
	Korea Research Institute of Bioscience and Biotechnology (South Korea)	3	1.38
	Karolinska Institutet (Sweden)	3	1.17
	University of South Australia (Australia)	3	1.04
	Arizona State University (United States)	3	0.38
	University of Aberdeen (United Kingdom)	2	11.95

+

Table 16.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for China. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Australia	University of Victoria BC (Canada)	6	2.80
	Texas A and M University (United States)	6	2.33
	University of Zurich (Switzerland)	5	3.95
	Vrije Universiteit (Netherlands)	4	8.57
	Leuphana Universitat Luneburg (Germany)	4	5.09
	International Crops Research Institute for the Semi-Arid Tropics (India)	4	3.28
	INRA Institut National de La Recherche Agronomique (France)	4	2.60
	The James Hutton Institute (United Kingdom)	4	2.57
	University of Dundee (United Kingdom)	4	2.57
	International Rice Research Institute (Philippines)	4	2.30
	University College London (United Kingdom)	4	1.97
	United Nations (United States)	4	0.96
	Stockholm University (Sweden)	3	24.67
	Stanford University (United States)	3	18.97
	Zhejiang University (China)	3	8.32
	Norwegian University of Life Sciences (Norway)	3	7.46
	University of Botswana (Botswana)	3	7.33
	University of Stellenbosch (South Africa)	3	5.06
	NOAA (United States)	3	3.68
	Ministry of Education China (China)	3	2.91

Table 16.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Australia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Canada	University of Stellenbosch (South Africa)	7	1.58
	Australian National University (Australia)	5	13.03
	University of Sussex (United Kingdom)	5	7.26
	Indiana University Bloomington (United States)	4	15.14
	University of East Anglia (United Kingdom)	4	8.53
	Chinese Academy of Agricultural Sciences (China)	4	7.02
	Texas A and M University (United States)	4	2.35
	INRA Institut National de La Recherche Agronomique (France)	4	2.07
	University of Wisconsin (United States)	3	27.08
	CSIRO (Australia)	3	22.90
	Stockholm University (Sweden)	3	21.15
	Arizona State University (United States)	3	19.59
	University of Alaska Fairbanks (United States)	3	19.57
	University of Zurich (Switzerland)	3	7.87
	U.S. Department of Agriculture (United States)	3	7.13
	Wageningen University & Research (Netherlands)	3	7.05
	United Nations (United States)	3	6.80
	University of Cambridge (United Kingdom)	3	6.49
	Vrije Universiteit (Netherlands)	3	6.42
	James Cook University Queensland (Australia)	3	5.88

+

Table 16.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Canada. (Source: Scopus)*

16.6.2 Collaboration impact analysis

To visualize the citation impact of collaborations, the ratio of FWCI from SDG16 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG16 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG16 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. For SDG16 research from 2007-2016, the majority of Colombia's collaborations with top 20 academic partners were mutually beneficial to both Colombia and the collaboration partner in terms of citation impact (Figure 16.8). As mentioned in section 16.6.1, a single paper[22] represents 10 of the collaborations. Beyond the collaborations from that single paper, it is notable that collaborations with the University of Essex and the University of Ohio were of particular benefit to Colombia in terms of citation impact.

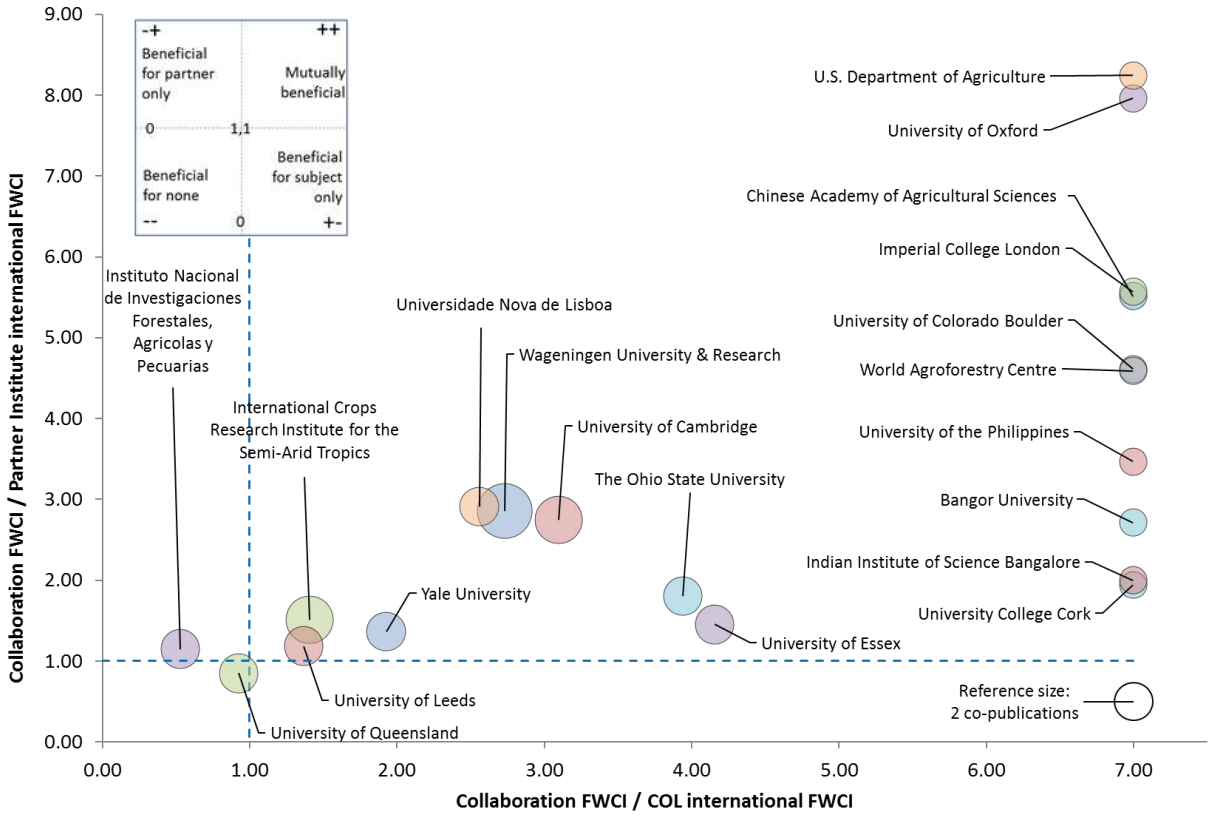

Figure 16.8— *Collaboration quadrant of Colombia's Top 20 collaborations in SDG16-related research with other institutions. Collaboration FWCI refers to the FWCI of all SDG16-related research co-authored by Colombia and the partner institute during the period 2007-2016. Bubble size corresponds to number of co-authored publications (reference bubble depicted at top left of chart). Impact of collaboration between partners can be interpreted based on quadrant position as described in legend on top left. (Source: Scopus).*

16.6.3 **Collaboration chart**

Figure 16.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG16. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 16.9 shows where there may be potential to improve output and impact through partnership. Colombia co-authored 1-4 publications with its top foreign partner institutes. Wageningen University & Research publishes the most SDG16 research (among Colombia's top 20 partners) with 68 publications. U.S. Department of Agriculture and University of Queensland were the next most prolific among Colombia's top 20, with 57 and 56 publications, respectively. Among Colombia's top 20 partners, University of Essex has the highest FWCI for SDG16 research at 4.91. Colombia may want to leverage its existing relationship with these institutions to increase its publication output and impact on SDG16 research.

Figure 16.9— *Chart showing Colombia's top 20 collaborators on SDG16 from 2007-2016. Circle (node) size is proportional to the number of SDG16 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (4.91) and lightest shade of green indicating the lowest FWCI (1.19). (Source: Scopus).*

Chapter 17
Partnerships for the Goals

In this Chapter, we assess research related to SDG17, which aims to revitalize the global partnership for sustainable development. Statistics are provided for the top 5 countries publishing research in this field along with Colombia, Mexico, and Brazil.

17.1 Key Findings

Goal 17: Revitalize the global partnership for sustainable development

WORLD RESEARCH OUTPUT

60,652

Number of SDG17 publications, 2007-2016.

SDG17 PATENTS

271

Number of SDG17 patents, 2007-2016.

COLOMBIA RESEARCH OUTPUT

266

Colombia's SDG17 publications, 2007-2016.

COLOMBIA'S RESEARCH OUTPUT CAGR

30%

Compound annual growth rate for Colombia's 2007-2016 SDG17 publications.

COLOMBIA TOP TEN PERCENTILE FOR CITATION

32

Colombia's SDG17 publications within the top ten percentile for citations, 2007-2016.

COLOMBIA FIELD WEIGHTED CITATION IMPACT

1.15

Average field-weighted citation impact for Colombia's SDG17 publications, 2007-2016.

17.2 SDG17 – Revitalize the global partnership for sustainable development

According to the United Nations,

> *"A successful sustainable development agenda requires partnerships between governments, the private sector and civil society. These inclusive partnerships built upon principles and values, a shared vision, and shared goals that place people and the planet at the centre, are needed at the global, regional, national and local level.*
>
> *Urgent action is needed to mobilize, redirect and unlock the transformative power of trillions of dollars of private resources to deliver on sustainable development objectives. Long-term investments, including foreign direct investment, are needed in critical sectors, especially in developing countries. These include sustainable energy, infrastructure and transport, as well as information and communications technologies. The public sector will need to set a clear direction. Review and monitoring frameworks, regulations and incentive structures that enable such investments must be retooled to attract investments and reinforce sustainable development. National oversight mechanisms such as supreme audit institutions and oversight functions by legislatures should be strengthened."*[23]

The targets for SDG 17 are multi-pronged. According to the United Nations, these are:

> *"Finance*
>
> - *Strengthen domestic resource mobilization, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection.*
> - *Developed countries to implement fully their official development assistance commitments, including the commitment by many developed countries to achieve the target of 0.7 per cent of ODA/GNI to developing countries and 0.15 to 0.20 per cent of ODA/GNI to least developed countries ODA providers are encouraged to consider setting a target to provide at least 0.20 per cent of ODA/GNI to least developed countries.*
> - *Mobilize additional financial resources for developing countries from multiple sources.*
> - *Assist developing countries in attaining long-term debt sustainability through coordinated policies aimed at fostering debt financing, debt relief and debt restructuring, as appropriate, and address the external debt of highly indebted poor countries to reduce debt distress.*
> - *Adopt and implement investment promotion regimes for least developed countries.*
>
> *Technology*
>
> - *Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism.*
> - *Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed.*
> - *Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology.*

[23] http://www.un.org/sustainabledevelopment/globalpartnerships/

Capacity building

- *Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the sustainable development goals, including through North-South, South-South and triangular cooperation.*

Trade

- *Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the world Trade Organization, including through the conclusion of negotiations under its Doha Development Agenda.*
- *Significantly increase the exports of developing countries, in particular with a view to doubling the least developed countries' share of global exports by 2020.*
- *Realize timely implementation of duty-free and quota-free market access on a lasting basis for all least developed countries, consistent with World Trade Organization decisions, including by ensuring that preferential rules of origin applicable to imports from least developed countries are transparent and simple, and contribute to facilitating market access.*

Systemic issues

Policy and institutional coherence

- *Enhance global macroeconomic stability, including through policy coordination and policy coherence*
- *Enhance policy coherence for sustainable development.*
- *Respect each country's policy space and leadership to establish and implement policies for poverty eradication and sustainable development.*

Multi-stakeholder partnerships

- *Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the sustainable development goals in all countries, in particular developing countries.*
- *Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships.*

Data, monitoring and accountability

- *By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts.*
- *By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries."*[23]

Research can play a role in supporting the above goals. To identify research that aims to support the above goals and SDG17 in general, the following search terms were used in combination with sustainab* OR "sustainable development goal" in a query of the Scopus database. The full conditions of the search query, including methodology for identifying search terms and subject limitations imposed on the query, can be found in Appendix B.

The analyses within this chapter give an overview of scholarly output and impact in the field as well as leading countries, institutions, researchers, and journals in terms of scholarly output.

17.3 SDG17: Leaders in the field

17.3.1 Top 5 countries conducting SDG1 research

The top 5 countries publishing on SDG17 based on cumulative publication output from 2007-2016 are shown in Table 17.1 and Figure 17.1. The United States ranks 1st according to Publication Count, Percentage of Global Output, and Citation Count. The United Kingdom ranks 1st in FWCI with 1.76, which is much higher than the world average (world average for SDG17 research is 1.16). Except for China, all other countries' FWCI exceed the average as well.

Table 17.1— *Top 5 countries based on publication output from 2007-2016. (Source: Scopus)*

Country	Publication count	Percentage of Global Output	Citation Count	FWCI
United States	12,678	20.90%	158,741	1.51
United Kingdom	6,735	11.10%	94,536	1.76
China	4,462	7.36%	29,417	0.91
Australia	4,067	6.71%	53,198	1.64
Germany	3,519	5.80%	46,197	1.62
World	60,652	100.00%	204,102	1.16

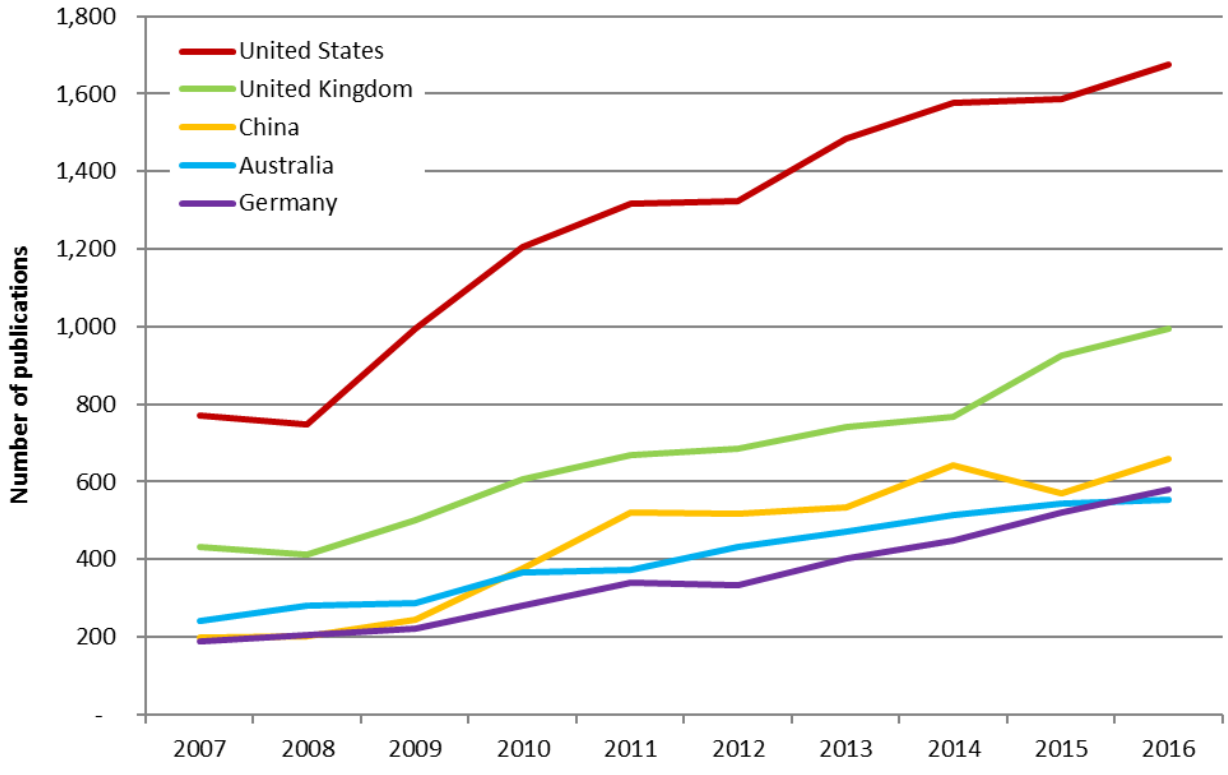

Figure 17.1— *2007-2016 trend in publication output for the top 5 countries publishing SDG17 research. (Source: Scopus)*

17.3.2 Top 20 institutes conducting SDG17 research

A list of the top 20 research institutes publishing SDG17-related research is shown in Table 17.2. Wageningen University & Research ranks 1st in Publication Count and surpasses the next ranked institute by 95 publications. Among the top 20 institutes, CSIRO (Australia) has the highest FWCI at nearly three times the world average. All the top 20 institutes have a mean FWCI above world average in this research field. The trends in publication output from 2007-2016 are shown in Figure 17.2. (Note that the figure is limited to the top 8 institutes to facilitate visualization. To see the trends for all 20 institutes, please refer to accompanying data files.)

Rank	Institution (Country)	Publication count	Citation Count	FWCI
1	Wageningen University & Research (Netherlands)	622	15,018	2.69
2	Chinese Academy of Sciences (China)	527	6,661	1.24
3	University of British Columbia (Canada)	353	6,598	2.14
4	Arizona State University (United States)	348	8,207	2.67
5	University of Queensland (Australia)	341	5,967	2.08
6	CNRS (France)	341	4,873	2.12
7	Delft University of Technology (Netherlands)	316	4,674	2.20
8	CSIRO (Australia)	292	9,049	3.05
9	University of Cambridge (United Kingdom)	279	5,833	2.63
10	University of Leeds (United Kingdom)	266	5,562	2.74
11	University of Oxford (United Kingdom)	259	5,957	2.54
12	University of California at Berkeley (United States)	249	7,283	2.64
13	ETH Zurich (Switzerland)	244	5,151	2.36
14	Universidade de Sao Paulo (Brazil)	243	2,007	1.23
15	Griffith University Queensland (Australia)	241	3,000	1.78
16	University of Manchester (United Kingdom)	241	3,554	2.08
17	Australian National University (Australia)	235	5,415	2.54
18	Monash University (Australia)	234	4,108	1.78
19	Lund University (Sweden)	232	4,345	2.56
20	United Nations (United States)	232	3,239	1.60

Table 17.2— *Top 20 research Institutes ranked based on SDG1 publication output and FWCI from 2007-2016. (Source: Scopus)*

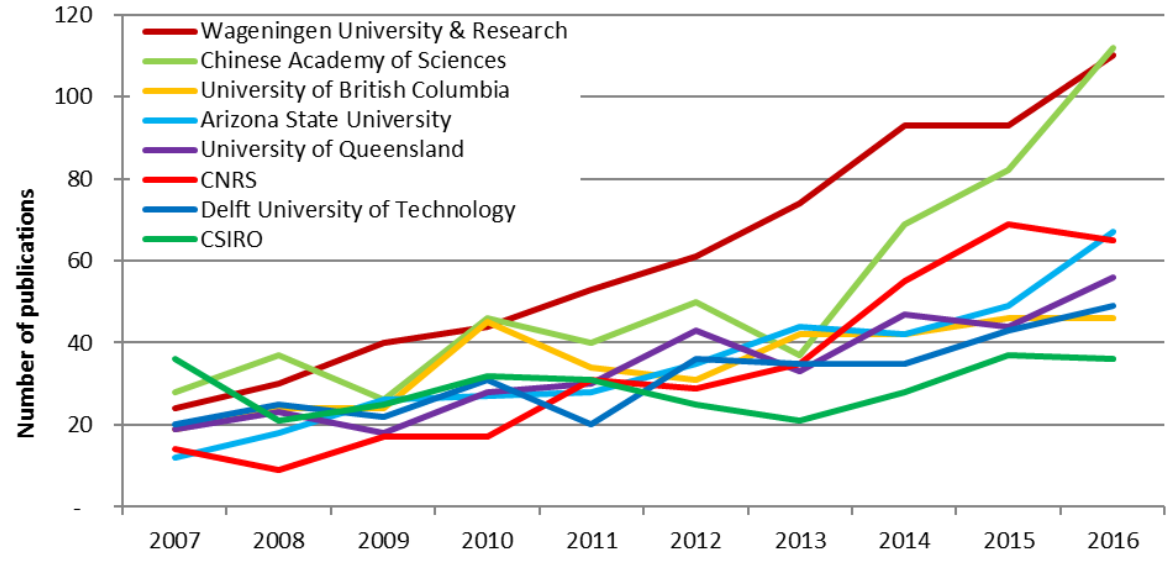

Figure 17.2— *2007-2016 trend in publication output for the top 8 institutes conducting research on SDG17. (Source: Scopus)*

17.3.3 Top 20 researchers conducting SDG17 research

A list of the top 20 researchers publishing in the SDG17 field based on publication output from 2007-2016 is shown in Table 17.3. Wiek A. ranks 1st in Publication Count followed by Huisingh D. and Taisch M.
Smith P., Sarkis J., and Haberl H. are the top 3 researchers in this list in terms of H-index.

Rank	Researcher	Institution (Country)	Pub count	Citation Count	FWCI	h-index
1	Wiek A.	Leuphana Universitat Luneburg (Germany)	42	1,508	3.89	30
2	Huisingh D.	University of Tennessee, Knoxville (United States)	35	1,329	8.20	26
3	Taisch M.	Politecnico di Milano (Italy)	34	278	2.00	15
4	Brown R.	Monash University (Australia)	33	893	2.23	24
5	Stringer L.	University of Leeds (United Kingdom)	32	764	2.02	29
6	Sarkis J.	Worcester Polytechnic Institute (United States)	29	1,144	4.34	62
7	Geng Y.	Shanghai Jiaotong University (China)	26	708	3.04	41
8	Lozano R.	Utrecht University (Netherlands)	25	1,287	10.91	22
9	Pahl-Wostl C.	Universitat Osnabruck (Germany)	25	1,063	3.79	41
10	Mol A.	Hollandseweg 1 (Netherlands)	25	601	2.83	34
11	Rashid Sumaila U.	Institute for the Oceans and Fisheries (Canada)	24	600	2.56	42
12	Hickey G.	McGill University (Canada)	24	198	1.11	13
13	Gößling S.	Lunds Universitet (Sweden)	23	867	5.29	32
14	Haberl H.	Alpen-Adria-UniversitÃ¤t Klagenfurt (Austria)	23	1,049	4.93	46
15	Smith P.	University of Aberdeen (United Kingdom)	21	1,173	5.58	71
16	Madani K.	Imperial College London (United Kingdom)	21	315	4.63	21
17	Rieradevall J.	Institut de Ciencia i Tecnologia Ambientals (ICTA)-UAB (Spain)	21	431	2.11	29
18	Gupta J.	University of Amsterdam (Netherlands)	21	232	2.02	23
19	Mihelcic J.	University of South Florida Tampa (United States)	21	432	1.90	26
20	Gabarrell X.	Institut de Ciencia i Tecnologia Ambientals (ICTA)-UAB (Spain)	21	337	1.89	26

Table 17.3— *Top 20 researchers publishing SDG17 related research ranked based on 2007-2016 publication output and their FWCI. FWCI is based on SDG17 publications, h-index is based on all publications by the researcher that are indexed in the Scopus database. (Source: Scopus)*

17.3.4 Top 10 journals publishing SDG17 research

A list of the top 10 journals publishing SDG17-related research from 2007-2016 is shown in Table 17.4. *Journal of Cleaner Production* published 903 SDG17 related publications, making it the highest ranked journal in terms of SDG17 publications. *Journal of Cleaner Production* also had the highest FWCI and CiteScore among the top 10 journals publishing the most research related to this goal. Eight of the ten journals among the top 10 had a cite score below 1.0, indicating that publications within the journal get less than one citation on average over a 3-year period after publication.

