

Annex 4: Background information on the bibliometric study of research trends on selected topics related to *The 2030 Agenda for Sustainable Development*

OVERVIEW

In 2020, UNESCO commissioned a study from Science-Metrix of the volume of scientific publications advancing the sustainable development agenda at the global, regional and national levels between 2011 and 2019. The study was not designed to be exhaustive. Rather, it focused on 56 sample research topics identified by UNESCO that were of particular relevance to eight of the Sustainable Development Goals (SDGs).

The aim of the study was three-fold:

- **to assess the volume of articles published** by each country in the world between 2011 and 2019 on key topics of relevance to the SDGs;
- **to identify the degree of specialization on each topic**, by assessing the number of publications produced by a given country over the 2012–2019 period as a proportion of that country's total scientific output. This level of specialization was then compared with the global average to give the **specialization index**. For example, a country which produced 2% of its output on a specific topic accounting for 1% of all research on that same topic at the global level would score 2.00 on the specialization index for this indicator because it produced twice as many publications as would be expected on this topic (for further details of this analysis, see Annex 5); and
- **to identify the growth rate of each topic**, in order to monitor change in the priority accorded to these topics since the adoption of *Agenda 2030 for Sustainable Development* in 2015. In order to avoid annual fluctuations, the study compared scientific output between two periods: 2012–2015 and 2016–2019.

This bibliometric study was undertaken in June 2020. Science-Metrix identified publications on each topic through searches for keywords across the complete Scopus (Elsevier) database, including as concerns the Arts, Humanities and Social Sciences. The section that follows describes the scope of each topic. The specific keywords used for each topic are available on the open access *UNESCO Science Report* portal as an online supplement.

The selected topics are grouped by Sustainable Development Goal. In some cases, an individual topic may be relevant to more than one goal, such as that on traditional knowledge. Moreover, as the key words are not mutually exclusive, there may be occasions when the same article has been counted under more than one topic; for instance, an

article on the impact of radiation on human health (SDG3) may also be referenced under the topic on radioactive waste management (SDG9).

The complete datasets for this bibliometric study are available from the *UNESCO Science Report* portal. A summary of the key findings for individual countries and regions may be found in chapters 4–26 and a global summary in chapter 2 of the present report.

SCOPE OF THE STUDY

Topics relating to SDG2: Zero hunger

The data are presented in Table F1 of the statistical annex, available online, along with the full dataset.

Pest-resistant crops

This dataset includes articles on technology to activate or enhance plant resistance to pathogens. Articles on the genetic engineering of plants to resist pests, essentially *Bacillus thuringiensis* (Bt) crops, constitute a large share of the dataset.

Help for smallholder food producers

This dataset covers efforts to increase the agricultural productivity and income of smallholder food producers, including through value addition. The dataset includes articles on the productivity, sustainability, profitability and security of small-scale agriculture and farming, such as community agriculture/farming, family agriculture/farming, subsistence agriculture/farming and smallholders.

Precision agriculture

This dataset includes articles on precision agriculture, precision farming and other synonymous expressions. It also includes articles on data-monitoring technologies whenever articles also mention terms such as crops. Specific precision agriculture aspects such as precision irrigation, seed metering, variable-rate application, soil sensing, yield mapping, precision planting, site-specific management and the like have also been targeted.

Agro-ecology

This dataset focuses on agri-environmental practices and the impact of those practices, including environmentally promising agricultural practices such as reduced tillage,

agroforestry, cover crops, crop rotation, low-input agriculture, conservation agriculture, silvopastures, alley cropping, integrated crop-livestock and more. Publications measuring and comparing the environmental impact of conventional agriculture are included. The topic includes alternatives to chemical pesticides.

Maintain genetic diversity of food crops

This dataset includes articles on maintaining the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species. Articles discussing the genetic diversity and use of wild or heirloom varieties are also included. All studies related to landraces, plant genetic resources, crop varieties, wild relative and germplasm conservation have been included, provided that they refer to agricultural plants or animals.