Rank	Journal	Publication count	FWCI	CiteScore
1	Journal of Cleaner Production	903	3.35	3.70
2	Sustainability	822	1.04	0.92
3	IFIP Advances in Information and Communication Technology	516	1.21	0.18
4	Lecture Notes in Computer Science	510	0.98	0.50
5	Advanced Materials Research	497	0.47	0.17
6	WIT Transactions on Ecology and the Environment	407	0.06	0.08
7	Proceedings of the 27th International Business Information Management Association Conference - Innovation Management and Education Excellence Vision 2020: From Regional Development Sustainability to Global Economic Growth, IBIMA 2016	397	0.70	0.00
8	Energy Policy	377	1.75	3.52
9	ASEE Annual Conference and Exposition, Conference Proceedings	351	0.49	0.00
10	Ecology and Society	297	2.05	3.05

Table 17.4— *Top 10 journals based on SDG17 publication output from 2007-2016. FWCI is mean FWCI for all SDG17 publications in the journal during the period; CiteScore is based on data for the journal as a whole. (Source: Scopus)*

17.4 Research efforts focused on SDG17

17.4.1 Research output

Research output as measured by volume of publications (i.e. articles, reviews and conference proceedings indexed in Scopus) is shown in the charts and tables in this section. Publication output is provided for the top 5 countries based on publication output during the period 2007-2016. In addition, metrics are provided for Colombia, Mexico, and Brazil. As shown in Figure 17.3, the United States is by far the leader in terms of research output related to SDG17. The United Kingdom follows, along with China, Australia, and Germany. Among comparators, Colombia has the lowest output in this field, just below Mexico. However, as shown in Table 1.5, Colombia has the greatest growth in research output in this field with a Compound Annual Growth Rate (CAGR) of 29.9%. All countries analysed have a CAGR above 9% in this field. The CAGR for all SDG17 research done globally is 10.8%, exceeded by all comparator countries except the Anglophone ones.

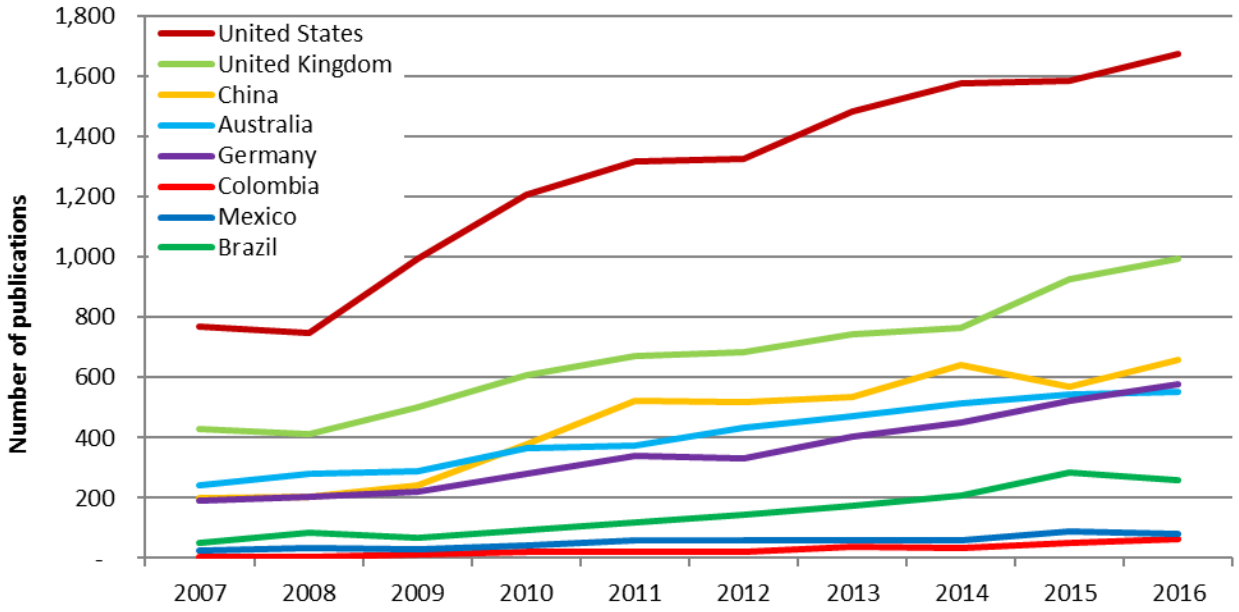

Figure 17.3— *Total number of publications; per country for Colombia, Mexico, Brazil, and the 5 most prolific countries for the period 2007-2016. (Source: Scopus)*

Country	Publication count	CAGR
United States	12,678	9.00%
United Kingdom	6,735	9.70%
China	4,462	14.30%
Australia	4,067	9.70%
Germany	3,519	13.20%
Colombia	266	29.90%
Mexico	541	13.10%
Brazil	1,483	19.50%
World	60,652	10.80%

Table 17.5— *Number of publications per country and the Compound Annual Growth Rate (CAGR) for publication output during the period 2007-2016. (Source: Scopus)*

17.4.2 Field Weighted Citation Impact

To understand the scientific impact of research, we use a citation measure called field-weighted citation impact (FWCI). FWCI reflects the number of citations that a publication receives relative to the number of citations expected based on the subject, age, and type of publication. An FWCI of 1.0 represents the world average for all research done worldwide. The mean FWCI for SDG17 related research from 2006-2017 is 1.16.

Country	FWCI
United States	1.51
United Kingdom	1.76
China	0.91
Australia	1.64
Germany	1.62
Colombia	1.15
Mexico	1.48
Brazil	1.06
World	1.16

Comparing the FWCI of SDG17 publications from each of the eight countries included in this chapter reveals that the United Kingdom leads in terms of FWCI (Table 17.6). Among countries analysed, only China has an FWCI below the world average for this subject.

Table 17.6— *FWCI for SDG17 research from 2007-2016 per country and world. FWCI values below the world average for all research (i.e. below 1.0) are highlighted in green. (Source: Scopus)*

17.4.3 Top 10 Percent Most Highly Cited

The top ten percent most highly cited publications (also known as top ten percentile) are those publications that have an FWCI greater than 90% of papers worldwide. Contribution to the top ten percentile gives an indication of how many publications from a country are among the 'most influential' papers. As shown in Figure 17.4 and Table 17.7, the United States leads in terms of SDG17 publications with 2,171 publications that are among the top 10% most cited. The United Kingdom, Australia, and Germany follow in that order. Colombia has 32 publications among the top 10% most cited during this time period. Although China has the lowest count of highly cited publications among the top 5 countries, the high CAGR for China's SDG17 publications during the period suggests that China may surpass Germany and Australia in the near future, as it has done for all publications on SDG17.

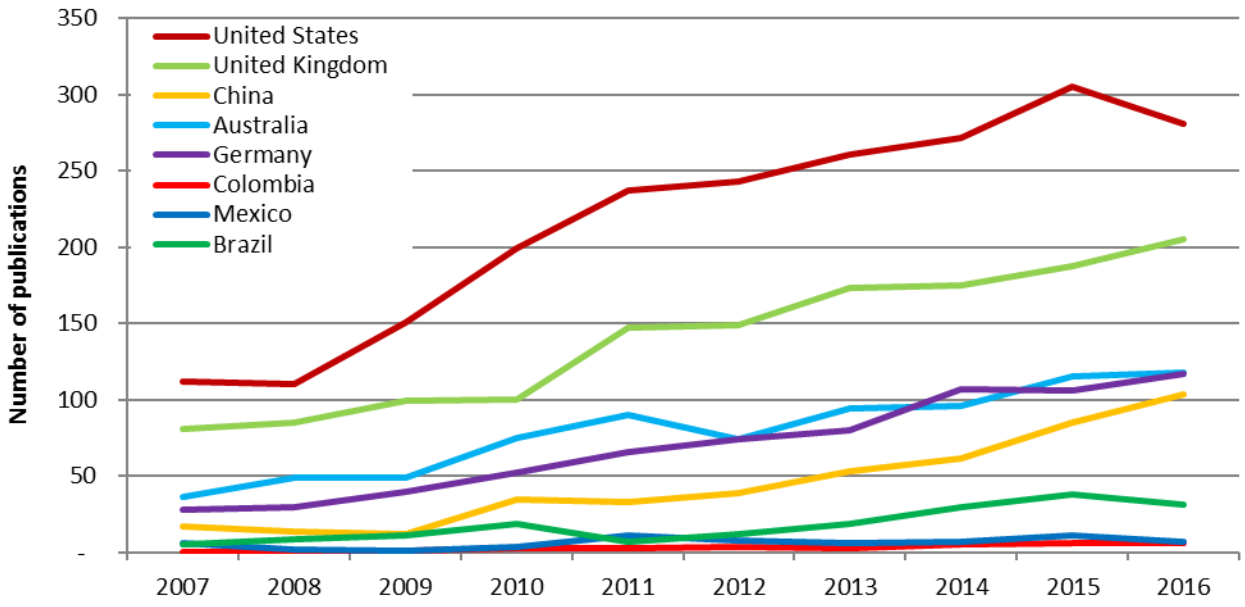

Figure 17.4— *Top 10% most cited publications on SDG1 from 2007-2016 per country. CAGR shown at top of each bar. (Source: Scopus)*

Country	Count of Top 10% Publications	CAGR
United States	2,171	10.76%
United Kingdom	1,402	10.87%
China	454	22.29%
Australia	796	14.10%
Germany	700	17.22%
Colombia	32	-
Mexico	63	1.73%
Brazil	181	22.47%
World	7,953	12.91%

Table 17.7— *Top 10% most highly cited publications and their Compound Annual Growth Rate (CAGR) for each country's SDG17 publications from 2007-2016. (Source: Scopus)*

17.4.4 Patents citations in articles

Typically, a patent application will include one or more claims that define the invention. As such, many patent applications cite publications to support claims that the invention is novel. The number of publications cited in patent applications is therefore an indicator of the success with which research findings published in the journal literature are used to justify the patentability of an invention. It is also a measure of how much the research is supporting translation into real world applications. Table 17.8 provides the count of SDG17 publications from each country that have been cited in patents and the number of patents that have cited these publications. For the United States, 41 US publications on SDG17 have been cited in 154 patents. The United Kingdom, China, and Australia have 4-8 publications cited in 7-11 patents while Brazil has 1 publication cited in 2 patents. Colombia and Mexico have no patent citations in this field.

Country	Patent Cited Publications	Patents Citing Publications
United States	41	154
United Kingdom	4	9
China	7	7
Australia	8	11
Germany	8	10
Colombia	-	-
Mexico	-	-
Brazil	1	2

Table 17.8— *Number of publications cited in patent and patents citing publications on SDG17 from 2007 to 2016. (Source: Scopus)*

17.4.5 Patents

By mining the LexisNexis TotalPatent database, we counted the number of patents issued that focus on SDG17. To identify patents relevant to SDG17, we retrieved all the patents citing any SDG17-related publication. Patents retrieved were limited to those in the following patent authorities: WIPO, EPO, and USPTO. From 2006 to 2016, the United States had the highest number of SDG17-related patents (both applied for and granted) with 62 patent applications and 101 patents granted (Table 17.9). China and Germany applied for a small number of patents and Colombia was granted one patent in this field during the period. Note that China and Australia may have patents in a local patent office not included in this analysis.

Country	Patents applied for	Patents Granted	Total	% of World Total
United States	62	101	163	60.15%
United Kingdom	2	5	7	2.58%
China	13	1	14	5.17%
Australia	2	1	3	1.11%
Germany	9	2	11	4.06%
Colombia	-	1	1	0.37%
Mexico	1	-	1	0.37%
Brazil	1	1	2	0.74%
World	141	130	271	

Table 17.9— *Number of patents applied for and granted during the period 2006-2016. (Source: Lexis-Nexis)*

17.4.6 **Research Focus**

Within the topic of SDG17-related research, there can be differences in research focus from country to country. This can occur as researchers are motivated by national interests, countries build upon their own inherent research strengths, and countries set different social and economic priorities that influence their respective scientific agenda. In this section, we investigate the differences in research focus in SDG17-related research from Colombia, Mexico, Brazil and the top five most prolific countries in this research field. To do this, we employ Elsevier's Fingerprint Engine™, which uses natural language processing (NLP) technology and domain-specific thesauri to analyze the information contained in textual publication data from the title, abstract and keywords, and assigns to each publication a collection of key phrases (weighted) that represent it. Key phrases based on Fingerprint technology are of higher quality and more representative than standard sets of author-provided keywords which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. A word cloud of the 50 most relevant key phrases in each country's SDG17 research is shown in Figure 17.5. More details on the methods employed for key phrase analysis and generation of relevance scores can be found in Appendix A.

Among the top 20 key phrases for SDG17 research from Colombia, the term that stands out as unique to Colombia is 'Multi Agent Systems'. Among the top 50 key phrases the terms 'Education'; 'Industry', 'Climate Change', 'Environmental Management', 'Societies and Institutions', 'Innovation', and 'Ecosystem Service' were common among the countries analyzed. The term 'Region' stands out as unique to the Latin American countries. Figure 17.5 provides a visualization of the top 50 key phrases for SDG17 research from each country. The accompanying data files provide a list of the key phrases as well as the relevance score for each key phrase.

Colombia

Mexico

Figure 17.5 — *Research focus; per country for Colombia, Mexico, and Brazil and the top prolific countries from 2012-2016. (Source: Scopus, SciVal and Elsevier's Fingerprint Engine)*

Brazil

United States

United Kingdom

China

Australia

Germany

17.5 The reach of Colombia's SDG17 research

Citation impact is a lagging indicator: for citations to accrue, newly published articles must be read and referenced in newly written articles that are then accepted for publication and included in a citation index such as Scopus. Measures such as article downloads can give a broader and more rapid perspective of how much the research is being used or read. In this report, the number of downloads accrued by ScienceDirect (SD) articles are used as a proxy to understand research usage (more details on the methodology can be found in Appendix A).

To facilitate the analysis of download counts across publication sets, the number of ScienceDirect article downloads is normalized against the total number of ScienceDirect articles within the set, resulting in a metric called 'mean downloads per ScienceDirect Paper.' To account for differences in subject area and publication year an indicator similar to the field-weighted citation impact, called field-weighted download impact (FWDI), is also used here.

17.5.1 Downloads

As shown in the Figure 17.6, the mean count of downloads per ScienceDirect publication is similar across all countries. The average count of downloads per SD publication was the same for all countries. For Colombia, there is a prominent peak in 2009, resulting from two SD articles, resulting in a high 'mean' value.

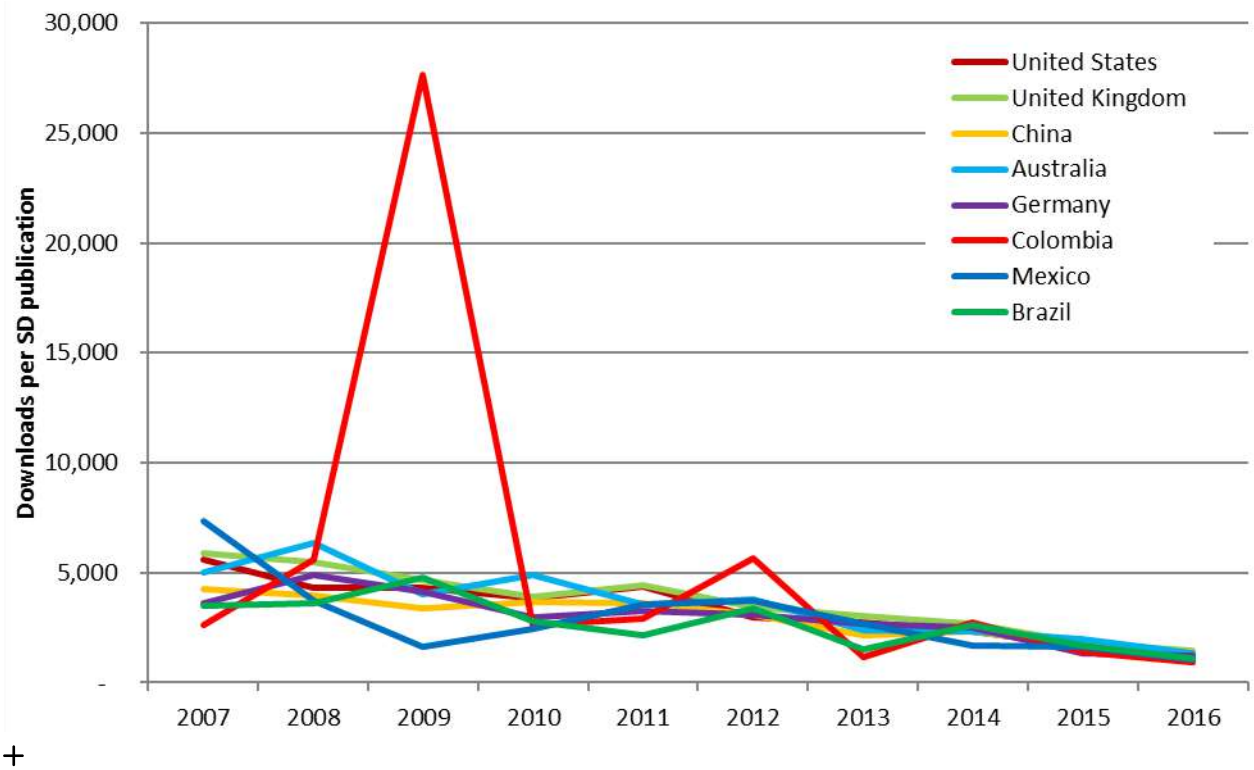

Figure 17.6— *Average downloads per ScienceDirect (SD) publication for Colombia, Mexico, Brazil, and the 5 most prolific countries from 2007-2016. (Source: ScienceDirect)*

17.5.2 **Field Weighted Download Impact (FWDI)**

Field weighted download impact (FWDI) measures 'ScienceDirect Downloads' normalized against the world benchmark of downloads received for all ScienceDirect articles of the same type, age, and subject. The FWDI for all countries except Brazil exceeded the world average for SDG17 research (1.52).

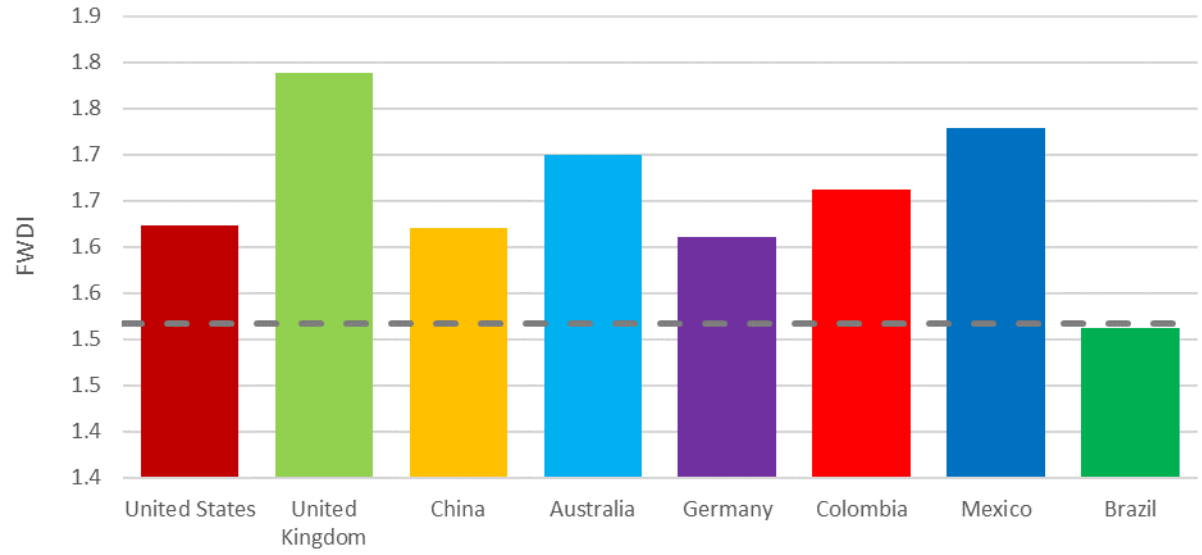

Figure 17.7 — *Field Weighted Download Impact (FWDI) for Colombia and selected countries, 2007-2016. Grey dotted line indicates average for all SDG17 research. (Source: ScienceDirect)*

17.6 SDG17 collaboration network

17.6.1 Top Collaboration Partners

Understanding and comparing the top foreign institutes that each country partners with for SDG17-related research can provide insight on potential international partnerships that Colombia can pursue. Tables 17.10-17.17 provide a list of top international collaboration partners identified as the research institutes with which each country co-publishes the most high impact SDG17 publications with. Among academic partner institutes, Colombia has published the 6 SDG17 papers in collaboration with 3 top partners: Stanford University (United States), Universidad Nacional Autonoma de Mexico (Mexico), and Columbia University (United States), Publications with Stanford yielded the highest FWCI among these 3 partners. However, the highest FWCI among the top 20 partners resulted from three publications with the Food and Agriculture Organization of the United Nations (Italy).

Country	Institution (Country)	Publication Count	FWCI
Colombia	Stanford University (United States)	6	4.38
	Universidad Nacional Autonoma de Mexico (Mexico)	6	2.36
	Columbia University (United States)	6	1.56
	World Agroforestry Centre (Kenya)	5	6.50
	University of Cambridge (United Kingdom)	5	5.73
	Universitat Autonoma de Barcelona (Spain)	5	2.29
	CSIC (Spain)	5	2.21
	Wageningen University & Research (Netherlands)	4	6.97
	University of Copenhagen (Denmark)	4	4.43
	University of Leeds (United Kingdom)	4	3.78
	Universitat Politecnica de Catalunya (Spain)	4	2.01
	Food and Agriculture Organization of the United Nations (Italy)	3	10.86
	University of Wisconsin (United States)	3	8.60
	University of Tennessee, Knoxville (United States)	3	6.43
	KU Leuven (Belgium)	3	6.32
	University of British Columbia (Canada)	3	6.08
	University of Vermont (United States)	3	4.53
	CIRAD (France)	3	4.30
	Universite Catholique de Louvain (Belgium)	3	4.23
	Universidade Federal do Rio de Janeiro (Brazil)	3	3.01

Table 17.10— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Colombia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Mexico	Arizona State University (United States)	10	3.59
	Wageningen University & Research (Netherlands)	9	2.68
	Texas A and M University (United States)	8	1.41
	Clark University (United States)	8	0.79
	SUNY Albany (United States)	8	0.71
	Griffith University Queensland (Australia)	7	3.62
	INRA Institut National de La Recherche Agronomique (France)	7	3.32
	University of Twente (Netherlands)	7	2.26
	University of Michigan (United States)	7	0.96
	Utrecht University (Netherlands)	5	12.57
	Delft University of Technology (Netherlands)	5	10.11
	Stockholm University (Sweden)	5	10.02
	Council for Scientific and Industrial Research South Africa (South Africa)	5	7.78
	University of Copenhagen (Denmark)	5	7.52
	Stanford University (United States)	5	5.45
	University of Wisconsin (United States)	5	4.14
	University of Vermont (United States)	5	2.81
	Universidad de Cordoba (Spain)	5	1.93
	Technical University of Denmark (Denmark)	5	1.77
	University of California at Berkeley (United States)	5	1.62

Table 17.11— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Mexico. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Brazil	University of Florida (United States)	20	2.24
	Wageningen University & Research (Netherlands)	19	3.97
	CSIRO (Australia)	14	4.76
	CIRAD (France)	14	2.18
	INRA Institut National de La Recherche Agronomique (France)	13	5.35
	U.S. Department of Agriculture (United States)	13	3.70
	University of East Anglia (United Kingdom)	13	3.00
	IRD (France)	11	6.61
	CNRS (France)	10	5.37
	University of Oxford (United Kingdom)	10	4.30
	Universidade Nova de Lisboa (Portugal)	10	2.16
	Universidade de Lisboa (Portugal)	10	1.66
	Colorado State University (United States)	9	5.73
	University of British Columbia (Canada)	9	5.64
	University of Aberdeen (United Kingdom)	9	4.97
	Yale University (United States)	9	2.39
	University of Minho (Portugal)	9	0.82
	Universite Catholique de Louvain (Belgium)	8	8.55
	Universite de Montreal (Canada)	8	4.16
	United Nations (United States)	8	2.72

Table 17.12— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Brazil. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United States	University of British Columbia (Canada)	93	3.15
	Chinese Academy of Sciences (China)	93	2.24
	Wageningen University & Research (Netherlands)	84	4.70
	CSIRO (Australia)	62	5.64
	University of Cambridge (United Kingdom)	53	4.64
	Stockholm University (Sweden)	52	6.81
	University of Oxford (United Kingdom)	52	3.79
	CNRS (France)	46	3.99
	Australian National University (Australia)	39	5.59
	International Institute for Applied Systems Analysis, Laxenburg (Austria)	38	3.88
	University of Queensland (Australia)	38	3.12
	James Cook University Queensland (Australia)	36	3.79
	McGill University (Canada)	35	4.44
	University of Leeds (United Kingdom)	34	6.43
	ETH Zurich (Switzerland)	34	5.21
	Imperial College London (United Kingdom)	34	3.92
	Delft University of Technology (Netherlands)	33	7.73
	Universidade de Sao Paulo (Brazil)	33	3.03
	Tsinghua University (China)	33	2.62
	University of Toronto (Canada)	33	2.38

+

Table 17.13— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United States. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
United Kingdom	Wageningen University & Research (Netherlands)	111	4.64
	CSIRO (Australia)	42	5.81
	CNRS (France)	42	5.19
	Stockholm University (Sweden)	38	6.27
	European Commission Joint Research Centre Institute (Belgium)	37	2.77
	Australian National University (Australia)	34	4.72
	United Nations (United States)	33	3.86
	Delft University of Technology (Netherlands)	32	2.89
	University of British Columbia (Canada)	30	4.58
	Utrecht University (Netherlands)	29	4.46
	University of Copenhagen (Denmark)	28	5.87
	Stockholm Environment Institute (Sweden)	27	4.49
	ETH Zurich (Switzerland)	27	4.35
	Lund University (Sweden)	27	2.81
	University of Queensland (Australia)	27	2.55
	Arizona State University (United States)	26	7.92
	University of Maryland (United States)	26	4.44
	James Cook University Queensland (Australia)	26	4.37
	CSIC (Spain)	26	2.21
	Vrije Universiteit (Netherlands)	25	5.79

+

Table 17.14— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for the United Kingdom. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
China	Hong Kong Polytechnic University (Hong Kong)	49	2.06
	City University of Hong Kong (Hong Kong)	35	1.69
	University of Hong Kong (Hong Kong)	35	1.60
	Arizona State University (United States)	33	3.12
	Wageningen University & Research (Netherlands)	29	3.50
	Colorado State University (United States)	29	1.28
	U.S. Department of Agriculture (United States)	25	2.51
	CSIRO (Australia)	24	2.50
	Delft University of Technology (Netherlands)	23	3.22
	United Nations (United States)	20	3.21
	National Institute for Environmental Studies of Japan (Japan)	20	3.05
	National University of Singapore (Singapore)	20	1.73
	University of British Columbia (Canada)	19	2.50
	University of South Australia (Australia)	18	2.18
	Chinese University of Hong Kong (Hong Kong)	18	1.53
	University of Cambridge (United Kingdom)	16	3.98
	University of Maryland (United States)	16	3.33
	World Agroforestry Centre (Kenya)	15	2.54
	University of Michigan (United States)	15	1.93
	Cornell University (United States)	14	3.26

+

Table 17.15— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for China. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Australia	Wageningen University & Research (Netherlands)	42	5.84
	Chinese Academy of Sciences (China)	33	2.19
	National University of Singapore (Singapore)	28	3.14
	Stockholm University (Sweden)	25	8.12
	CNRS (France)	25	3.68
	University of British Columbia (Canada)	24	3.02
	Stanford University (United States)	23	4.98
	University of Auckland (New Zealand)	21	3.30
	University of Leeds (United Kingdom)	20	4.43
	University of Washington (United States)	20	3.36
	U.S. Department of Agriculture (United States)	18	4.16
	Food and Agriculture Organization of the United Nations (Italy)	18	3.68
	University College London (United Kingdom)	18	2.72
	University of Oxford (United Kingdom)	17	6.59
	Imperial College London (United Kingdom)	17	3.93
	United Nations (United States)	17	3.85
	NOAA (United States)	17	3.47
	University of Victoria BC (Canada)	17	3.08
	Vrije Universiteit (Netherlands)	16	6.51
	ETH Zurich (Switzerland)	16	4.61

+

Table 17.16— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Australia. (Source: Scopus)*

Country	Institution (Country)	Publication Count	FWCI
Germany	Wageningen University & Research (Netherlands)	79	3.71
	European Commission Joint Research Centre Institute (Belgium)	47	2.70
	ETH Zurich (Switzerland)	41	4.23
	CNRS (France)	35	4.44
	Vrije Universiteit (Netherlands)	31	5.22
	Lund University (Sweden)	28	4.00
	Utrecht University (Netherlands)	28	2.99
	University of Copenhagen (Denmark)	27	5.51
	International Institute for Applied Systems Analysis, Laxenburg (Austria)	26	3.63
	Stockholm University (Sweden)	25	6.63
	CSIRO (Australia)	23	5.44
	Technical University of Denmark (Denmark)	22	4.43
	Universite Paris Saclay (France)	22	4.38
	University of Bern (Switzerland)	20	3.21
	Universitat Autonoma de Barcelona (Spain)	19	3.44
	CEA (France)	19	2.66
	INRA Institut National de La Recherche Agronomique (France)	18	5.71
	University of Cambridge (United Kingdom)	18	4.62
	Delft University of Technology (Netherlands)	18	3.99
	United Nations (United States)	18	2.81

Table 17.17— *A list of the top 20 partnerships based on cumulative publication output from 2007-2016 for Germany. (Source: Scopus)*

17.6.2 Collaboration impact analysis

To visualize the citation impact of collaborations, the ratio of FWCI from SDG17 collaborations relative to the FWCI for all of Colombia's internationally collaborated SDG17 publications (x-axis) was plotted against the ratio of FWCI from collaborations relative to the FWCI for all of the partner's international publications on SDG17 (y-axis). The citation impact of collaborations can then be assessed as either mutually beneficial for one, both or neither partner based on the quadrant that the partner lies within. For SDG17 research from 2007-2016, the majority of Colombia's collaborations with top 20 academic partners were mutually beneficial to both Colombia and the collaboration partner in terms of citation impact (Figure 1.8). Publications with the University of Tenessee, Knoxville, were of greater benefit in terms of FWCI for Colombia than for the partner compared to other internationally collaborated SDG17 publications. Publications with Universite Catholique de Louvain were similarly more beneficial in citation impact for Colombia than for the partner.

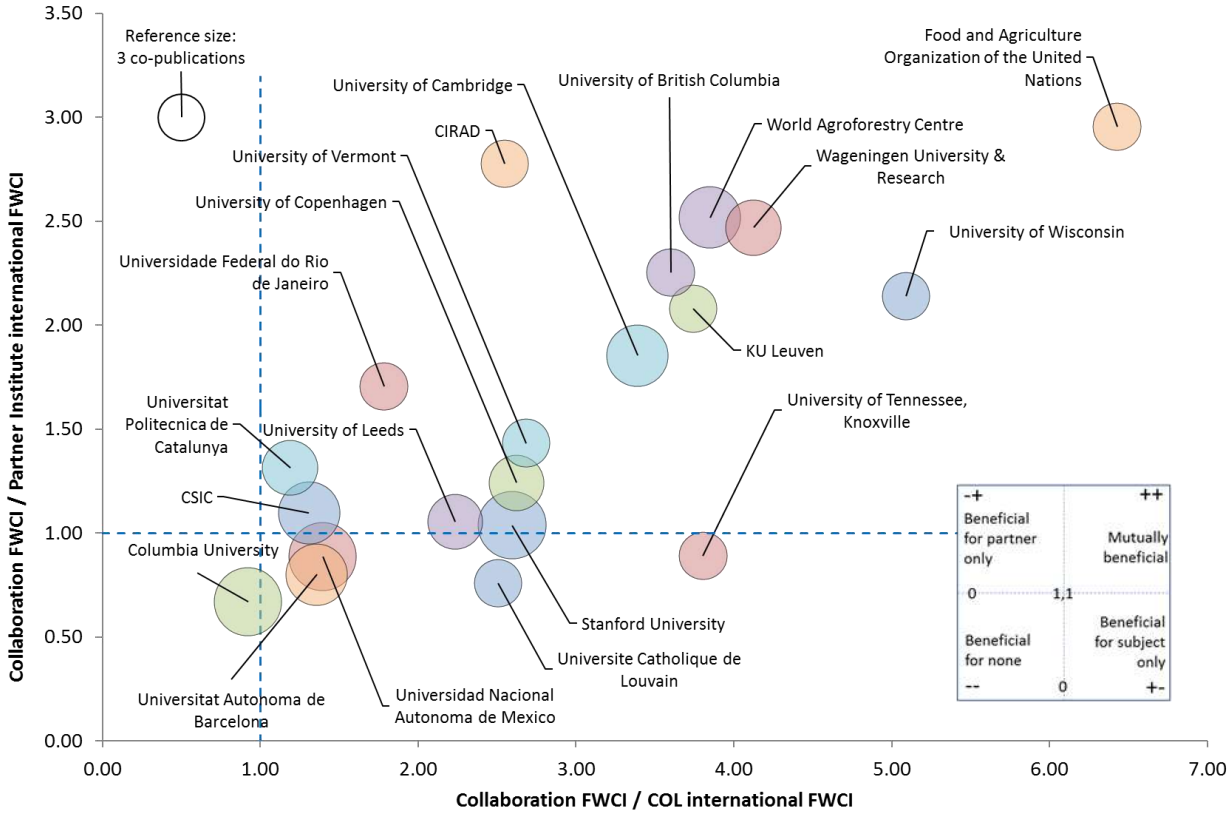

Figure 17.8— *Collaboration quadrant for Colombia and its top 20 collaborators on SDG1 from 2007-2016. (Source: Scopus).*

17.6.3 **Collaboration chart**

Figure 17.9 provides an alternative perspective to visualize Colombia's most productive collaborations with foreign institutional partners on SDG17. While the sections above elaborate on the most productive and impactful partnerships that Colombia is engaged in, Figure 17.9 shows where there may be potential to improve output and impact through partnership. Colombia co-authored 3-6 publications with its top foreign partner institutes. Wageningen University & Research publishes the most SDG17 research (among Colombia's top 20 partners) with 622 publications. The University of British Colombia and University of Cambridge are the next most prolific among Colombia's top 20 foreign partners, with 353 and 279 publications, respectively. Among Colombia's top 20 partners, University of Tenessee and Universite Catholique de Louvain have the highest FWCI for SDG17 research at 4.90 and 4.57, respectively. Colombia may want to leverage its existing relationship with these institutions to increase its publication output and impact on SDG17 research.

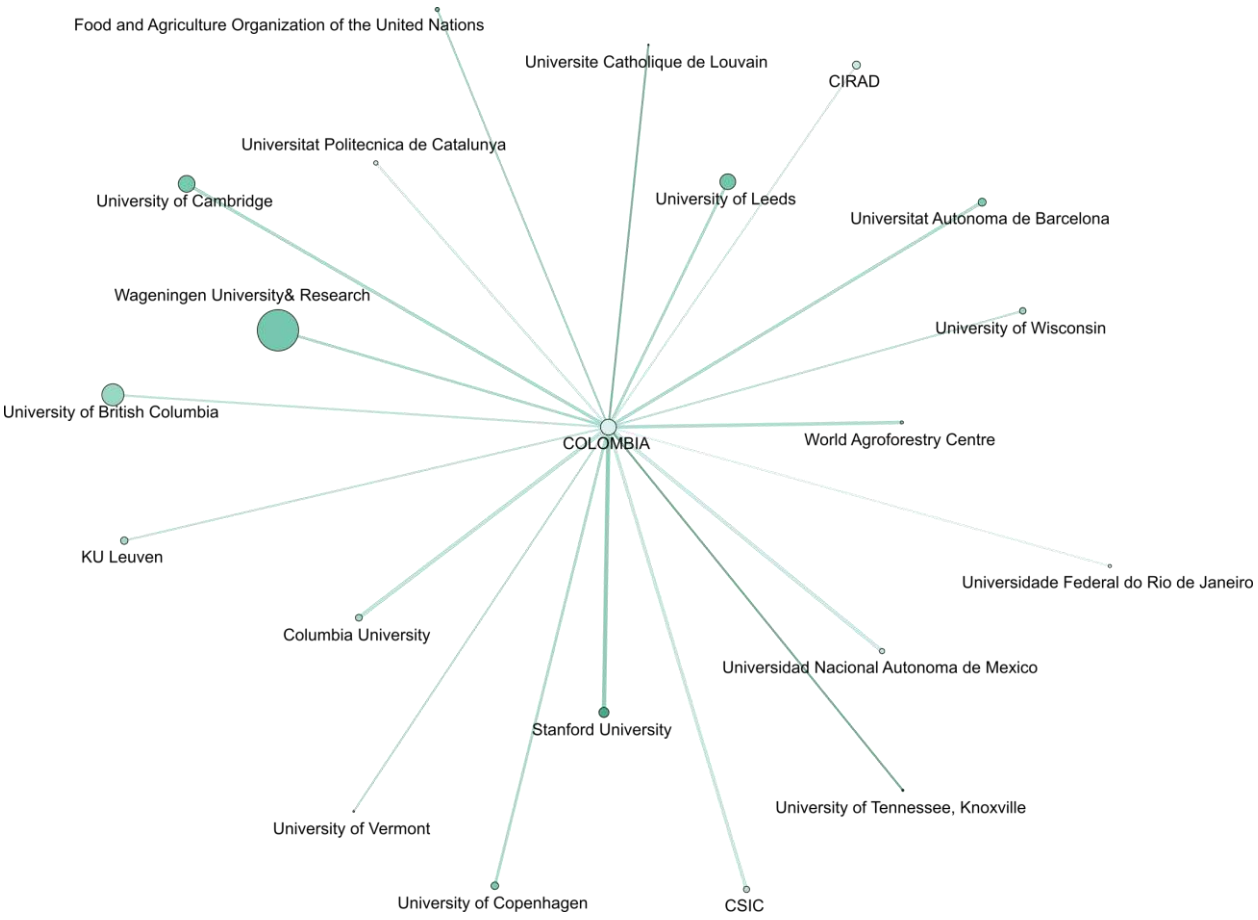

Figure 17.9— *Chart showing Colombia's top 20 collaborators on SDG17 from 2007-2016. Circle (node) size is proportional to the number of SDG17 publications by each entity (top institutional partners and Colombia); the thickness of connecting lines (edges) corresponds to the count of collaborated publications between Colombia and each partner institution. The colors of the nodes and edges reflect the FWCI of each institution's output and their collaboration with Colombia, respectively, with darkest shade of green indicating the highest FWCI (4.90) and lightest shade of green indicating the lowest FWCI (1.30). (Source: Scopus).*

Chapter 18
SDGs Connected

In this chapter, we analyse the connections between the 17 SDGs. SDGs are visualized in a network map to facilitate visualization of publications that fall in multiple SDG categories and co-citation patterns amongst SDG-related research.

18.1 SDG Connections

The commitment of more than 190 world leaders to the 17 Sustainable Development Goals (SDGs) speaks to the global relevance of the major themes of the 17 SDGs: extreme poverty, fight inequality & in justice, and reduce climate change. Because achieving any of the 17 SDGs will have a positive impact towards the other SDGs, it is not surprising that a subset of the research analysed in this report contribute to the advancement of more than one SDG. In this section, we take a bibliometric approach to understand the connections between the 17 SDGs by showcasing the co-occurrence of research among SDGs and by showcasing the co-citation patterns of SDG research.

18.1.1 Analysis of publications that are shared among SDGs

As shown in Figure 18.1, SDG15 (life on land, 170,282), SDG13 (climate action, 136,652), and SDG14 (life below water, 104,313) rank Top 3 with the highest amount of publications (node size) among all 17 SDGs. Accordingly, SDG15 has the largest co-publication counts with other SDGs, especially with SDG13 and SDG14 (edge width). There are 100,563 publications belonging to both SDG15 and SDG13, 95,481 at the intersection of SDG15 and SDG14, and 66,343 between SDG13 and SDG12). The top 20 co-publication counts are all from the overlap of other SDGs with either SDG15, SDG13, or SDG14.

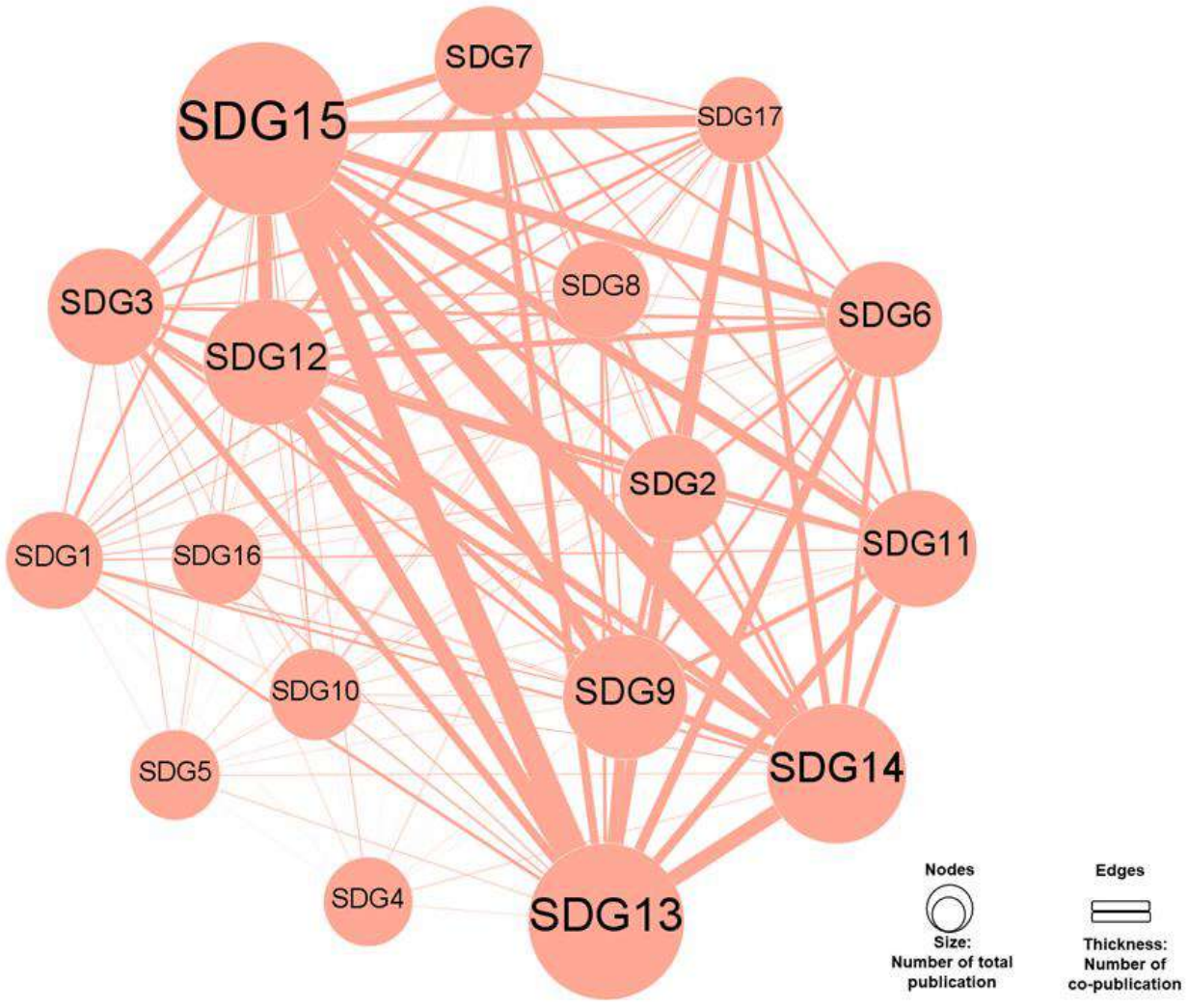

Figure 18.1— *Network map of SDG publication output. Each circle (node) represents the publication output from an SDG and the size of circles (nodes) is proportional to the count of publications related to that SDG. The thickness of connecting lines (edges) corresponds with the count of publications shared between SDGs.*

18.1.2 **Analysis of publications that are cite multiple SDGs**

Figure 18.2 shows similar results to Figure 18.1. SDG15 (life on land, 170,282), SDG13 (climate action, 136,652), and SDG14 (life below water, 104,313) rank Top3 with highest amount of publications (node size) among all 17 SDGs. The citation pattern among the 17 SDGs is represented by the edge width in Figure 18.2. The citation counts of SDG13 citing SDG15 (6,288,413) and SDG15 citing SDG13 (6,201,893) rank Top2 followed by SDG14 citing SDG15 (5,879,250) and SDG15 citing SDG14 (5,836,509), respectively. From this aspect, climate change is still the big issue globally.