Traditional knowledge

This dataset includes articles relating to the recording of knowledge from traditional, indigenous or local populations or derived technologies. This topic is grouped under SDG2 but extends to other SDGs. Ethno-disciplines such as ethno-agriculture, ethnomedicine, ethnobotany and ethnomycology are part of the dataset. About 700 indigenous population names from every continent were used to help build this dataset, combined with terms related to traditional knowledge. The keyword 'local knowledge' was used only in combination with 'indigenous'. Ancestral knowledge from very large populations is voluntarily excluded; for instance, traditional Chinese medicine is excluded.

Topics relating to SDG3: Good health and well-being

The data are presented in Table F2 of the statistical annex, available online, along with the full dataset.

Reproductive health and neonatology

This dataset includes articles on reproductive health, neonatology and maternal health. It covers women's sexual health, in general. It does not extensively cover research on sexually transmitted diseases and excludes the human immunodeficiency virus, which is analysed as a separate topic.

Human immunodeficiency virus (HIV)

This dataset includes all articles on research into HIV and acquired immune deficiency syndrome (AIDS). For example, this includes articles on the epidemiology, treatment and prevention of the disease and/or its social impact.

Tropical communicable diseases

This dataset covers those diseases that figure in the list of neglected tropical diseases established by the World Health Organization, namely: Buruli ulcer; Chagas disease; dengue and chikungunya; dracunculiasis (Guinea-worm disease); echinococcosis; food-borne trematodiasis; human African trypanosomiasis (sleeping sickness); leishmaniasis; leprosy (Hansen's disease); lymphatic filariasis;

mycetoma; chromoblastomycosis and other deep mycoses; onchocerciasis (river blindness); rabies; scabies and other ectoparasites; schistosomiasis; soil-transmitted helminthiasis; snakebite envenoming; taeniasis/cysticercosis; trachoma; and yaws (endemic treponematoses). Malaria and water-borne diseases such as coliform-caused illness, giardiasis, cholera and norovirus are also included.

Human resistance to antibiotics

This dataset covers all aspects of human resistance to antibiotics, with the exception of papers related to environmental aspects that were more difficult to identify.

Regenerative medicine

This dataset covers articles on stem cell research, as well as on regenerative technologies and therapies such as tissue engineering, biomaterials and nanoscaffolds.

Impact on health of soil, freshwater and air pollution

This dataset contains articles related to the assessment and mitigation of the impact of air, soil and freshwater pollution on the environmental health of humans. Topics covered include pollution monitoring, the assessment and effects of exposure to heavy metals, plastics, particulate matter, radiation and other pollutants.

Medicines and vaccines for tuberculosis

This dataset includes all articles on tuberculosis, except bovine tuberculosis.

New or re-emerging viruses that can infect humans

This dataset covers research on human resistance to new or re-emerging viruses that can infect humans. For example, this dataset includes articles on epidemiology, treatment, prevention and transmission vectors of emerging viruses such as Influenza A subtype H1N1, SARS-CoV, Ebola and hantaviruses. This topic excludes articles on HIV, which is treated separately. Also excluded are articles on SARS-CoV-2 (Covid-19), as it had not yet been identified in 2019.

Type 2 diabetes

This dataset covers research on prevention, effects, treatment and epidemiology of type 2 diabetes, also known as non-insulin-dependent diabetes mellitus or adult-onset diabetes. Efforts were made to include articles which study the impact of socio-economic factors on the development of the disease, such as obesity, malnutrition, lack of education and a sedentary lifestyle. Articles about insulin resistance, prediabetes and maturity onset diabetes of the young were also included. Studies of the genetic factors that play a role in development of the disease were also included. Some articles on other health conditions for which diabetes may be an aggravating condition are included but are not the focus of this dataset. Articles about heart disease were removed, unless they contained diabetes-related terms in their title, as were papers which mentioned diabetes in the abstract when the topic was then found to be peripheral to the dataset. Articles that only addressed type I diabetes or were

ambiguous about the type of diabetes studied were excluded. Articles were included, on the other hand, if the particular type of diabetes was not indicated in the title, keywords or abstract but the publication mentioned risk factors like obesity that are more specific to type 2.