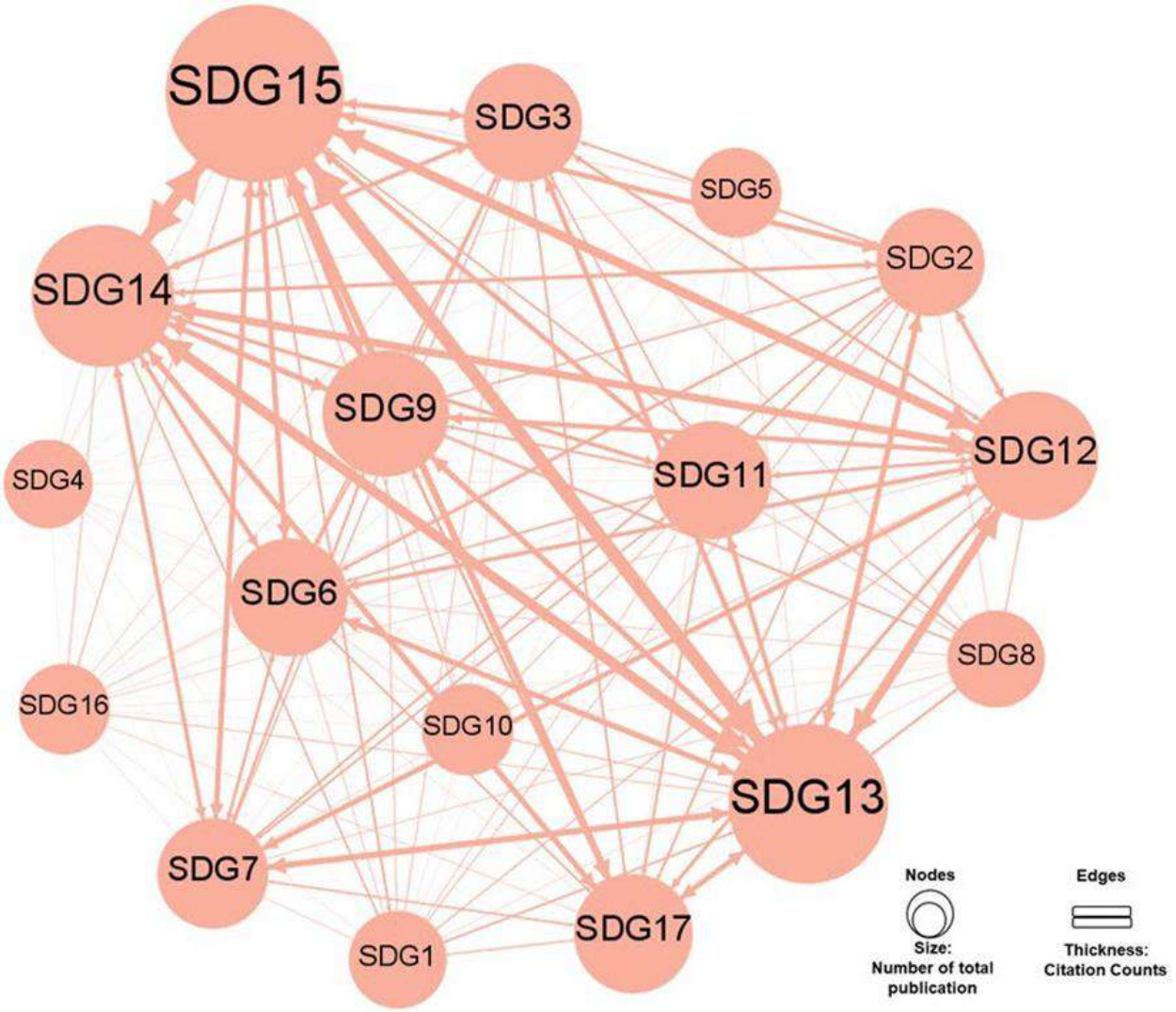

Figure 18.2— *Chart of SDG publications citing other SDGs. Circle (node) size correlates with publication output, the thickness of connecting lines (edges) corresponds with the count of citations from one SDG to another.*

Appendix A
Methodology and Data Sources

Methodology and Rationale

Our methodology is based on the theoretical principles and best practices developed in the field of quantitative science and technology studies, particularly in science and technology indicators research. The *Handbook of Quantitative Science and Technology Research: The Use of Publication and Patent Statistics in Studies of S&T Systems* (Moed, Glänzel and Schmoch, 2004)[24] gives a good overview of this field and is based on the pioneering work of Derek de Solla Price (1978),[25] Eugene Garfield (1979)[26] and Francis Narin (1976)[27] in the US, and Christopher Freeman, Ben Martin and John Irvine in the UK (1981, 1987)[28], and in several European institutions including the Centre for Science and Technology Studies at Leiden University, the Netherlands, and the Library of the Academy of Sciences in Budapest, Hungary.

The analyses of bibliometric data in this report are based upon recognized advanced indicators (e.g., the concept of relative citation impact rates). Our base assumption is that such indicators are useful and valid, though imperfect and partial measures, in the sense that their numerical values are determined by research performance and related concepts, but also by other, influencing factors that may cause systematic biases. In the past decade, the field of indicators research has developed a best practices which state how indicator results should be interpreted and which influencing factors should be taken into account. Our methodology builds on these practices.

Counting

All analyses make use of whole counting rather than fractional counting. For example, if a paper has been co-authored by one author from Colombia and one author from Canada, then that paper counts towards both the publication count of Colombia, as well as the publication count of Canada. Total counts for each institution are the unique count of publications.

Key phrase Analysis

Key phrase analysis was done in SciVal to generate the word clouds of top 50 concepts represented in research at each institute in this report. SciVal uses the Elsevier Fingerprint Engine to extract distinctive key phrases within the Research Area. The text mining is done through applying a variety of Natural Language Processing techniques to the titles and abstracts of the documents from the institute in order to identify important concepts.

Concepts are matched against a set of thesauri spanning all major disciplines. For each document the distinctive key phrases are selected based on Inverse Document Frequency (IDF), by incorporating a factor that diminishes the weight of words that occur frequently in the document set, and increases the importance of words that occur rarely.

Each key phrase is given a relevance between 0 and 1 with 1 given to the most frequently occurring key phrase. Remaining key phrases are given a value based on their relative frequency.

For this report, key phrases were retrieved using Elsevier's tool, SciVal. SciVal permits the assessment of keyphrases from the past 5 years through the trends module. This is done because because language in research changes over time and assessing a longer period of research can dilute the ability to accurately capture the focus of recent work. Therefore, key phrase analysis focuses on research from the period 2012-2016.

Measuring Article Downloads

Citation impact is by definition a lagging indicator: newly-published articles need to be read, after which they might influence studies that will be carried out, which are then

[24] Moed H., Glänzel W., & Schmoch U. (2004). Handbook of Quantitative Science and Technology Research, Kluwer: Dordrecht.

[25] de Solla Price, D.J. (1977–1978). "Foreword," Essays of an Information Scientist, Vol. 3, v–ix.

[26] Garfield, E. (1979). Is citation analysis a legitimate evaluation tool? Scientometrics, 1 (4), 359-375.

[27] Pinski, G., & Narin, F. (1976). Citation influence for journal aggregates of scientific publications: Theory with application to literature of physics. Information Processing & Management 12 (5): 297–312.

[28] Irvine, J., Martin, B. R., Abraham, J. & Peacock, T. (1987). Assessing basic research: Reappraisal and update of an evaluation of four radio astronomy observatories. Research Policy, 16(2-4), 213-227.

written up in manuscript form, peer-reviewed, published and finally included in a citation index such as Scopus. Only after these steps are completed can citations to the earlier article be systematically counted. For this reason, investigating downloads has become an appealing alternative, since it is possible to start counting downloads of full text articles immediately upon online publication and to derive robust indicators over windows of months rather than years.

While there is a considerable body of literature on the meaning of citations and indicators derived from them,[29] the relatively recent advent of download derived indicators means that there is no clear consensus on the nature of the phenomenon that is measured by download counts.[30] A small body of research has concluded however that download counts may be a weak predictor of subsequent citation counts at the article level.[31]

In this report, a download is defined as the event where a user views the full-text HTML of an article or downloads the full-text PDF of an article from ScienceDirect, Elsevier's full-text journal article platform; views of an article abstract alone, and multiple full-text HTML views or PDF downloads of the same article during the same user session, are not included in accordance with the COUNTER Code of Practice 35. ScienceDirect provides download data for approximately 16% of the articles indexed in Scopus; it is assumed that user downloading behaviour across countries does not systematically differ between online platforms. Field-weighted download impact is calculated from these data according to the same principles applied to the calculation of field-weighted citation impact.

Data Sources

Scopus is Elsevier's abstract and citation database of peer-reviewed literature, covering 70 million documents published in over 22,800 journals, book series and conference proceedings by some 5,000 publishers.

Scopus coverage is multi-lingual and global: approximately 22% of titles in Scopus are published in languages other than English (or published in both English and another language). In addition, more than half of Scopus content originates from outside North America, representing many countries in Europe, Latin America, Africa and the Asia Pacific region. Scopus covers approximately 6,400 titles from North-America, 11,800 from Europe and 2,500 from Asia-Pacific and 1,500 from Latin-America and Africa. The geographical breadth of Scopus ensures comprehensive coverage of research outputs and impact of regionally-collaborated research.

Scopus coverage is also inclusive across all major research fields, with 7,500 titles in the Physical Sciences, 6,800 in the Health Sciences, 4,500 in the Life Sciences, and 8,100 in the Social Sciences (the latter including some 2,800 Arts & Humanities related titles). Titles which are covered are predominantly serial publications (journals, trade journals, book series and conference material), but considerable numbers of conference papers are also covered from stand-alone proceedings volumes (a major dissemination mechanism, particularly in the computer sciences). Acknowledging that a great deal of important literature in all fields (but especially in the Social Sciences and Arts & Humanities) is published in books, Scopus has begun to increase book coverage in 2013, and currently covers more than 121,000 books.

For this report, a static version of the Scopus database from November 1. 2017, covering the period 2007-2016 inclusive was aggregated by institution, country, region, and subject. This means we are analysing Scopus content as it was on November 11, 2017. Results obtained using Scopus.com are up to date as of the date of query and may, therefore, differ slightly from the results presented in this report.

When aggregating article and citation counts, an integer counting method was employed where, for example, a paper with two authors from a United States address and one from a United Kingdom address would be counted as one article for each country (i.e. 1 United States and 1 United Kingdom). This method was favoured over fractional counting, in which the above paper would count as 0.67 for the United States and 0.33 for the United Kingdom, to maintain consistency with other reports (both public and private) we have conducted on the topic.

[29] Cronin, B. (2005). A hundred million acts of whimsy? Current Science, 89(9), 1505-1509. Retrieved from http://www.currentscience.ac.in/Downloads/article_id_089_09_1505_1509_0.pdf; Bornmann, L., & Daniel, H.-D. (2008). What do citation counts measure? A review of studies on citing behavior. Journal of Documentation, 64(1), 45-80. doi:10.1108/00220410810844150

[30] Kurtz, M. J., & Bollen, J. (2010). Usage bibliometrics. Annual Review of Information Science and Technology, 44(1), 1-64. doi:10.1002/aris.2010.1440440108

[31] Moed, H. F. (2005). Statistical relationships between downloads and citations at the level of individual documents within a single journal. Journal of the American Society for Information Science and Technology, 56(10), 1088-1097. doi:10.1002/asi.20200; Schloegl, C., & Gorraiz, J. (2010). Comparison of citation and usage indicators: the case of oncology journals. Scientometrics, 82(3), 567-580. doi:10.1007/s11192-010-0172-1; Schloegl, C., & Gorraiz, J. (2011). Global usage versus global citation metrics: The case of pharmacology journals. Journal of the American Society for Information Science and Technology, 62(1), 161-170. doi:10.1002/asi.21420

A body of literature is available on the limitations and caveats in the use of such 'bibliometric' data, such as the accumulation of citations over time, the skewed distribution of citations across articles, and differences in publication and citation practices between fields of research, different languages, and applicability to social sciences and humanities research. In social sciences and humanities, the bibliometric indicators presented in this report for these fields must be interpreted with caution because a reasonable proportion of research outputs in such fields take the form of books, monographs and non-textual media. As such, analyses of journal articles, their usage and citation, provides a less comprehensive view than in other fields, where journal article comprise the vast majority of research outputs.

ScienceDirect is a leading full-text articles and books scientific platform. With an invaluable and incomparable customer base, the use of scientific research on ScienceDirect.com provides a different type of performance measurement. ScienceDirect.com is used by more than 12,000 institutions worldwide, with more than 15 million active users and over 700 million full text article downloads in 2012. The average click through to full-text per month is 60 million. ScienceDirect covers over 10,500 books going back as far as 1993 The full-text article download metrics based on the large number of users in ScienceDirect.com provide a new dimension into measuring research impact on areas such as education and industrial sector by indicating what articles are requesting now and therefore can be a leading (future) indication of citation behaviour.

LexisNexis® is a leader in comprehensive and authoritative legal, news and business information and tailored applications. LexisNexis® is a member of Reed Elsevier Group plc. Patents are obtained via a partnership with LexisNexis and include over 96 million records from over 100 patent authorities, including those from the United States Patent and Trademark Office (USPTO), the European Patent Office (EPO), the Japanese Patent Office (JPO), the Patent Cooperation Treaty (PCT) of the World Intellectual Property Organization (WIPO) and the UK Intellectual Property Office (UKIPO). The patent database will be particularly useful in establishing trends in research and technology development providing downstream indicators of outputs from the research base. Patent coverage per patent office: UKIPO from 1916 (pre-grants), USPTO from 1,790 (grants and pre-grants), EPO from 1,978 (grants and pre-grants), WIPO from 1,978 (pre-grants), and JPO from 1976 (pre-grants).

Appendix B
Methodology for defining the SDGs

Query methodology

Query terms to search for the SDGs are an important step in identifying scientific production on the subject. The UDEP team and Elsevier worked on the identification of relevant query terms to identify scientific literature on SDGs for three months, in an iterative process. Although we tried to be as accurate as possible, it has to be acknowledged that the searches are only approximations because sustainable development is not a disciplinary subject but a set of interrelated issues for which there is not a consistent taxonomy or thesaurus at the moment. This effort, however, is a contribution to other studies that want to build on it to advance on the identification of scientific literature and other types of knowledge on sustainable development and the SDGs. The methodology is the following:

1. Elsevier provided UDEP with a list of query terms that were collected for their study on the 17 SDGs.
    - These query terms based on the previously vetted and established query terms used to define the 6 themes of the Sustainability Science in the report Sustainability Science in a Global Landscape. The query terms used for each of these 6 themes were selected by the input of experts and the methodology is described in detail starting from page 16 of the report, Sustainability Science in a Global Landscape. Appendix A of the report lists the experts involved in defining the original keyword list. To generate the query terms for the 17 SDGs, the terms from the 6 sustainability themes were mapped to the 17 SDGs.
    - Additional query terms were extracted from the sustainable development knowledge platform.
    - The complete set of query terms were used to extract Scopus-indexed articles. Data from this search was then provided to internal and external experts for validation. The data provided to the experts was as follows:
        i. A list of 2000 articles (titles, bibliographic information, and abstracts) retrieved by the search
        ii. Aggregate data about the keyword search results including most frequent query terms represented by the publication set, top authors in the field, subject areas represented by the publications.
        iii. The internal experts used the data from i. and ii. to validate the query. This step was repeated until a consensus was achieved.
2. The UDEP team added to the query terms provided by Elsevier by identifying additional terms via literature review of handbooks on different sustainability subjects edited by recognised publishing houses. Their glossaries were used as a first database of terms but they were further refined by consulting experts in the field. This refinement was led by heads of National Research Councils.
3. The refined database was used to build search queries for Scopus, and Elsevier's Analytical Services team performed test searches. The results were examined by UDEP's team to find false positives, identify relevant subject areas and discard others. A set of 2000 papers (titles and abstracts) per SDG was revised by UDEP and adjustments were made.
4. The queries presented herein are the query terms that were used for this report, following validation by UDEP.

The table below provides a list of sources used by UDEP for the selection of query terms to search for literature on SDGs.

Type	Source
Bibliographic reference	Ben-Aryeh, A., Frønes, I., Casas, F., & Korbin, J. E. (Eds.). (2014). Handbook of child well-being: Theories, methods and policies in global perspective (pp. 1-27). New York, NY, USA:: Springer.
Bibliographic reference	Colciencias, IDEAM, PNUD, MADS, DNP, Cancillería, Observatorio de Ciencia y Tecnología (2016). Tercera comunicación nacional de cambio climático. "cienciometría del cambio climático en colombia". http://observatorio.epacartagena.gov.co/ftp-uploads/pub-cienciometria-cambio-climatico.pdf
Bibliographic reference	Davis, K., Evans, M., & Lorber, J. (Eds.). (2006). Handbook of gender and women's studies. Sage.
Bibliographic reference	Elsevier and Scidev (2015). The Role of Technology and Innovation in Inclusive and Sustainable Industrial Development. https://www.elsevier.com/_data/assets/pdf_file/0018/119061/SustainabilityScienceReport-Web.pdf
Bibliographic reference	Galarraga, I., González-Eguino, M., & Markandya, A. (Eds.). (2011). Handbook of sustainable energy. Edward Elgar Publishing.
Bibliographic reference	Handbook of Agricultural Economics Science direct
Bibliographic reference	Hanushek, E. A., Machin, S. J., & Woessmann, L. (Eds.). (2016). Handbook of the Economics of Education. Elsevier.
Bibliographic reference	Hassan, S. U., Haddawy, P., & Zhu, J. (2014). A bibliometric study of the world's research activity in sustainable development and its sub-areas using scientific literature. Scientometrics, 99(2), 549-579.
Bibliographic reference	Haughton, Jonathan; Khandker, Shahidur R.. 2009. Handbook on poverty and inequality (English). Washington, DC: World Bank. http://documents.worldbank.org/curated/en/488081468157174849/Handbook-on-poverty-and-inequality
Bibliographic reference	Herring, R. J. (Ed.). (2015). The Oxford Handbook of Food, Politics, and Society. Oxford Handbooks.
Bibliographic reference	INEE (2012). Minimum Standards for Education: preparedness, response, recovery. http://s3.amazonaws.com/inee-assets/resources/INEE_Minimum_Standards_Handbook_2010_English.pdf
Bibliographic reference	ONU Colombia. (2015). 1er Reporte sobre el estado de las ciudades de Colombia: camino hacia la prosperidad urbana. Bogotá. Recuperado el, 24(08), 2016.
Bibliographic reference	Potschin, M., & Haines-Young, R. (2006). "Rio+ 10", sustainability science and Landscape Ecology. Landscape and urban planning, 75(3-4), 162-174.
Bibliographic reference	Ryan, R. M., & Deci, E. L. (2001). On happiness and human potentials: A review of research on hedonic and eudaimonic well-being. Annual review of psychology, 52(1), 141-166.
Bibliographic reference	Sawin, J. L., Sverrisson, F., Seyboth, K., Adib, R., Murdock, H. E., Lins, C., ... & Satzinger, K. (2013). Renewables 2017 Global Status Report.
Database	OECD Indicators
Database	SDG Mapping universities - http://ap-unsdsn.org/wp-content/uploads/2017/04/Compiled-Query terms-for-SDG-Mapping_Final_17-05-10.xlsx
Expert committee	PNCTeI Ambiente, biodiversidad y hábitat Colciencias
Expert committee	PNCTeI Mar y Recursos Hidrobiológicos Colciencias
Expert committee	PN de Biotecnología Colciencias
Expert Committee	Quality Assurance in Higher Education
Expert Committee	Taxonomy ACM Plan Estratégico TIC
Expert Committee	UDEP Colciencias
Website	La iniciativa de los ODS y las ciudades prosperas Onu Habitat: http://cpi.unhabitat.org/
Website	UNCTAD
Website	WEB UN.org

Website	*WEB unctad.org*
Website	*WEB who.int*

The section below includes the queries used for the analysis.

SDG 1 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND ("absolute poverty lines" OR "additive poverty measures" OR "basic public services" OR "benefit incidence analysis" OR "benefits to poor" OR "causes of poverty" OR "child lab*" OR "child labor" OR "child labour" OR "chronic poverty" OR "commitment to basic income" OR "community-level characteristics associated with poverty" OR "consumer price index" OR "consumption expenditure" OR "consumption of calories" OR "cost of basic needs method" OR "current consumption expenditure deficit" OR "DCI method" OR "deflation problem" OR "demographic characteristics associated with poverty" OR "dependency ratio" OR "determinants of poverty" OR "development aid" OR "development cooperation on poverty" OR "direct caloric intake method" OR "disaster mortality" OR "disaster related economic loss" OR "distributional effect" OR "drinking water and poverty" OR "durable goods" OR "economic characteristics associated with poverty" OR "economic indicators" OR "economic resource" OR "economically disadvantaged" OR "education spending" OR "elasticity of poverty" OR "Encuesta de Desarrollo Social" OR "Encuesta sobre el Nivel de Vida" OR "end poverty" OR "energy poverty" OR "equal rights to economic resources" OR "expenditure progressivity" OR "extreme poverty" OR "financ*" OR "financial crisis" OR "financial inclusion" OR "food and nutrition" OR "food bank" OR "food banks" OR "food consumption" OR "food energy intake" OR "frameworks for analysing poverty" OR "gender and poverty" OR "gender-sensitive poverty reduction policies" OR "geography and poverty" OR "gini coefficient" OR "goods coverage index" OR "growth incidence curve" OR "headcount index or ratio" OR "health spending" OR "household and individual level indicators" OR "household budget survey" OR "income equality" OR "income inequality" OR "income security" OR "income shock" OR "inequality measures" OR "inflation as related to poverty" OR "informality" OR "international poverty comparisons" OR "investment in poverty erradication" OR "land ownership" OR "land tenure" OR "living standard indicators" OR "living standards measurement study" OR "lsms" OR "lorenz curve" OR "losses and damage from disasters" OR "measurement of poverty" OR "microfinanc*" OR "monitoring and evaluation of poverty" OR "participatory poverty assessments" OR "per capita consumption" OR "per household consumption" OR "poverty alleviation" OR "poverty and empowerment" OR "poverty and innovation" OR "poverty and technology" OR "poverty deficit curve" OR "poverty determinant" OR "poverty gap index" OR "poverty incidence curve" OR "poverty income*" OR "poverty index" OR "poverty line" OR "poverty profiles" OR "poverty rates" OR "poverty resilience" OR "pro-poor" OR "purchasing power parity" OR "reduction of poverty" OR "regressive tax" OR "relative poverty risks" OR "resilien* and po*" OR "resilience of the po*" OR "right to land" OR "rural finance" OR "safety net" OR "safety nets" OR "sanitation and poverty" OR "small farmer" OR "smallholder" OR "social exclusion" OR "social inequality" OR "social protection systems" OR "social protection" OR "software adept" OR "stochastic poverty" OR "sustainable development goal 1" OR "underemployment" OR "unemployment" OR "unmet basic needs" OR "vulnerability" OR "watts index" OR "watts poverty index" OR "wealth distribution"))) AND (DOCTYPE("ar ") OR DOCTYPE(" cp ") OR DOCTYPE(" re ")) AND (SUBJAREA("SOCI ") OR SUBJAREA(" ENVI ") OR SUBJAREA(" BUSI ") OR SUBJAREA(" AGRI ") OR SUBJAREA(" ENGI ") OR SUBJAREA(" MEDI ") OR SUBJAREA(" ECON ") OR SUBJAREA(" ENER ") OR SUBJAREA(" EART ") OR SUBJAREA(" COMP ") OR SUBJAREA(" DECI ") OR SUBJAREA(" ARTS ") OR SUBJAREA(" BIOC ") OR SUBJAREA(" NURS ") OR SUBJAREA(" MATH ") OR SUBJAREA(" PSYC ") OR SUBJAREA(" CENG ") OR SUBJAREA(" MULT ") OR SUBJAREA(" MATE ") OR SUBJAREA(" IMMU "))

SDG 2 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND ("access to nutritious food" OR "access to safe food" OR "access to sufficient food" OR "act on organic farming" OR "agra initiative" OR "agrarian economics" OR "agricultur*" OR "agricultural biodiversity" OR "agricultural development strategies" OR "agricultural development" OR "agricultural economics" OR "agricultural orientation index" OR "agricultural production" OR "agricultural productivity improvement" OR "agricultural sustainability" OR "agricultural technology" OR "agriculture and climate change" OR "agriculture and local ecological knowledge" OR "agriculture and local knowledge" OR "agriculture and ownership" OR "agriculture reforms" OR "agriculture" OR "agrifood industry" OR "agrobiodiversity" OR "agroecological intensification" OR "agroecology" OR "agronomic traits" OR "alternative agriculture" OR "anaemia" OR "anemia" OR "anti-gmo activism" OR "antinutrients" OR "biofortification" OR "biofuels vs food production" OR "biopesticides" OR "cartagena protocol on biosafety" OR "cash & carry chains" OR "cash and carry chains" OR "cash-crop export farming" OR "CGIAR" OR "children underweight" OR "climate friendly agriculture" OR "codex alimentarius" OR "commission on plant genetic resources for food and agriculture" OR "community supported agriculture" OR "conservation agriculture" OR "conservation of genetic diversity/biodiversity of cultivated plants" OR "conservation of genetic diversity/biodiversity of farmed animals" OR "conservation of genetic diversity/biodiversity of seeds" OR "consultative group on international agricultural research" OR "convention on biological diversity" OR "conventional farming system" OR "counter couisine"

OR "cover crops" OR "crop diversification" OR "crop diversity" OR "crop residue composting" OR "crop rotation" OR "cropland availability" OR "deforestation" OR "desertification" OR "doha development round" OR "doha round" OR "drought*" OR "eating as political act" OR "eating habits" OR "ecological agriculture" OR "ecosystem adapation to climate change" OR "ecosystem adaptation to disaster" OR "ecosystem adaptation to drought" OR "ecosystem adaptation to extreme weather" OR "ecosystem adaptation to flood" OR "enhance agricultural productive capacity in developing countries" OR "environmental degradation" OR "environmental kuznets curve" OR "environmental poverty traps" OR "extreme hunger" OR "fair trade certification" OR "family farms" OR "famine" OR "farm productivity gender differences" OR "farm social capital" OR "farm succession" OR "farmer's debt" OR "farmer's rights" OR "farming systems" OR "farming" OR "fertilizer usage" OR "fertilizer" OR "food for peace programme" OR "food aid programs" OR "food allergens" OR "food and agricultural organisation" OR "food and biotechnologies" OR "food and climate change" OR "food and indigenous knowledge" OR "food autonomy" OR "food commodification" OR "food crisis" OR "food diversity index" OR "food ethical consumerism" OR "food ethics" OR "food expenditure elasticities" OR "food gap" OR "food insecurity" OR "food labeling" OR "food policy" OR "food politics" OR "food price spikes" OR "food price" OR "food processing" OR "food production per capita" OR "food reserves" OR "food right" OR "food safety" OR "food security" OR "food sovereignity" OR "food subsidies" OR "food transgenics" OR "food-health relationships" OR "foreing aid food" OR "frugal food consumption" OR "genetic counselling" OR "genetic diversity of seeds" OR "genetically modified crops and organisms" OR "genetically modified food" OR "gm crop adoption rate" OR "gmo food" OR "gmo regulation" OR "golden rice" OR "good nutrition" OR "grain for green" OR "group farming" OR "heritage plant varieties" OR "homeodomain leucine zipper proteins" OR "hunger erradication" OR "hunger" OR "hybrid crops" OR "IBPGR" OR "IFOAM" OR "impact of climate change on agriculture and food production" OR "improved nutrition" OR "improvement of nutrition" OR "income of small-scale food producers" OR "increased agricultural productivity/production" OR "industrial agriculture" OR "integrated pest management" OR "intercropping" OR "international assessment of agricultural knowledge, science and technology for development" OR "international board on plant genetic resources" OR "international cooperation on food" OR "international federation of organic agriculture movements" OR "international treaty on plant genetic resources for food and agriculture" OR "international undertaking on plant genetic resources" OR "inter-species gene transfer" OR "investment in agricultural research" OR "investment in agricultural technology development" OR "investment in extension services" OR "investment in livestock gene banks" OR "investment in plant gene banks" OR "investment in rural infrastructure" OR "irrigation systems" OR "ITPGR" OR "IUPGR" OR "junk food legislation" OR "land degradation" OR "land quality improvement" OR "land reform" OR "land right" OR "land tenure" OR "land-food nexus" OR "livelihood-enhancing land policy" OR "livestock management" OR "malnourish*" OR "malnourishment" OR "malnutrition" OR "mass food consumption" OR "meat production" OR "metabolic engineering" OR "mountain farms" OR "mutation breeding" OR "natural resource sociology" OR "nitrogen uptake efficienty" OR "non-farm employment" OR "non-timber forest products" OR "nutrition improvement" OR "nutrition production function" OR "nutritional needs of people" OR "nutritional needs" OR "nutritious diets" OR "obesity" OR "organic agriculture" OR "organic farming" OR "organic farming" OR "organic food" OR "overweight" OR "pastoralism" OR "pastoralists" OR "pesticides" OR "plant breeding" OR "polycultures " OR "poor nutrition" OR "post-harvest*" OR "precision agriculture" OR "precision farming" OR "pre-harvest*" OR "pro-poor land policy" OR "public private partnerships for agriculture and food production" OR "rainfed cultivation" OR "rainfed" OR "rain-fed" OR "rainwater harvesting" OR "resilient agricultural practices" OR "resilient agriculture" OR "rural development" OR "rural ecology" OR "rural economics" OR "rural finance" OR "rural geography" OR "rural health" OR "rural infrastructure" OR "rural technological challenges" OR "rural technology adoption" OR "shifting cultivation" OR "slash-and-burn agriculture" OR "smallholder farmers" OR "smallholder*" OR "small-scale food producers" OR "soil adaptations" OR "soil degradation" OR "soil microorganisms benefit" OR "soil quality improvement" OR "special program on food security (spfs)" OR "starvation" OR "stealth seeds" OR "subsistence agriculture" OR "sufficient food" OR "suicide seeds" OR "supply chain efficiency" OR "support to women farmers" OR "sustainable agricultural practices" OR "sustainable development goal 2" OR "sustainable food production systems" OR "swidden agriculture" OR "system of rice intensification" OR "technologhy deficits in agriculture" OR "tenure farm*" OR "terminator seeds" OR "third world peasants" OR "transgenics" OR "transnational agrarian movements" OR "transnational collective action (on food and agriculture)" OR "undernourish*" OR "undernourishment" OR "undernutrition" OR "urban agriculture" OR "vitamin deficiencies" OR "vitamin deficiency" OR "weed control" OR "wild food interactions" OR "wild foods" OR "women as food producers" OR "zero hunger"))) AND (DOCTYPE("ar ") OR DOCTYPE(" cp ") OR DOCTYPE(" re ")) AND (SUBJAREA("AGRI ") OR (SUBJAREA(" ENVI ") OR (SUBJAREA(" SOCI ") OR (SUBJAREA(" ENGI ") OR (SUBJAREA(" MEDI ") OR (SUBJAREA(" ENER ") OR (SUBJAREA(" BIOC ") OR (SUBJAREA(" EART ") OR (SUBJAREA(" BUSI ") OR (SUBJAREA(" ECON ") OR (SUBJAREA(" COMP 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SDG 3 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND ("access to safe medicines" OR "acculturative stress" OR "adjusted life year" OR "adjusted life years" OR "adolescent health" OR "affordable medicines" OR "affordable vaccines" OR "aids"

OR "alcohol use" OR "alcoholism" OR "anti-retroviral therapy" OR "anti-school attitudes" OR "antisocial behavior" OR "art education" OR "battered child syndrome" OR "body dissatisfaction" OR "body image" OR "body-ideals" OR "bullying" OR "cancer" OR "cardiovascular disease" OR "cardiovascular diseases" OR "chagas" OR "child abuse and neglect" OR "child and youth well-being index" OR "child death" OR "child deaths" OR "child mortality" OR "child rights" OR "child-birth complications" OR "child-parent centers" OR "cholera" OR "chronic respiratory disease" OR "chronic respiratory diseases" OR "civic engagement" OR "civic participation" OR "colonial education" OR "commercialized images of gender" OR "communicable diseases" OR "communication rights" OR "constructions of gender and of sexualities" OR "convention on the rights of the child" OR "cooperative breeding" OR "coping mechanisms" OR "crc" OR "cwi" OR "dengue" OR "diabetes" OR "diarrheal disease" OR "diarrheal diseases" OR "diarrhoeal disease" OR "diarrhoeal diseases" OR "discrimination" OR "disease*" OR "divorce" OR "doha declaration on the trips agreement and public health" OR "drug abuse" OR "drug addiction" OR "dysentery" OR "ebola" OR "emotional competence" OR "emotional disturbances" OR "emotions" OR "ethic of care" OR "eudaimonia" OR "families" OR "family policy" OR "family" OR "father involvement" OR "femininity and masculinity" OR "gendered classroom talk" OR "gendered worlds" OR "global childhoods" OR "global health risks" OR "happiness" OR "health care access" OR "health care" OR "health finance" OR "health financing" OR "health prevention" OR "health risk" OR "health system" OR "health systems" OR "health treatment" OR "health workforce in developing countries" OR "healthcare access" OR "healthy life" OR "hepatitis" OR "hiv" OR "hiv/aids" OR "household accident" OR "human death*" OR "human immunodeficiency virus" OR "human" OR "identit*" OR "illness*" OR "immigrant children" OR "immigrant families" OR "immunization campaign" OR "inclusive health" OR "increasing life expectancy" OR "individual differences" OR "infant death" OR "infant deaths" OR "infant mortality" OR "infectious disease" OR "infectious diseases" OR "intergenerational discrepancies" OR "international health policy" OR "international health regulations" OR "intertransculturality" OR "life expecancy" OR "life satisfaction" OR "malaria" OR "maltreatment" OR "maternal death" OR "maternal deaths" OR "maternal health" OR "maternal mortality" OR "measles" OR "medicin*" OR "mental disease" OR "mental health promotion" OR "mental health" OR "mentoring interventions" OR "mortality" OR "neglected diseases" OR "neonatal death" OR "neo-natal death" OR "neonatal deaths" OR "neo-natal deaths" OR "neonatal mortality" OR "neo-natal mortality" OR "obesity" OR "online harassment" OR "optimal experience" OR "orphans" OR "parental support" OR "parent-child conflicts" OR "parent-child relationship" OR "personality development" OR "physical health" OR "planned abortion" OR "plasmodium" OR "polio" OR "positive affect" OR "post natal depression" OR "postnatal depression" OR "post-natal depression" OR "premature death" OR "premature deaths" OR "premature mortality" OR "preventable child deaths" OR "preventable death" OR "preventable deaths of newborns and children" OR "preventable deaths" OR "preventable diseases" OR "psychological harm" OR "psychological well-being" OR "psychological-mindedness" OR "public health" OR "reduce premature mortality" OR "refugees and health services" OR "reproductive health care" OR "reproductive health" OR "road accident" OR "road accidents" OR "road traffic accidents prevention" OR "safe vaccines" OR "schistosomiasis" OR "self-determination rights" OR "self-esteem" OR "self-realization" OR "sexually transmitted disease" OR "sexually transmitted diseases" OR "sexually-transmitted disease" OR "sexually-transmitted diseases" OR "sleeping sickness" OR "social determinants of health" OR "spiritual development" OR "spiritual well-being" OR "spontaneous abortion" OR "stress" OR "subjective well-being" OR "substance abuse" OR "suicide" OR "support to research on vaccines" OR "teacher-student relationships" OR "time use" OR "tobacco control and use" OR "tobacco use" OR "traffic accident" OR "traffic accidents" OR "tropical disease" OR "tropical diseases" OR "tuberculosis" OR "typhoid" OR "universal health coverage" OR "unplanned pregnancy" OR "vaccin*" OR "victimization" OR "water borne diseases" OR "water, sanitation and hygiene for all (wash)" OR "water-borne disease" OR "water-borne diseases" OR "welfare" OR "well-being" OR "wellness" OR "world health organization convention" OR "world health organization" OR "zika" OR "zikv"))) AND (DOCTYPE("ar ") OR DOCTYPE(" cp ") OR DOCTYPE(" re ")) AND ((SUBJAREA("MEDI ") OR (SUBJAREA(" ENVI ") OR (SUBJAREA(" SOCI ") OR (SUBJAREA(" AGRI ") OR (SUBJAREA(" ENGI ") OR (SUBJAREA(" BIOC ") OR (SUBJAREA(" BUSI ") OR (SUBJAREA(" ENER ") OR (SUBJAREA(" COMP ") OR (SUBJAREA(" EART ") OR (SUBJAREA(" ECON ") OR (SUBJAREA(" NURS ") OR (SUBJAREA(" IMMU ") OR (SUBJAREA(" MATE ") OR (SUBJAREA(" CHEM ") OR (SUBJAREA(" PHAR ") OR (SUBJAREA(" CENG ") OR (SUBJAREA(" DECI ") OR (SUBJAREA(" PSYC ") OR (SUBJAREA(" HEAL ") OR (SUBJAREA(" MULT ") OR (SUBJAREA(" NEUR ") OR (SUBJAREA(" DENT "))

SDG 4 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND ("access to education" OR "access to quality higher education" OR "accountability and education" OR "accountable education" OR "accreditation and education" OR "active learning" OR "admission, enrolment and retention" OR "adult learners" OR "affordable higher education" OR "armed conflict and education" OR "autonomy and education" OR "child-friendly schools" OR "child-friendly spaces and schools" OR "class size" OR "class-based learning hybrid learning" OR "class-based learning" OR "classroom management" OR "cognitive processes" OR "community education committees" OR "community education" OR "consistency and education" OR "continous improvement and education" OR "continuity of education" OR "core competencies" OR "cost effective education" OR "curricula and content" OR "curricula" OR "design and maintenance of learning spaces" OR "digital learning" OR "disability and education" OR "disasters and education" OR "distance to school" OR "early childhood development" OR "early childhood education" OR "education access" OR "education and

conflict mitigation" OR "education and corruption" OR "education and diversity" OR "education and humanitarian response" OR "education attainment" OR "education capacity" OR "education enrollment" OR "education enrolment" OR "education ethics" OR "education for cultural diversity" OR "education for gender equality" OR "education for global citizenship" OR "education for health and nutrition" OR "education for human rights" OR "education for peace" OR "education for refugees" OR "education for sustainability" OR "education for sustainable development" OR "education in emergencies" OR "education internally displaced persons" OR "education law and policy formulation" OR "education needs" OR "education policy" OR "education quality" OR "education relevance" OR "education rights and goals" OR "educational access" OR "educational resource" OR "educational resources" OR "effective learning environments" OR "efficiency and education" OR "e-learning" OR "equitable basic education" OR "equitable education" OR "excellence and education" OR "experience and qualifications" OR "female education" OR "fitness for purpose and education" OR "formal learning" OR "formal training" OR "free basic education" OR "further education" OR "gender and education" OR "gender balance" OR "girls education" OR "girls' education" OR "high academic standards and education" OR "higher education" OR "highschool" OR "highschools" OR "immediate education priorities" OR "inclusive education" OR "increasing student enrollments" OR "informal education" OR "informal learning" OR "informal training" OR "instructional materials" OR "learning environment" OR "learning environments" OR "learning material" OR "learning materials" OR "learning opportunity" OR "learning outcome" OR "learning outcomes" OR "learning site distance" OR "learning sites" OR "learning spaces" OR "learning spaces" OR "lifelong learning" OR "literacy" OR "local education action plans" OR "massification and education" OR "m-learning" OR "national and local education plans" OR "non formal education" OR "non-violent classroom management" OR "numeracy" OR "parental education" OR "participatory learning" OR "performance appraisals" OR "planning and implementation" OR "poverty and education" OR "practical learning" OR "primary education" OR "primary school" OR "primary schools" OR "purposeful education" OR "qualified teachers" OR "quality assurance and education" OR "quality basic education" OR "quality education" OR "quality education" OR "quality enhancement and education" OR "quality of education" OR "quality preprimary education" OR "recruitment and selection of teachers" OR "reduce gender disparities in education" OR "refugees and learning" OR "relevance of education" OR "relevant education" OR "right to education" OR "safety in school" OR "scholarships for developing countries for higher education" OR "school attendance" OR "school discrimination" OR "school distance" OR "school distress" OR "school enrollment" OR "school enrolment rate" OR "school enrolment" OR "school fee" OR "school fees" OR "school safety" OR "schooling" OR "secondary education" OR "secondary school" OR "secondary schools" OR "sexuality education" OR "skills for employment" OR "skills for work" OR "student-focused learning" OR "students support and coordination" OR "students support and supervision" OR "teacher compensation" OR "teacher qualification" OR "teacher training" OR "teaching methods" OR "technical training" OR "tertiary education" OR "transformative learning" OR "universal access to education" OR "upgrade education facilities" OR "value-added education" OR "vocational training" OR "women education" OR "women's education"))) AND (DOCTYPE("ar ") OR DOCTYPE(" cp ") OR DOCTYPE(" re ")) AND (SUBJAREA("SOCI ") OR SUBJAREA(" ARTS ") OR SUBJAREA(" PSYC ") OR SUBJAREA(" NURS "))