Topics relating to SDG6: Clean water and sanitation

The data are presented in Table F3 of the statistical annex, which is available online, along with the full dataset.

Sustainable withdrawal and supply of freshwater

This dataset includes all articles pertaining to the sustainable governance, management and policy of withdrawal, supply and use of freshwater. Freshwater sources include groundwater, lakes and rivers.

Water harvesting

This dataset includes articles on techniques for harvesting precipitation, stormwater, runoff and fog. It also includes articles on rainfed agriculture and irrigation.

Desalination

This dataset includes articles related to desalination technologies, such as osmosis, membrane distillation, solar distillation and micro- and nanofiltration.

Wastewater treatment, recycling and re-use

This dataset includes articles on the management and treatment of wastewater, sewage water, polluted water and greywater, as well as re-use and recycling techniques.

National integrated water resource management

This dataset includes articles pertaining to the management of water resources and their allocation for domestic, agricultural and industrial use. It includes articles on policies and laws pertaining to water use and allocation (e.g. reservoir management), as well as system modelling (e.g. water use, reservoir or water quality) to enable strategic decision-making and the optimization of processes. Articles about management of water distribution networks or the smart water grid are also part of the dataset. Some articles may analyse the situation at local level, since the use of the key word 'national level' served, above all, to exclude articles on transboundary water resource management, as this topic is treated separately.

Transboundary water resource management

This dataset includes articles on governance, management, co-operation, law, allocation and sharing of transboundary and international freshwater resources, as well as related conflicts and disputes. Water resources analysed encompass aquifers, groundwater, lakes and rivers.

Topics relating to SDG7: Affordable and clean energy

The data are presented in Table F4 of the statistical annex, which is available online, along with the full dataset.

Cleaner fossil fuel technology

This dataset includes articles on clean coal technology, integrated carbon capture and storage technology, carbon dioxide (CO₂) capture from fossil fuel power plants, desulfurization of flue gases, the clean production of synthetic fuel, refinery processes to limit contaminants emitted, the clean synthesis of methanol and the conversion of CO₂ to hydrocarbons or fuel.

Photovoltaics

This dataset includes articles relating to stationary hosts, namely, solar cells, solar panels and photovoltaic cells. It also includes larger-scale projects, such as solar farms. Articles about developing materials specifically for solar cells are included.

Hydropower

This dataset includes articles relating to both large and small hydropower projects. It includes articles on the different types of dams but also on other hydropower methods (e.g. tidal and wave energy) and the development of specific hydropower station parts like hydroturbines.

Biofuels and biomass

This dataset includes articles on the main biofuels, such as bioethanol, biomethane, biobutanol and biocrude, as well as their production in biorefineries. Articles on the processing of biomass to create biofuels are also included. Little content was found on the hydraulic head of such processes.

Wind turbine technologies

This dataset includes articles about wind turbines and wind farms, with a focus on both their conception and their use. All main types of wind turbines are included, such as horizontal-axis, vertical-axis, offshore and floating wind turbines. Articles about the main types of generator used in the turbines are also part of this dataset, examples being doubly fed induction and Savonius.

Nuclear fusion

This dataset includes articles relating to studies of nuclear fusion for energy purposes, as well as articles relating to the development of materials, parts and methods to build nuclear fusion reactors. It voluntarily excludes articles focused on nuclear fusion reactions in stars because those are mostly unrelated to energy production on Earth.

Geothermal energy

This dataset contains articles on geothermal energy, the generation of electricity from geothermal energy and different techniques for harnessing this energy, most notably, enhanced geothermal systems and hydraulic stimulation. A small number of articles about the safe digging of wells to access this energy is also included.

Hydrogen energy

This dataset contains articles on most aspects of hydrogen energy harnessing. Machines and systems designed to have hydrogen as their source of power, the industrial production and storage of hydrogen and hydrogen-based fuel cells (i.e. most fuel cells) are all included.