SDG 5 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND ("aboriginal women" OR "abortion in women" OR "academic feminism" OR "academics feminists" OR "access to child care" OR "androcentrism" OR "antimen" OR "anti-men" OR "antiwomen" OR "anti-women" OR "approach to gender" OR "autonomous women's groups" OR "autonomy of academic feminism" OR "biological sex differences" OR "black feminism" OR "black women's cultural production" OR "boys' access to justice" OR "boys' education" OR "bulimia nervosa" OR "changing patterns of family" OR "child custody" OR "child marriage" OR "child marriages" OR "civil partnership" OR "civil partnerships" OR "crisis in masculinity" OR "defining women" OR "diversity of family" OR "divorce right" OR "divorce rights" OR "domestic violence women" OR "early marriage" OR "early marriages" OR "eating disorders" OR "ecofeminism" OR "emancipation of women by war" OR "employment equity" OR "employment inequalities" OR "empower*" OR "families of choice" OR "family and masculinity" OR "family and women's employment" OR "family friendly employment policies" OR "family planning" OR "family structure" OR "family structures" OR "female education" OR "female employment" OR "female genital cutting" OR "female genital mutilation" OR "female infanticide" OR "female infanticides" OR "female labor force participation" OR "female labour force participation" OR "female leadership" OR "female political participation" OR "female unemployment" OR "feminine gender norms" OR "femininity" OR "feminism and state" OR "feminism" OR "feminist consciousness-raising" OR "feminist critiques of religion" OR "feminist critiques" OR "feminist empiricism" OR "feminist environmental studies" OR "feminist environmentalism" OR "feminist epistemology" OR "feminist ethics" OR "feminist ethnography" OR "feminist history" OR "feminist knowledge" OR "feminist methodology wars" OR "feminist philosophy" OR "feminist political practice" OR "feminist political strategies" OR "feminist political theory" OR "feminist politics of location" OR "feminist postmodern epistemologies" OR "feminist research" OR "feminist spirituality movement" OR "feminist standpoint theories" OR "feminist study of bodies" OR "feminist study of care" OR "feminist study of citizenship" OR "feminist study of friendship" OR "feminist study of men" OR "feminist study of nationalism" OR "feminist study of religion" OR "feminist study of science and technology" OR "feminist study of women and nature" OR "feminist theory" OR "feminization of labour market" OR "feminization of poverty" OR "femocrats" OR "fetal rights" OR "focus of feminist study" OR "forced marriage" OR "forced marriages" OR "forced prostitution" OR "fragile families and child" OR "gay marriage" OR "gay men"

OR "gay studies" OR "gender activism" OR "gender and development" OR "gender difference" OR "gender displays" OR "gender distinction" OR "gender equality policy" OR "gender equality" OR "gender hierarchies" OR "gender identity" OR "gender impact assessment studies" OR "gender inequality" OR "gender labour force" OR "gender mainstreaming, in environmental studies" OR "gender moral conservatism" OR "gender moral development" OR "gender moral epistemology" OR "gender moral motherhood" OR "gender moral panics" OR "gender moral psychology" OR "gender moral rationalities" OR "gender moral repair" OR "gender norms" OR "gender obesity" OR "gender occupational segregation" OR "gender oppression" OR "gender relations with technoscience" OR "gender relations, and violent conflict" OR "gender relationship with culture" OR "gender revolution" OR "gender roles" OR "gender studies" OR "gender" OR "gendered assumptions" OR "gendered social order" OR "gene modification technology" OR "genital surgery" OR "genus studies" OR "girls' access to justice" OR "girls' education" OR "global campaign for women's human rights" OR "global context of feminism" OR "global crisis of masculinity" OR "global perspective in feminism" OR "grounded feminist knowledge" OR "heteronormativity" OR "heterorelationality" OR "heterosexual couples, gender convergence" OR "heterosexuality" OR "homosexuality" OR "honor killing" OR "honor killings" OR "honour killing" OR "honour killings" OR "hormone replacement therapy" OR "household technologies" OR "human fertility" OR "human hermaphroditism" OR "human infertility" OR "human intersexuality" OR "hybridized identities" OR "institutionalization of feminism" OR "international concern with masculinities" OR "international women's movement" OR "intra-household allocation" OR "legal system, and feminism" OR "leisure, and masculinity" OR "lesbian cultural production" OR "lesbian families" OR "lesbian friendship networks" OR "lesbian identity" OR "lesbian marriage" OR "lesbian pupils and parents" OR "lesbian sex wars" OR "lesbian studies" OR "lesbianism" OR "liberal feminism" OR "liberal-rights tradition" OR "location, of feminist study" OR "male culture" OR "male education" OR "male employment" OR "male gender norms and" OR "male genital cutting" OR "male genital mutilation" OR "male labor force participation" OR "male labour force participation" OR "male leadership" OR "male political participation" OR "male sex role" OR "male unemployment" OR "man victims of sexual violence" OR "marxist feminism" OR "masculine gender norms" OR "masculine identities" OR "masculine, challenging" OR "masculinities and policy" OR "masculinities" OR "masculinity in crisis" OR "masculinity studies" OR "masculinity" OR "materiality of sex" OR "maternal mortality" OR "maternal thinking" OR "men in leadership" OR "men labor force participation" OR "men labour force participation" OR "men violence" OR "men's education" OR "men's political participation" OR "men's unemployment" OR "men's health" OR "men's studies" OR "mens' employment" OR "misandry" OR "misogyny" OR "objectification of women" OR "patriarchal dividend" OR "patriarchy" OR "post-feminist cultural production" OR "post-heterorelational friendship" OR "pragmatism, in feminist epistemology" OR "pragmatist-feminist" OR "pregnan*" OR "pre-menstrual syndrome" OR "radical feminism" OR "radicalesbians" OR "reproductive health" OR "reproductive rights of women" OR "reproductive rights" OR "reproductive technologies" OR "role in household labour" OR "same sex marriage" OR "same sex marriages" OR "same-sex couples" OR "same-sex marriage" OR "same-sex marriages" OR "sex change procedures" OR "sex differences sex hormones" OR "sex differences" OR "sex roles" OR "sex traffic" OR "sexual behaviour" OR "sexual health" OR "sexual identity" OR "sexual rights" OR "sexual violence in war" OR "sexual violence" OR "single parents" OR "single-parent families" OR "single-parent poverty" OR "social construction perspective on gender" OR "social policy familialism" OR "socialist feminism" OR "structural barriers to women's employment" OR "study of men and masculinities" OR "subjugated knowledges" OR "third world feminists" OR "transgender studies" OR "transgender" OR "transgendering" OR "transnational feminism" OR "transsexualism" OR "unequal pay" OR "unequal salary" OR "unpaid care work" OR "unpaid work" OR "victimization of women in war" OR "victims of sexual violence" OR "violence girl*" OR "wage differential" OR "western approach to difference" OR "western feminism" OR "woman equality" OR "woman participants in conflict" OR "woman suffrage movement" OR "woman victims of violence" OR "woman vulnerability" OR "woman" OR "woman´s suicide" OR "woman´s voice, and citizenship" OR "women and development" OR "women care workers" OR "women in leadership" OR "women in management" OR "women labor force participation" OR "women labour force participation" OR "women religious leaders" OR "women scientists" OR "women" OR "women, environment and development" OR "women's education" OR "women's political participation" OR "women's rights" OR "women's unemployment" OR "women's access to justice" OR "women's bodies" OR "women's commissions" OR "women's environment and development organization" OR "women's movements" OR "women's organizations" OR "women's peace movement" OR "women's shared" OR "women's spirituality" OR "womens' employment")) AND (DOCTYPE("ar") OR DOCTYPE("cp") OR DOCTYPE("re")) AND (SUBJAREA("SOCI") OR SUBJAREA("MEDI") OR SUBJAREA("AGRI") OR SUBJAREA("ENVI") OR SUBJAREA("BUSI") OR SUBJAREA("ENGI") OR SUBJAREA("ECON") OR SUBJAREA("BIOC") OR SUBJAREA("ARTS") OR SUBJAREA("COMP") OR SUBJAREA("NURS") OR SUBJAREA("EART") OR SUBJAREA("PSYC") OR SUBJAREA("IMMU") OR SUBJAREA("DECI") OR SUBJAREA("HEAL") OR SUBJAREA("CENG") OR SUBJAREA("MULT") OR SUBJAREA("PHAR") OR SUBJAREA("MATE") OR SUBJAREA("CHEM") OR SUBJAREA("NEUR") OR SUBJAREA("DENT"))

SDG 6 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND ("access to water" OR "Acute diarrheal disease" OR "antifouling membrane" OR "anti-fouling membrane" OR "antifouling membranes" OR "anti-fouling membranes" OR "aquatic ecotoxicology" OR "aquatic toxicology" OR "Aquifers and water" OR "Badlands and water" OR "biosphere's reserve" OR "black

water" OR "blue water footprint" OR "blue water" OR "brominated flame retardants" OR "cholera" OR "clean water" OR "clofibric acid" OR "constructed wetlands" OR "denitrification" OR "desertification" OR "domestic wastewater" OR "drinking water treatment" OR "drinking water" OR "drought avoidance" OR "drought resistance" OR "drought stress" OR "drought tolerance" OR "drought" OR "dysentery" OR "Ecosystems and water" OR "endocrine disruptor" OR "Equitable access to sanitation" OR "eutrophication" OR "flocculation" OR "flood control" OR "flood damage" OR "flood defence" OR "flood forecasting" OR "flood hazard management" OR "flood management" OR "flood risk" OR "flood simulation modelling" OR "flood warning" OR "flooding tolerance" OR "floodplain geomorphology" OR "floodplain restoration" OR "floods monitoring" OR "Forests and water" OR "free water" OR "freshwater" OR "green water footprint" OR "green water" OR "grey water footprint" OR "grey water" OR "groundwater contamination" OR "groundwater flow" OR "groundwater management" OR "groundwater quality" OR "groundwater recharge" OR "groundwater" OR "hygienic toilet" OR "hygienic toilets" OR "infiltration based storm water management" OR "integrated water resources management" OR "integrated watershed management" OR "integrated watershed modelling" OR "leached" OR "malaria" OR "membrane bioreactor" OR "membrane filtration" OR "membrane fouling" OR "microfiltration" OR "microplastic*" OR "microplastic*" OR "municipal wastewater" OR "nanofiltration" OR "nitrogen removal" OR "nutrient removal" OR "optimal water use" OR "palmer drought severity index" OR "pesticide" OR "pharmaceutical" OR "pharmaceuticals" OR "phosphorus removal" OR "pollution" OR "polycyclic aromatic hydrocarbons" OR "potable water" OR "rainwater harvesting" OR "reverse osmosis" OR "river basin management" OR "river restoration" OR "river" OR "rural water supply" OR "sanitation and water conservation" OR "Sanitation and water" OR "sanitation" OR "seawater intrusion" OR "sequencing batch reactor" OR "sewage sludge" OR "sewer*" OR "shared water" OR "soil and water conservation" OR "storage aquifers" OR "stormwater management" OR "structuration" OR "submarine groundwater discharge" OR "surface water" OR "textile wastewater" OR "typhoid" OR "ultrafiltration" OR "underground dams" OR "underground water" OR "urban floods" OR "urban water" OR "virtual water" OR "waste water treatment" OR "waste water" OR "wastewater management" OR "wastewater reuse" OR "wastewater treatment plant" OR "wastewater treatment plants" OR "wastewater treatment" OR "wastewater" OR "wastewaters" OR "water and sanitation" OR "water availability" OR "water balance" OR "water borne disease" OR "water borne diseases" OR "water conservation" OR "water contaminant" OR "water contaminant" OR "water contaminants" OR "water contamination" OR "water contamination" OR "water costs" OR "water deficit" OR "water demand" OR "water eco-system*" OR "water ecotoxicology" OR "water efficient maize for africa (wema)" OR "water filters" OR "water footprint" OR "water framework directive" OR "water grabbing" OR "water infrastructure" OR "water inventory" OR "water logging" OR "water loss" OR "water management" OR "water policy" OR "water pollutant" OR "water pollutants" OR "water pollution" OR "water pricing" OR "water productivity" OR "water purification" OR "Water purification" OR "water quality index" OR "water quality" OR "Water quality" OR "water recycling" OR "water resource management" OR "water resource" OR "water resources depletion" OR "water resources development" OR "water resources management" OR "water resources" OR "water reuse" OR "wáter reuse" OR "water rights" OR "water security" OR "water shortage" OR "water shortage" OR "water stress" OR "water stressed countries" OR "water supplies" OR "water supply" OR "water toxicology" OR "water treatment" OR "water use efficiency" OR "water use" OR "water uses" OR "water" OR "water-borne disease" OR "water-borne diseases" OR "watershed management")) AND (DOCTYPE("ar ") OR DOCTYPE(" cp ") OR DOCTYPE(" re ")) AND (SUBJAREA("ENVI ") OR SUBJAREA(" ENGI ") OR SUBJAREA(" AGRI ") OR SUBJAREA(" ENER ") OR SUBJAREA(" SOCI ") OR SUBJAREA(" EART ") OR SUBJAREA(" CENG ") OR SUBJAREA(" CHEM ") OR SUBJAREA(" MATE ") OR SUBJAREA(" MEDI ") OR SUBJAREA(" BIOC ") OR SUBJAREA(" COMP ") OR SUBJAREA(" BUSI ") OR SUBJAREA(" PHYS ") OR SUBJAREA(" ECON ") OR SUBJAREA(" IMMU ") OR SUBJAREA(" PHAR ") OR SUBJAREA(" MATH ") OR SUBJAREA(" MULT ") OR SUBJAREA(" DECI ") OR SUBJAREA(" ARTS ") OR SUBJAREA(" VETE ") OR SUBJAREA(" NURS ") OR SUBJAREA(" HEAL "))

SDG 7 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND ("access to energy" OR "alkaline" OR "Alternative energy" OR "Biodegradable Energy" OR "bioenergy" OR "biofuel" OR "BIOFUEL" OR "biofuels" OR "biofuels" OR "biogas" OR "biomass energy" OR "biomass" OR "cooling component" OR "cooling device" OR "cooling equipment" OR "dams" OR "demand-side management" OR "direct methanol" OR "district heat" OR "district heating" OR "dye sensitized" OR "dye-sensitized solar cell" OR "electric vehicle" OR "electric vehicles" OR "electricity generation" OR "electrochemical and energy and system" OR "electromagnetic pollution" OR "energiewende" OR "energy conversion efficiency" OR "energy costs" OR "energy distributed generation" OR "energy efficiency" OR "Energy infrastructure" OR "energy management" OR "energy storage" OR "enhanced geothermal system" OR "enhanced geothermal systems" OR "geothermal energy" OR "geothermal heat pump" OR "geothermal heat pumps" OR "geothermal heating" OR "geothermal power generation" OR "geothermal power plant" OR "geothermal power" OR "geothermics" OR "ground source heat pump geothermal" OR "ground-coupled heat" OR "heating component" OR "heating device" OR "heating equipment" OR "high voltage direct current transmission" OR "HVDC transmission" OR "hybrid vehicles" OR "hydraulic energy" OR "hydraulic microcentrals" OR "hydrogen and powered and engines" OR "hydropower" OR "life cycle assessment" OR "life cycle assessments" OR "life-cycle assessment" OR "life-cycle assessments" OR "lithium-ion batteries" OR "lithium-ion battery" OR "micro grid" OR "microbial fuel cell" OR "mineral carbon" OR "Non-polluting energies" OR "nuclear energy"

OR "ocean energy." OR "offshore wind energy" OR "organic photovoltaic" OR "organic photovoltaics" OR "organic photovoltaics" OR "organic solar cell" OR "organic solar cells" OR "organic solar cells" OR "phosphoric acid or molten carbonate or solid oxide" OR "photovoltaic cell" OR "photovoltaic cells" OR "photovoltaic power systems" OR "photovoltaic" OR "photovoltaics" OR "polymer electrolyte membrane" OR "Radiation" OR "renewable energies" OR "renewable energy and integration" OR "renewable energy and source" OR "renewable energy systems" OR "renewable energy technologies" OR "renewable energy" OR "Renewable energy" OR "Renewable energy" OR "renewables" OR "reversible and fuel cell" OR "smart grid technology" OR "smart grid" OR "smart grids" OR "smart meter" OR "smart meters" OR "smart micro grid" OR "smart micro grids" OR "smart microgrid" OR "smart micro-grid" OR "smart microgrids" OR "smart micro-grids" OR "solar cell" OR "solar cells" OR "solar collect" OR "solar collector" OR "solar energy" OR "solar energy" OR "solar energy" OR "syngas and biomass" OR "system wecs" OR "waste conversion" OR "water energy" OR "wave energy" OR "wind energy conversion system" OR "wind energy generation" OR "wind energy potential" OR "wind energy" OR "wind energy" OR "wind farm" OR "wind park" OR "wind power generation" OR "wind power plant" OR "wind power" OR "wind power" OR "wind turbine" OR "wind turbines"))) AND (DOCTYPE("ar ") OR DOCTYPE(" cp ") OR DOCTYPE(" re ")) AND (SUBJAREA("ENER ") OR SUBJAREA(" ENGI ") OR SUBJAREA(" ENVI ") OR SUBJAREA(" COMP ") OR SUBJAREA(" SOCI ") OR SUBJAREA(" CENG ") OR SUBJAREA(" AGRI ") OR SUBJAREA(" MATE ") OR SUBJAREA(" CHEM ") OR SUBJAREA(" BUSI ") OR SUBJAREA(" BIOC ") OR SUBJAREA(" PHYS ") OR SUBJAREA(" EART ") OR SUBJAREA(" MATH ") OR SUBJAREA(" ECON ") OR SUBJAREA(" DECI ") OR SUBJAREA(" IMMU ") OR SUBJAREA(" MULT ") OR SUBJAREA(" ARTS ") OR SUBJAREA(" PHAR ") OR SUBJAREA(" HEAL ") OR SUBJAREA(" NEUR "))

SDG 8 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND "carbon offset" OR "carbon offsets" OR "carbon offsetting" OR "child lab*" OR "Child labour" OR "child soldier" OR "circular economy" OR "decent job" OR "decent jobs" OR "decent work" OR "Demographic bonus" OR "economic development" OR "economic geography" OR "economic growth" OR "economic policies" OR "economic policy" OR "economic productivity" OR "employment protection" OR "forced lab" OR "forced labour" OR "formalization" OR "full employment" OR "global jobs" OR "human trafficking" OR "inclusive economy" OR "inclusive growth" OR "income group" OR "income groups" OR "industrial development" OR "informal economy" OR "informal employment" OR "informal sector" OR "informal sector" OR "informal sectors" OR "informal" OR "innovation and uneployment" OR "job creation" OR "lab market institution" OR "lab market institutions" OR "lab right" OR "lab rights" OR "labour intensive" OR "labour market institution" OR "labour market institutions" OR "labour right" OR "labour rights" OR "labour-intensive" OR "living wage" OR "local investment" OR "local investments" OR "low carbon economy" OR "low-carbon economy" OR "medium enterprise" OR "medium enterprises" OR "medium entrepreneur" OR "medium entrepreneurs" OR "microcredit*" OR "micro-credit*" OR "microenterprise*" OR "micro-enterprise*" OR "microfinanc*" OR "micro-financ*" OR "migrant workers" OR "minimum wage" OR "modern slavery" OR "offset project" OR "offset projects" OR "precarious employment" OR "precarious job" OR "precarious jobs" OR "productive development" OR "productive employment" OR "productive sophistication" OR "prosperity" OR "quality job" OR "quality jobs" OR "rural economy" OR "small enterprise" OR "small enterprises" OR "small entrepreneur" OR "small entrepreneurs" OR "social entrepreneurship" OR "starting entrepreneur" OR "starting entrepreneurs" OR "structural change" OR "sustainable tourism" OR "taxes" OR "technological upgrading" OR "trade support" OR "trade union" OR "trade unions" OR "unemploy* youth" OR "unemployment" OR "unequal pay" OR "working environment" OR "working environments" OR "working policy" OR "youth employ*"))) AND (DOCTYPE("ar ") OR DOCTYPE(" cp ") OR DOCTYPE(" re ")) AND (SUBJAREA("SOCI ") OR SUBJAREA(" ENVI ") OR SUBJAREA(" ENGI ") OR SUBJAREA(" BUSI ") OR SUBJAREA(" ENER ") OR SUBJAREA(" ECON ") OR SUBJAREA(" AGRI ") OR SUBJAREA(" COMP ") OR SUBJAREA(" MEDI ") OR SUBJAREA(" EART ") OR SUBJAREA(" DECI ") OR SUBJAREA(" MATH ") OR SUBJAREA(" MATE ") OR SUBJAREA(" CENG ") OR SUBJAREA(" CHEM ") OR SUBJAREA(" PHYS ") OR SUBJAREA(" MULT ") OR SUBJAREA(" PHAR ") OR SUBJAREA(" NURS ") OR SUBJAREA(" HEAL "))

SDG 9 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND (“accessibility" OR "artificial intelligence" OR "collaborative and social computing" OR "collaborative innovation" OR "communication hardware, interfaces and storage" OR "computational complexity and cryptography" OR "computer forensics" OR "computer graphics" OR "computer systems organization" OR "computers in other domains" OR "computing methodologies" OR "concurrent computing methodologies" OR "congestion" OR "continuous mathematics" OR "cross-computing tools and techniques" OR "cryptography" OR "data management systems" OR "database and storage security" OR "dependable and fault-tolerant systems and networks" OR "design and analysis of algorithms" OR "digitally enabled open innovation" OR "discrete mathematics" OR "distributed computing methodologies" OR "document management and text processing" OR "document types" OR "electronic commerce" OR "electronic design automation" OR "embedded and cyber-physical systems" OR "emerging technologies" OR "enterprise computing" OR "formal languages and automata theory" OR "formal methods and theory of security" OR "global value chain" OR "green process" OR "green processes" OR "green product" OR "green products" OR "grenn industry" OR "hardware test" OR "hardware validation" OR "hardware" OR

"human and societal aspects of security and privacy" OR "human computer interaction" OR "human-centered computing" OR "inclusive innovation" OR "incremental innovation" OR "industrial development" OR "industrial diversification" OR "INDUSTRIAL DIVERSIFICATION" OR "industrial ecology" OR "industrial growth" OR "industrial hygiene" OR "industrial pollution" OR "industrial safety" OR "INDUSTRIAL SOPHISTICATION" OR "industrial waste management" OR "industrial waste treatment" OR "industrialization" OR "industry" OR "information retrieval" OR "information storage systems" OR "information systems applications" OR "information systems" OR "information theory" OR "infrastructural development" OR "INFRASTRUCTURAL INVESTMENT" OR "infrastructure investment" OR "innovation" OR "innovative process" OR "innovative processes" OR "integrated circuits" OR "interaction design" OR "internet access" OR "intrusion/anomaly detection and malware mitigation" OR "logistics" OR "low carbon production" OR "machine learning" OR "manufacturing" OR "mathematical analysis" OR "mathematical software" OR "mathematics of computing" OR "medium enterprise" OR "medium enterprises" OR "medium entrepreneur" OR "medium entrepreneurs" OR "microenterprise*" OR "micro-enterprise*" OR "mission-oriented innovation" OR "modeling and simulation" OR "models of computation" OR "network algorithms" OR "network architectures" OR "network components" OR "network performance evaluation" OR "network properties" OR "network protocols" OR "network security" OR "network services" OR "network types" OR "networks" OR "operations research" OR "organizational innovation" OR "parallel computing methodologies" OR "physical sciences and engineering" OR "power and energy" OR "printed circuit boards" OR "probability and statistics" OR "product innovation" OR "public infrastructure" OR "public infrastructures" OR "radical innovation" OR "randomness, geometry and discrete structures" OR "real-time systems" OR "resilient infrastructure" OR "resilient infrastructures" OR "robustness" OR "security and privacy" OR "security in hardware" OR "security services" OR "small enterprise" OR "small enterprises" OR "small entrepreneur" OR "small entrepreneurs" OR "software and application security" OR "software and its engineering" OR "software creation and management" OR "software notations and tools" OR "software organization and properties" OR "structural change" OR "structural equity" OR "symbolic and algebraic manipulation" OR "systems security" OR "technological capabilities" OR "technological change" OR "technological development" OR "technology policy" OR "technology transfer" OR "theory and algorithms for application domains" OR "theory of computation" OR "transborder infrastructure" OR "transborder infrastructures" OR "transportation research and development" OR "ubiquitous and mobile computing" OR "very large scale integration design" OR "world wide web")) AND (DOCTYPE("ar ") OR DOCTYPE(" cp ") OR DOCTYPE(" re ")) AND (SUBJAREA("ENGI ") OR SUBJAREA(" ENVI ") OR SUBJAREA(" SOCI ") OR SUBJAREA(" COMP ") OR SUBJAREA(" BUSI ") OR SUBJAREA(" ENER ") OR SUBJAREA(" AGRI ") OR SUBJAREA(" DECI ") OR SUBJAREA(" EART ") OR SUBJAREA(" MATE ") OR SUBJAREA(" ECON ") OR SUBJAREA(" CENG ") OR SUBJAREA(" MATH ") OR SUBJAREA(" CHEM ") OR SUBJAREA(" BIOC ") OR SUBJAREA(" ARTS ") OR SUBJAREA(" MULT ") OR SUBJAREA(" IMMU ") OR SUBJAREA(" PHAR ") OR SUBJAREA(" PSYC "))

SDG 10 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND ("accumulation" OR "center periphery" OR "convergence and divergence" OR "democracy and inequality" OR "development on a human scale" OR "development assistance" OR "developed countries" OR "development gap" OR "development gaps" OR "discrimination" OR "distribution of wealth" OR "Endogenous development" OR "emigration" OR "equality" OR "eradication of poverty" OR "foreign direct investment" OR "Gini coefficient" OR "GINI" OR "global distribution of wealth" OR "immigration" OR "income accruing to the top groups" OR "income concentration" OR "income shares" OR "income tax data" OR "inequality and growth path" OR "inequality and human development" OR "inequality reduction" OR "inequality" OR "inequiality and political conflict" OR "Knowledge and skill diffusion" OR "Kuznets Curve" OR "marginalised population" OR "marginalised populations" OR "marginalized population" OR "marginalized populations" OR "MASS POVERTY" OR "migrant remittance" OR "migration policies" OR "migration policy" OR "north-south" OR "personal income tax" OR "political inclusion" OR "private capital" OR "PROSPERITY AND POVERTY" OR "reform program" OR "reform programme" OR "reform programmes" OR "reform programs" OR "responsible migration" OR "rural poverty" OR "segregation" OR "social exclusion" OR "social inclusion" OR "social needs" OR "social protection" OR "structural heterogeneity" OR "structure of inequality" OR "taxes" OR "technological progress and inequality" OR "underdevelopment" OR "wealth inequality" OR "WTID"))) AND (DOCTYPE("ar ") OR DOCTYPE(" cp ") OR DOCTYPE(" re ")) AND (SUBJAREA("SOCI ") OR SUBJAREA(" ENVI ") OR SUBJAREA(" BUSI ") OR SUBJAREA(" MEDI ") OR SUBJAREA(" ENER ") OR SUBJAREA(" ECON ") OR SUBJAREA(" AGRI ") OR SUBJAREA(" EART ") OR SUBJAREA(" ARTS ") OR SUBJAREA(" MATE ") OR SUBJAREA(" DECI ") OR SUBJAREA(" MATH ") OR SUBJAREA(" CENG ") OR SUBJAREA(" PHYS ") OR SUBJAREA(" NURS ") OR SUBJAREA(" PSYC ") OR SUBJAREA(" IMMU ") OR SUBJAREA(" MULT ") OR SUBJAREA(" PHAR ") OR SUBJAREA(" HEAL "))

SDG 11 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND ("Access to basic services" OR "Access to housing" OR "basic service" OR "basic services" OR "bike" OR "building design" OR "buildings design" OR "built environment" OR "bus transport priority measures" OR "cities and infrastructures" OR "cities and territories" OR "cities" OR "city and territory" OR "city planning" OR "city sistems" OR "city" OR "common rail system" OR "Community actions" OR "Community Development" OR "Community participation" OR "community transport" OR "conectividad urbana de internert " OR "Conflicts of coexistence" OR "congestion" OR "Connectivity between cities" OR "conurbation" OR "design for environment" OR "disaster risk reduction" OR "Disposal of solid waste" OR "ecodesign" OR "eco-design" OR "eco-driving" OR "electric vehicle" OR "electric vehicles" OR "emerging cities" OR "Employment centers in the city" OR "environment friendly" OR "environmental impacts of urban transport" OR "equity and social inclusion" OR "feeder transport" OR "Financing of housing" OR "Food security in the city" OR "freight modal shift" OR "fuel cell electric vehicle" OR "fuel efficient transport" OR "fuel efficient vehicle" OR "gentrification" OR "GINI index" OR "Governance of the city" OR "green car" OR "green mobility" OR "green roofs" OR "green transport cycling" OR "green vehicles" OR "high pressure common rail" OR "Home building " OR "Housing deficit" OR "Housing for rent" OR "Housing policy" OR "housing" OR "human settlement" OR "human settlements" OR "hybrid alternative drive vehicles" OR "hybrid electric vehicle" OR "hybrid electric vehicles" OR "hybrid electric vehicles" OR "hybrid vehicle" OR "hybrid vehicles" OR "inclusive urbanization" OR "inland waterway navigation" OR "innovation and cities" OR "innovations in freight transport" OR "integrated transport policy" OR "intelligent car" OR "intermodal transport" OR "intermodality" OR "inter-vehicle networks" OR "invasions" OR "land use change" OR "liquid nitrogen powered engine" OR "Living place" OR "local transport planning" OR "marginal settlements" OR "marginal willingness to pay for car" OR "megacities" OR "metropolitan areas" OR "metropolitan planning" OR "modal shift" OR "motor vehicle safety" OR "multimodal transport" OR "multinomial logit model" OR "neighborhoods" OR "nested logit model" OR "new suburbanism" OR "new urbanism" OR "non-mot motorized transport" OR "park-and ride" OR "passenger transport" OR "pedestrian safety" OR "plug-in hybrid electric vehicle" OR "public space policy" OR "Public space" OR "public transport policy" OR "public transport" OR "public urban transport" OR "Quality of urban life" OR "Recycling" OR "regenerative braking" OR "regional planning" OR "resilient building" OR "resilient buildings" OR "Right to the city" OR "Risk management" OR "road pricing" OR "road safety" OR "road transport" OR "road vehicle electric propulsion" OR "rural transport" OR "rural zones and cities" OR "sendai framework" OR "slum*" OR "Slums" OR "Smart cities" OR "smart cities" OR "smart growth" OR "Smog" OR "Social appropriation" OR "Social equipment" OR "Social housing" OR "Social participation" OR "spatial planning" OR "suburban climate" OR "suburban containment" OR "suburban design" OR "suburban development" OR "suburban ecology" OR "suburban environment" OR "suburban expansion" OR "suburban finance" OR "suburban footprint" OR "suburban forestry" OR "suburban form" OR "suburban governance" OR "suburban growth" OR "suburban heat island" OR "suburban housing" OR "suburban infrastructure" OR "suburban management" OR "suburban morphology" OR "suburban planning" OR "suburban policy" OR "suburban regeneration" OR "suburban renewal" OR "suburban services" OR "suburban sprawl" OR "suburban strategy" OR "suburban transport" OR "suburban transportation" OR "suburban utilities" OR "suburbanisation" OR "suburbanization" OR "Suburbs" OR "sustainable building" OR "sustainable buildings" OR "sustainable cities" OR "sustainable mobility" OR "sustainable transport and mobility" OR "sustainable transport indicators" OR "sustainable transport performance indicators" OR "sustainable transport policy" OR "sustainable transport" OR "sustainable transportation" OR "sustainable urban mobility" OR "sustainable urban transport" OR "territorial planning" OR "town*" OR "traffic congestion" OR "traffic management" OR "traffic planning" OR "traffic safety" OR "transit oriented development" OR "transit oriented development" OR "transport economics" OR "transport emission reduction" OR "transport management" OR "transport planning" OR "transport policy" OR "transport sustainability" OR "transportation" OR "travel demand management" OR "urban areas" OR "Urban basic sanitation" OR "Urban centralities" OR "urban centralities" OR "urban climate" OR "Urban coexistence" OR "urban containment" OR "Urban crime" OR "urban design" OR "Urban Development" OR "urban ecology" OR "urban environment" OR "urban expansion" OR "urban finance" OR "urban footprint" OR "urban forestry" OR "urban form" OR "urban freight logistic" OR "urban freight transport" OR "urban governance" OR "urban growth" OR "urban habitat" OR "urban heat island" OR "urban housing" OR "urban infrastructure" OR "urban management" OR "urban mobility" OR "urban morphology" OR "Urban overcrowding" OR "Urban parks" OR "Urban planification" OR "urban planning" OR "urban policy" OR "urban pollution" OR "Urban poverty" OR "urban prosperity" OR "urban public transport" OR "urban rail" OR "urban regeneration" OR "urban renewal" OR "Urban renewal" OR "urban security" OR "Urban segregation" OR "urban services" OR "Urban space" OR "urban sprawl" OR "urban strategy" OR "urban traffic control" OR "urban traffic" OR "urban transport policy" OR "urban transport strategy formulation" OR "urban transport" OR "urban transportation" OR "urban transpot" OR "urban utilities" OR "urban" OR "urbanisation" OR "urbanization and development" OR "urbanization" OR "use bike" OR "vehicle safety" OR "vehicle security" OR "vehicular congestion" OR "waste management" OR "wheel-rail system" OR "zero energy building" OR "zero energy buildings" OR "zero-energy building" OR "zero-energy buildings"))) AND (DOCTYPE("ar ") OR DOCTYPE(" cp ") OR DOCTYPE(" re ")) AND ((SUBJAREA ("ENGI ") OR (SUBJAREA (" ENVI ") OR (SUBJAREA (" SOCI ") OR (SUBJAREA (" ENER ") OR (SUBJAREA (" AGRI ") OR (SUBJAREA (" BUSI ") OR (SUBJAREA (" COMP ") OR (SUBJAREA (" EART ") OR (SUBJAREA (" MEDI ") OR (SUBJAREA (" DECI ") OR (SUBJAREA (" MATE ") OR (SUBJAREA (" CENG ") OR (SUBJAREA (" ECON ") OR (SUBJAREA (" CHEM ") OR (SUBJAREA (" BIOC ") OR (SUBJAREA (" MATH ") OR (SUBJAREA (" PHYS ") OR (SUBJAREA (" ARTS

") OR (SUBJAREA (" MULT ") OR (SUBJAREA (" PHAR ") OR (SUBJAREA (" NURS ") OR (SUBJAREA (" PSYC ") OR (SUBJAREA (" HEAL "))

SDG 12 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND ("biobased product" OR "bio-based product" OR "biobased products" OR "bio-based products" OR "biodegradable" OR "biofuel production" OR "biogasification" OR "biowaste" OR "clean production" OR "cleaner production" OR "composting" OR "consumer behavior" OR "consumer behaviors" OR "consumer behaviour" OR "consumer behaviours" OR "consumption" OR "corporate sustainability" OR "eco-efficiency" OR "ecological footprint" OR "eco-supply chain" OR "energy from waste" OR "e-waste" OR "fair trade" OR "fly ash" OR "food waste" OR "gasification" OR "green consumerism" OR "green core competence" OR "green innovation" OR "green marketing" OR "green process innovation" OR "Green product innovation" OR "greening of industry" OR "hazardous chemical" OR "hazardous chemicals" OR "hazardous waste" OR "household waste" OR "incineration" OR "industrial ecology" OR "industrial sustainability" OR "industrial symbiosis" OR "industrial waste" OR "input–output analysis" OR "integrated product policy" OR "landfill" OR "landfills" OR "leachate treatment" OR "leachate" OR "leaching test." OR "low carbon economy" OR "low-carbon economy" OR "MSW" OR "municipal solid waste" OR "municipal solid waste" OR "nuclear waste" OR "organic waste" OR "packaging waste" OR "pesticide*" OR "pollutant*" OR "post-harvest" OR "product service system" OR "product stewardship" OR "production" OR "pyrolysis" OR "radioactive waste disposal" OR "radioactive waste" OR "recycl*" OR "recycling" OR "resource footprint" OR "Self-consumption" OR "solid waste management" OR "solid waste" OR "solid wastes" OR "source reduction" OR "supply chain" OR "sustainable chemistry" OR "sustainable consumption and production" OR "sustainable consumption" OR "sustainable energy use" OR "sustainable lifestyle" OR "sustainable procurement" OR "sustainable production and consumption" OR "sustainable production" OR "toxic chemical" OR "toxic chemicals" OR "waste activated sludge" OR "waste characterization" OR "waste collection" OR "waste disposal" OR "waste generation" OR "waste management" OR "waste materials" OR "waste minimization" OR "waste plastics" OR "waste recycling" OR "waste utilization" OR "waste valorization" OR "zero waste")) AND (DOCTYPE("ar ") OR DOCTYPE(" cp ") OR DOCTYPE(" re ")) AND ((SUBJAREA ("ENVI ") OR (SUBJAREA (" ENGI ") OR (SUBJAREA (" AGRI ") OR (SUBJAREA (" ENER ") OR (SUBJAREA (" SOCI ") OR (SUBJAREA (" BUSI ") OR (SUBJAREA (" EART ") OR (SUBJAREA (" COMP ") OR (SUBJAREA (" CENG ") OR (SUBJAREA (" MATE ") OR (SUBJAREA (" CHEM ") OR (SUBJAREA (" BIOC ") OR (SUBJAREA (" MEDI ") OR (SUBJAREA (" ECON ") OR (SUBJAREA (" DECI ") OR (SUBJAREA (" PHYS ") OR (SUBJAREA (" MATH ") OR (SUBJAREA (" IMMU ") OR (SUBJAREA (" MULT ") OR (SUBJAREA (" PHAR ") OR (SUBJAREA (" VETE ") OR (SUBJAREA (" NURS ") OR (SUBJAREA (" PSYC ") OR (SUBJAREA (" HEAL ") OR (SUBJAREA (" Undefined "))

SDG 13 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND ("abrupt climate change" OR "adaptation" OR "adaptive management" OR "air-sea interactions" OR "anthropocene" OR "anthropogenic" OR "atmosphere" OR "biodivers*" OR "bioeconomy" OR "biogeochemical cycle" OR "biological production" OR "carbon dioxide" OR "carbon sequestration" OR "carbon" OR "clean development mechanism" OR "climate action" OR "climate adaptation" OR "climate change adaptation" OR "climate change and agriculture" OR "climate change" OR "climate effect" OR "climate feedback" OR "climate forcing" OR "climate impact" OR "climate mitigation" OR "climate model" OR "climate modeling" OR "climate modelling" OR "climate models" OR "climate policies" OR "climate policy" OR "climate prediction" OR "climate predictions" OR "climate resilience" OR "climate risk" OR "climate risks" OR "climate sensitivity" OR "climate service" OR "climate services" OR "climate signal" OR "climate signals" OR "climate tipping point" OR "climate variability" OR "climate variation" OR "climate variations" OR "climate warming" OR "climate" OR "climatic changes" OR "climatology" OR "conservation" OR "consumption" OR "deforestation" OR "drought" OR "ecoclimatology" OR "eco-climatology" OR "El Niño–Southern Oscillation" OR "effect permafrost" OR "emission*" OR "ENSO" OR "extreme" OR "floods" OR "food chain" OR "food chains" OR "glacier retreat" OR "global change" OR "global climate change" OR "global warming potential" OR "global warming" OR "green jobs" OR "greenhouse gas (es)" OR "greenhouse gas emissions" OR "greenhouse gases" OR "greenhouse" OR "hazard*" OR "holocene" OR "human impact" OR "ice-ocean interaction" OR "ice-ocean interactions" OR "intergovermental panal on climate change (ipcc)" OR "ipcc" OR "island*" OR "kyoto protocol" OR "land use change" OR "land use" OR "megacit*" OR "methane" OR "migration" OR "mitigation" OR "nitrogen cycle" OR "nitrogen cycles" OR "north atlantic oscillation extreme events drought" OR "ocean acidification" OR "ocean ph" OR "ocean temperature" OR "ocean warming" OR "ozone" OR "paleoclimate" OR "palynology" OR "permafrost" OR "phenology" OR "policy" OR "precipitation changes" OR "production" OR "radiation" OR "radiative forcing" OR "regional climate" OR "regional climates" OR "scenarios" OR "sea ice" OR "sea level" OR "sea levels" OR "sea-level rise" OR "stable isotopes" OR "streamflow" OR "thermal expansion" OR "thermohaline circulation" OR "ultraviolet radiation" OR "UNFCCC" OR "United Nations Framework Convention on Climate Change" OR "urban climate" OR "urban climates" OR "warming")) AND (DOCTYPE("ar ") OR DOCTYPE(" cp ") OR DOCTYPE(" re ")) AND ((SUBJAREA ("ENVI ") OR (SUBJAREA (" ENGI ") OR (SUBJAREA (" AGRI ") OR (SUBJAREA (" SOCI ") OR (SUBJAREA (" ENER ") OR (SUBJAREA (" BUSI ") OR (SUBJAREA (" EART ") OR (SUBJAREA (" COMP ") OR (SUBJAREA (" MEDI ") OR (SUBJAREA (" CENG ") OR (SUBJAREA (" BIOC ") OR (SUBJAREA

(" ECON ") OR (SUBJAREA (" MATE ") OR (SUBJAREA (" CHEM ") OR (SUBJAREA (" PHYS ") OR (SUBJAREA (" DECI ") OR (SUBJAREA (" MATH ") OR (SUBJAREA (" IMMU ") OR (SUBJAREA (" MULT ") OR (SUBJAREA (" PHAR ") OR (SUBJAREA (" VETE ") OR (SUBJAREA (" HEAL "))

SDG 14 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND ("acidification of the oceans" OR "algae" OR "aquaculture" OR "artisanal fisheries" OR "artisanal fishing" OR "atlantic salmon" OR "barramundi" OR "barrier reef" OR "biochemical cycle" OR "biochemical cycles" OR "biogeochemical cycle" OR "biogeochemical cycles" OR "biological oceanography" OR "chemical oceanography" OR "coastal eutrophication" OR "coastal geography" OR "coastal habitat" OR "coastal habitats" OR "coastal management" OR "coastal zone" OR "cod" OR "coral bleach" OR "coral bleaching" OR "coral reef" OR "diatoms" OR "El Niño phenomenon" OR "eochromis" OR "euphotic zone" OR "eutrophicat" OR "eutrophication of aquatic ecosystems" OR "farmed acquatic animal" OR "fish biomass" OR "fish farm" OR "fish farming" OR "fish stocking" OR "fish sustainable" OR "fisheries management sustainable" OR "fisheries management" OR "fisheries sustainable development" OR "fishery management" OR "freshwater marine currents" OR "gadus mhua" OR "geological oceanography" OR "glacier dynamics" OR "glacier mass" OR "glacier retreat" OR "glaciology" OR "global circulation model" OR "global circulation modeling" OR "global circulation modelling" OR "global circulation models" OR "haddock" OR "halocline" OR "herring" OR "hydrography" OR "hydrology" OR "ice-ocean" OR "impacts of climate change" OR "integrated aquaculture" OR "kelp forest" OR "La Niña phenomenon" OR "limnology" OR "Lion fish" OR "littoral zone" OR "local fauna" OR "longline sustainable development sustainability" OR "Loss of marine biodiversity" OR "macroalgae" OR "mangrove" OR "mariculture" OR "marine biodiversity" OR "marine biodiversity" OR "marine biogeochemistry" OR "marine biogeography" OR "marine biology" OR "marine chemistry" OR "marine climatology" OR "Marine contamination" OR "marine ecology" OR "marine ecosystems" OR "marine geology" OR "marine mammals" OR "marine meteorology" OR "marine overfishing" OR "marine pollution" OR "marine productivy" OR "marine protected areas" OR "marine reserve" OR "marine reserves" OR "marine upwelling" OR "marine" OR "microalgae" OR "mollusk" OR "native fauna" OR "niloticus" OR "ocean acidification" OR "ocean circulation" OR "ocean currents" OR "oceanography" OR "overfishing" OR "paleoceanography" OR "paleo-oceanography" OR "penaeus monodon" OR "phenomena of El Niño and La Niña" OR "physical oceanography" OR "plankton" OR "Pterois antennata" OR "rainbow trout" OR "Rising sea levels" OR "salmo salar" OR "salmon farm" OR "salmon" OR "sea" OR "seabirds" OR "seagrass" OR "seas" OR "sedimentation" OR "shrimp aquaculture" OR "shrimp" OR "sponges" OR "submarine geophysics" OR "sustainability" OR "sustainable fisheries" OR "thermohaline circulation" OR "tilapia" OR "trawling sustainable development sustainability" OR "water cycle" OR "water cycles")) AND (DOCTYPE("ar ") OR DOCTYPE(" cp ") OR DOCTYPE(" re ")) AND ((SUBJAREA ("ENVI ") OR (SUBJAREA (" SOCI ") OR (SUBJAREA (" ENGI ") OR (SUBJAREA (" AGRI ") OR (SUBJAREA (" ENER ") OR (SUBJAREA (" BUSI ") OR (SUBJAREA (" COMP ") OR (SUBJAREA (" MEDI ") OR (SUBJAREA (" EART ") OR (SUBJAREA (" ECON ") OR (SUBJAREA (" BIOC ") OR (SUBJAREA (" MATE ") OR (SUBJAREA (" CENG ") OR (SUBJAREA (" DECI ") OR (SUBJAREA (" CHEM ") OR (SUBJAREA (" PHYS ") OR (SUBJAREA (" IMMU ") OR (SUBJAREA (" MULT ") OR (SUBJAREA (" PHAR ") OR (SUBJAREA (" VETE ") OR (SUBJAREA (" Undefined "))

SDG 15 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND ("afforestation" OR "Agricultural frontier expansion" OR "Agricultural frontier" OR "agroforestry" OR "alien species" OR "Amazon jungle" OR "aquifer contamination" OR "aquifer" OR "aquifers modelling" OR "astrobiology" OR "atmospheric chemistry" OR "biodiversity conservation" OR "biodiversity" OR "bioeconom" OR "bio-econom" OR "Biogeography" OR "Biological Diversity" OR "biological production" OR "Biomodels" OR "boreal forest" OR "Burning the ground" OR "carbon sequestration" OR "chytridiomycosis" OR "climate change and geology" OR "climatic change and geology" OR "climatology" OR "coarse woody debris" OR "coastal processes and geology" OR "coastal zones and geomorphology" OR "community forestry" OR "Conservation of ecosystems" OR "conservation planning" OR "Danger of Extinction" OR "data processing and hydrogeology" OR "deforestation" OR "Desertification" OR "dryland" OR "earth system" OR "ecological resilience" OR "ecosystem function" OR "ecosystem functioning" OR "ecosystem management" OR "ecosystem services" OR "ecosystem" OR "Ecosystems" OR "Elephant ivory" OR "endangered species" OR "endemism" OR "energy and ocean currents" OR "energy and thermal gradients" OR "environmental geology" OR "environmental health and geology" OR "estuarine processes and geology" OR "ethnobiology" OR "ethnobotany" OR "ethnogeology" OR "exotic species" OR "extinction risk" OR "extinction risks" OR "Extinction" OR "fluvial hydraulics" OR "food chain" OR "food chains" OR "forensic geology" OR "forest dynamics" OR "forest fire" OR "forest fires" OR "forest fragmentation" OR "forest health" OR "forest inventory" OR "forest management" OR "forest policy" OR "forest soil" OR "forest structure" OR "forest sustainability" OR "forest" OR "forestry" OR "fracking" OR "Genetic resources" OR "geodynamics" OR "geological engineering" OR "geological heritage" OR "geological oceanography" OR "geophysics" OR "geotechnics" OR "geothermal" OR "global warming and geology" OR "hábitat fragmentation" OR "habitat loss" OR "hydric monitoring" OR "hydrogeochemistry" OR "hydrogeological mapping" OR "hydrogeological monitoring" OR "hydrogeology and hydroelectric" OR "indicator species" OR "instrumentation and monitoring" OR "International Treaty on Plant Genetic Resources

for Food and Agriculture" OR "invasive alien species" OR "invasive species" OR "land conservation" OR "land degradation" OR "land use" OR "land uses" OR "landscape biota evolution" OR "Landscape ecology" OR "landslides and geology" OR "leaf area index" OR "limnology" OR "Loss of ecosystems" OR "macroecology" OR "macroinvertebrates" OR "madagascar" OR "marine platforms and geomorphology" OR "mass removal processes" OR "medical geology" OR "Melting of glaciers" OR "meteorology" OR "mineral deposits" OR "mineral resources" OR "mountain*" OR "Nagoya Protocol on Access to Genetic Resources" OR "Natural parks" OR "natural regeneration" OR "Natural reserves" OR "nature conservation" OR "neotectonics" OR "neotropics" OR "non-conventional hydrocarbons" OR "paleoclimatology" OR "Páramo" OR "phylogeography" OR "picea abies" OR "pinus ponderosa" OR "pinus sylvestris" OR "plant diversity" OR "Poaching" OR "ponderosa pine" OR "prescribed fire" OR "protected areas" OR "protected species" OR "Protection of ecosystems" OR "recharge of aquifer" OR "Red List Index" OR "Red list" OR "reforestation" OR "Reforestation" OR "reserve selection" OR "reservoir characterization" OR "reservoir simulation" OR "rhinoceros horn" OR "risk assessment and geology" OR "risk management and geology" OR "river systems and modelling" OR "Rosewood" OR "secondary forest" OR "sediment transport and modelling" OR "seeds" OR "seismic interpretation" OR "seismology" OR "seismotectonics" OR "shale" OR "silviculture" OR "Soil contamination" OR "soil degradation" OR "soil degradation" OR "solar energy" OR "species diversity" OR "species richness" OR "species-area relationship" OR "stand structure" OR "sustainability" OR "sustainable development" OR "sustainable forest management" OR "sustainable forestry" OR "Sustainable management of flora and fauna" OR "Terrestrial biodiversity" OR "territorial order and geology" OR "thinning" OR "threatened species" OR "Transgenic" OR "tropical deforestation" OR "tropical forest" OR "tropical forests" OR "tropical rain forest" OR "Tropical rainforest" OR "urban forestry" OR "vascular plants" OR "water data and modelling" OR "water data and processing" OR "wave power" OR "wetland" OR "wildfire" OR "wildlife and wild flora" OR "wildlife market" OR "wildlife markets" OR "wildlife product" OR "wildlife products" OR "wildlife traffic" OR "wildlife traffic" OR "wildlife trafficking" OR "wind energy")) AND (DOCTYPE("ar ") OR DOCTYPE(" cp ") OR DOCTYPE(" re ")) AND ((SUBJAREA ("ENGI ") OR (SUBJAREA (" ENVI ") OR (SUBJAREA (" SOCI ") OR (SUBJAREA (" AGRI ") OR (SUBJAREA (" ENER ") OR (SUBJAREA (" BUSI ") OR (SUBJAREA (" COMP ") OR (SUBJAREA (" EART ") OR (SUBJAREA (" ECON ") OR (SUBJAREA (" MATE ") OR (SUBJAREA (" DECI ") OR (SUBJAREA (" CENG ") OR (SUBJAREA (" BIOC ") OR (SUBJAREA (" CHEM ") OR (SUBJAREA (" MATH ") OR (SUBJAREA (" PHYS ") OR (SUBJAREA (" MULT ") OR (SUBJAREA (" IMMU ") OR (SUBJAREA (" PHAR ") OR (SUBJAREA (" VETE ") OR (SUBJAREA (" Undefined "))

SDG 16 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND ("accountable institution" OR "accountable institutions" OR "actual innocence" OR "armed conflict" OR "armed conflicts" OR "arms flow" OR "asset laundering" OR "bribery" OR "child abuse" OR "citizen oversight" OR "citizen participation" OR "civil conflict" OR "civil conflicts" OR "coexistence" OR "community-based primary production economies" OR "conflict management" OR "conflict resolution mechanisms" OR "corruption" OR "counternarcotic poli*" OR "crime" OR "crimes" OR "criminal organizations" OR "criminal policy strategy" OR "criminal" OR "criticism" OR "crop substitution" OR "Crop substitution" OR "crops for illicit use" OR "culture of peace" OR "de-mining and cleaning processes" OR "democracy" OR "democratization" OR "detention" OR "drug trafficking" OR "economic alternatives" OR "economic reincorporation" OR "effective institution" OR "effective institutions" OR "electoral participation" OR "end of conflict" OR "ethnic conflict" OR "ethnic conflicts" OR "ethnic groups" OR "exoneration" OR "extreme poverty eradication" OR "fair societies" OR "fair society" OR "fight against corruption" OR "formalization of land ownership" OR "freedom of information" OR "fundamental freedom" OR "fundamental freedoms" OR "genocide" OR "government budget" OR "government budgets" OR "Grassroots innovation" OR "homicid" OR "human right" OR "human rights" OR "human traffic" OR "human trafficking" OR "illegal economi" OR "illicit drugs" OR "illicit use crop" OR "inclusive institution" OR "inclusive institutions" OR "inclusive societies" OR "inclusive society" OR "independence of judiciary" OR "independent judiciary" OR "jail" OR "judicial system" OR "justice" OR "labour market formalisation" OR "land access" OR "land acquisition" OR "land expropriation" OR "land ownership" OR "land registration" OR "land registry" OR "laying down of arms" OR "legal identity for all" OR "legal remedies" OR "legal remedy" OR "monitoring and verification OF ACCORDS" OR "murder" OR "narcotics" OR "national natural park" OR "non-repetition" OR "non-replanting agreements" OR "participative planning" OR "participatory political culture" OR "peace agreement" OR "peace" OR "pluralism AND PEACE" OR "POLITICAL AGREEMENT" OR "political opposition" OR "political participation" OR "political reincorporation" OR "population well-being" OR "prevention mesures" OR "prison" OR "Pro-poor and inclusive innovation" OR "protection mesures" OR "public transparency" OR "reconciliation" OR "refugee" OR "regional transformation" OR "reparation" OR "responsible institution" OR "responsible institutions" OR "rule of law" OR "rural cadastres" OR "rural economy" OR "rural inclusion" OR "rural reform" OR "rural urban gap" OR "security guarantees" OR "separation of powers" OR "small growers of illicit crops" OR "social agreement" OR "social contract" OR "social contracts" OR "social development" OR "Social innovation" OR "social protest" OR "social reincorporation" OR "social services" OR "solidarity economies" OR "surveillance services" OR "technical assistance" OR "territorial planning" OR "territorial-based approach" OR "terrorism" OR "tolerance" OR "torture" OR "transitional justice" OR "transparent institution" OR "transparent institutions" OR "tribunal" OR "truth" OR "verification mechanisms" OR "victims" OR "violence" OR "violent conflict" OR "violent conflicts" OR "war" OR "wars")))) AND (DOCTYPE("ar ") OR DOCTYPE(" cp ") OR DOCTYPE(" re ")) AND (SUBJAREA(

"SOCI") OR SUBJAREA("AGRI") OR SUBJAREA("BUSI") OR SUBJAREA("ECON") OR SUBJAREA("ARTS") OR SUBJAREA("COMP") OR SUBJAREA("BIOC") OR SUBJAREA("PSYC"))

SDG 17 Query

(TITLE-ABS-KEY((sustainab* OR "sustainable development goal") AND ("academic corporate" OR "academic-corporate" OR "agenda 21" OR "agreement" OR "aid effectiveness" OR "alliance" OR "bilateral donor" OR "bilateral donors" OR "BRICS" OR "capacity building" OR "capacity-building" OR "CGIAR" OR "collaboration" OR "community based" OR "community-based" OR "cooperation" OR "cop 21" OR "corporate social responsibility" OR "CYTED program" OR "ECLAC" OR "FEALAC" OR "global governance" OR "global" OR "globelics" OR "governance" OR "horizon 2020" OR "Human Development and Capability Association" OR "innovation oecd" OR "institution*" OR "interdisciplinary" OR "inter-disciplinary" OR "international" OR "intersectorial" OR "inter-sectorial" OR "multidisciplinary" OR "multi-disciplinary" OR "multilateral" OR "multi-lateral" OR "multisectorial" OR "multi-sectorial" OR "multistakeholder" OR "multi-stakeholder" OR "north-South cooperation" OR "Official Develoment Aid" OR "open access" OR "open data" OR "open science" OR "open source" OR "participatory" OR "partnership" OR "public private" OR "public-private" OR "RICYT" OR "South-South cooperation" OR "transdisciplinary" OR "trans-disciplinary" OR "transsectorial" OR "trans-sectorial" OR "triangular cooperation"))) AND (DOCTYPE("ar") OR DOCTYPE("cp") OR DOCTYPE("re")) AND (SUBJAREA("SOCI") OR SUBJAREA("ENVI") OR SUBJAREA("ENGI") OR SUBJAREA("BUSI") OR SUBJAREA("COMP") OR SUBJAREA("ECON") OR SUBJAREA("EART") OR SUBJAREA("DECI") OR SUBJAREA("CENG"))

Appendix C
Glossary of Terms

Article/Publication types (unless otherwise indicated) denotes the main types of peer reviewed documents published in journals: articles, reviews, and conference papers.

Article/Publication output for an institute or country is the count of articles with at least one author from that institution or country respectively (according to the affiliation listed in the authorship byline). All analyses make use of 'whole' rather than 'fractional' counting: an article representing international collaboration (with at least two different countries listed in the authorship byline) is counted once each for every institution or country listed.

Compound Annual Growth Rate (CAGR) is defined as the year-over-year constant growth rate over a specified period of time. Starting with the first value in any series and applying this rate for each of the time intervals yields the amount in the final value of the series.

$$\mathrm{CAGR}(t_0, t_n) = (V(t_n)/V(t_0))^{\frac{1}{t_n - t_0}} - 1$$

$V(t_0)$: start value
$V(t_n)$: finish value
$t_n - t_0$: number of years.

Citation is a formal reference to earlier work made in an article or patent, frequently to other journal articles. A citation is used to credit the originator of an idea or finding and is usually used to indicate that the earlier work supports the claims of the work citing it. The number of citations received by an article from subsequently-published articles is a proxy of the importance of the reported research.

CiteScore is metric for measuring journal impact in Scopus. The calculation of CiteScore for the current year is based on the number of citations received by a journal in that year for the documents published in the journal in the past three years, divided by the documents indexed in Scopus published in those three years.

Field-weighted citation impact (FWCI) is an indicator of mean citation impact and compares the actual number of citations received by an article with the expected number of citations for articles of the same document type (article, review or conference proceeding paper), publication year and subject field. When an article is classified in two or more subject fields, the harmonic mean of the actual and expected citation rates is used. The indicator is therefore always defined with reference to a global baseline of 1.0 and intrinsically accounts for differences in citation accrual over time, differences in citation rates for different document types (reviews typically attract more citations than research articles, for example) as well as subject-specific differences in citation frequencies overall and over time and document types. It is one of the most sophisticated indicators in the modern bibliometric toolkit.
When field-weighted citation impact is used as a snapshot, an un-weighted variable window is applied. The field-weighted citation impact value for '2008', for example, is comprised of articles published in 2008 and their field-weighted citation impact in the period 2008-12, while for '2012,' it is comprised of articles published in 2012 and their field-weighted citation impact in 2012 alone. When field-weighted citation impact is used in trend analysis, a weighted moving window is applied. The field-weighted citation impact value for '2010', for example, is comprised of the weighted average of the unweighted variable field-weighted citation impact values for 2008 and 2012 (weighted 13.3% each), 2009 and 2011 (weighted 20% each) and for 2010 (weighted 33.3%). The weighting applies in the same ratios for previous years also. However, for 2011 and 2012 it is not possible to extend the weighted average by 2 years on either side, so weightings are readjusted across the remaining available values.

Field-weighted download impact (FWDI) is a similar indicator to FWCI that is based on downloads rather than citations.

h-index is the number of articles in the collection (h) that have received at least (h) citations over the whole period. For example, an h-index of 8 means that 8 of the collection's articles have each received at least 8 citations. h-index is not skewed by a single highly cited paper, nor by a large number of poorly cited documents. This flexible measure can be

applied to any collection of citable documents. However, when applied to the documents produced by a single author, it is important to acknowledge that h-index is often biased against early stage investigators because of their lower publication count. Throughout this report, h-index is calculated based on all of the researcher's publications (articles, reviews and conference proceedings) from 1996-2015.

International collaboration (i.e., research collaboration) in this report is indicated by articles with at least two different countries listed in the authorship byline.

Journal is a peer-reviewed periodical in which scholarship relating to a particular research field is published, and is the primary mode of dissemination of knowledge in many fields. Research findings may also be published in conference proceedings, reports, monographs and books and the significance of these as an output channel varies between fields.

Publication/article types (unless otherwise indicated) denotes the main types of peer reviewed documents published in journals: articles, reviews, and conference papers.

Publication/article output for an institute or country is the count of articles with at least one author from that institution or country respectively (according to the affiliation listed in the authorship byline). All analyses make use of 'whole' rather than 'fractional' counting: an article representing international collaboration (with at least two different countries listed in the authorship byline) is counted once each for every institution listed.

ScienceDirect Downloads are the count of the number of times ScienceDirect papers within the set are downloaded. A download is defined as either downloading a PDF of an article on ScienceDirect, Elsevier's full-text platform or looking at the full-text online on ScienceDirect, without downloading the actual PDF. Counts provided in this report are current up to December 31, 2017.

Top 10 percentile articles are those among the top 10% based on FWCI of all articles published and cited in a given period. An institution's number or share of highly-cited articles is treated as indicative of the excellence of their research. In this report, we present data on top 10% cited articles.

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MILAN SPLINTER, MSC

Milan Splinter is an Analytical Support Manager at Elsevier. Prior to joining Elsevier, he earned a master's degree in Population Studies from the University of Groningen. In his current position he conducts comparative research performance analysis for academic and government institutions.

DR. WEI WANG

Dr. Wang started her role as an analyst at Elsevier since the beginning of 2018. She focuses on the bibliometric analysis of science and technology to provide evidence based analytical results to policy maker, funding provider, researcher, research manager in the research entities, government, and corporate globally. Prior to that role, Dr. Wang worked at Clarivate (previously called Thomson Reuters IP & Science) for three years to focus on research performance evaluation, product training, thought leadership, value proposition in China. Before that, she worked as an associate professor in Chinese Academy of Sciences. She got her master degree in Ecology at Nankai University, China; and her PhD degree in Microbio-Ecology at University of Alberta, Canada.

SARAH HUGGETT

Sarah Huggett is Analytical Services Product Manager with Elsevier, which involves preparing reports on research performance. Sarah's first job at Elsevier in Research & Academic Relations gave her an understanding of how bibliometrics can be used to inform strategic planning. She has a particular interest in new developments in research evaluation, such as measures of attention and engagement. After completing a Bachelor's then Master's degrees at the University of Grenoble (France), Sarah moved to the UK to teach French at the University of

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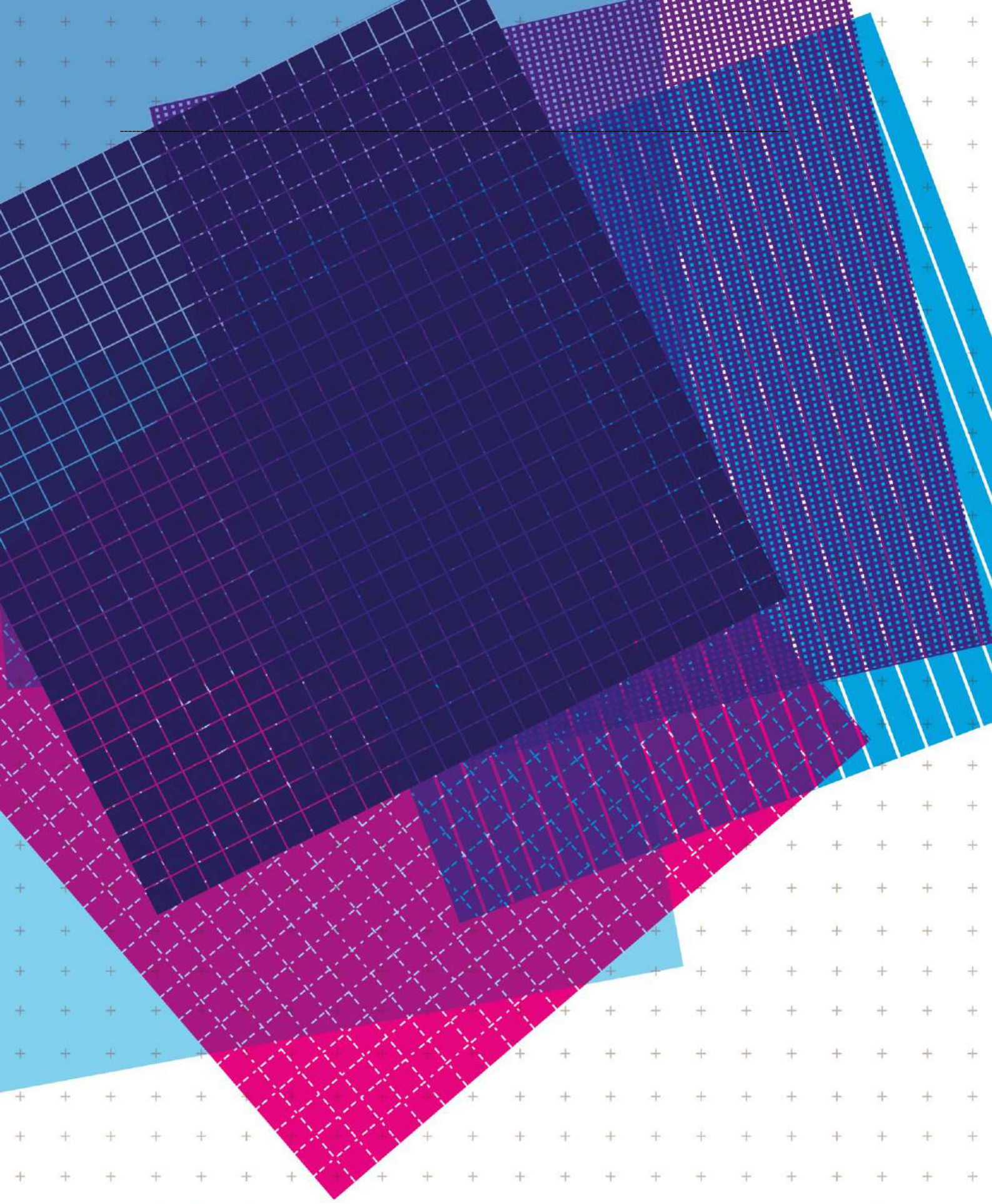
DR. JÖRG HELLWIG

In his role as Analytical Product Manager Dr. Hellwig focuses on analyzing the research performance and trends for public agencies and academic institutes. Prior to that role he worked as Customer Consultant Research Intelligence in Germany, the Netherlands, South Africa and the UK, responsible for supporting the adoption and use of SciVal, Scopus and various analytical tools and solutions for research performance and planning. This role implied a thorough knowledge of the Higher Education sector in various countries. Dr. Hellwig holds a PhD in Chemistry from Georg August University Göttingen in Germany with subsidiary subject Communication Theory and Publicism. After that he worked for almost ten years in pharmaceutical companies before he joined Elsevier in 2008.

Notes



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