Smart-grid technology

This dataset contains articles on smart grid technology and techniques and protocols to enable smarter, more reliable electrical networks. Articles are included on new devices such as smart power meters and grid-friendly appliances, as well as on protocols related to distributed grids and microgrids, such as islanding detection. Articles relating to the cybersecurity of smart grids are also included in the dataset. Furthermore, articles related to new challenges for the grid, such as electric vehicle (EV) charging on a national scale, are included because many of those articles advocate 'vehicle-to-grid' energy transfers and real-time pricing when mentioning EV charging. An effort was made to exclude papers specific to EVs that do not address the electrical grid. Some articles about renewable energy sources are part of the dataset but they only concern the integration of these new power sources in the grid.

Topics relating to SDG9: Infrastructure, industrialization and innovation

The data are presented in Table F5 of the statistical annex, which is available online, along with the full dataset.

Carbon pricing

This dataset includes articles related to all aspects of the taxation and trading of carbon and other greenhouse gas emissions (also known as cap and trade): the carbon market, carbon allowance, carbon credits, carbon trading, carbon pricing and carbon taxation.

Eco-industrial waste management

This dataset includes articles on the safe treatment and disposal of waste chemicals and other industrial wastes, such as those from the construction, pharmaceutical and electronic industries, reactive waste and wastewater treatment. Articles are also included on the minimization of waste production, such as zero-waste manufacturing and waste-to-energy processes. Articles about remediation techniques for soils contaminated with industrial wastes (heavy metals, petroleum, etc.) are included but these exclude nuclear waste, since it is treated separately.

Radioactive waste management

This dataset contains articles about radioactive waste management, storage and disposal. Articles about methods such as safe geological disposal, transmutation and vitrification of nuclear waste are included.

Eco-alternatives to plastics

This dataset includes articles studying the synthesis, effects and potential applications of ecologically friendly

alternatives to traditional fossil fuel-derived plastics.

Articles on biodegradable plastics or alternatives based on cellulose, starch or banana fibres are included. Any articles containing terms such as 'sustainable alternative to plastics' or 'environmentally degradable plastics' are also included.

Eco-construction materials

This dataset includes articles relating to 'eco-building', 'green building', 'sustainable construction', 'ecological housing', 'sustainable architecture' and other permutations of those terms. There is also a focus on low-energy and zero-energy buildings, sustainable building certifications (e.g. Leadership in Energy and Environmental Design [LEED] or Passivhaus) and environmentally friendly materials, sustainable materials and recycled materials. Articles on retrofitting buildings and infrastructure are included. The dataset is primarily focused on passive construction practices and materials, rather than active methods such as photovoltaic panels or wind generator integration, covered in other datasets (see Table F4). Sustainability here is almost always defined from an environmental standpoint but some articles are also focused on economic or social sustainability of buildings or infrastructure. For example, an article might tackle the health implications of using sustainable alternatives to traditional materials or designs for the occupants, or buildings that can better withstand the extreme conditions found in poorer countries or anticipated conditions relating to climate change.

Greater battery efficiency

This dataset contains articles on battery efficiency, new battery technologies and battery design and optimization. Since most articles are written to report improvements on batteries, most rechargeable battery types were included as keywords in the dataset, with the greatest contributions coming from more recent battery types such as Li-ion. Articles concerning the recycling of spent batteries and battery integration in the electrical grid are also part of the dataset.

Sustainable transportation

This database focuses on the development and use of sustainable means of transportation, including electric vehicles, solar vehicles, plug-in hybrid vehicles and hydrogen vehicles. Most articles indexed focus on cars but planes, boats, trains and trucks are all included. The dataset includes articles on self-driving cars and associated technologies, such as autonomous intersection management, lane detection and advanced driver assistance. This is because self-driving cars would achieve better fuel economy (or energy economy, if electric) and have the potential to reduce the number of road accidents. Articles are included on other methods of sustainable transportation and policies, such as carsharing, public bicycles, car-free cities and congestion pricing. 'Sustainable transport' is used as a keyword but, with the exception of publications using the terms 'solar boat' and 'electric boat', shipping is not explicitly included in this dataset.

Topics relating to SDG13: Climate action

The data are presented in Table F6 of the statistical annex, which is available online, along with the full dataset.

National and urban greenhouse gas emissions

This dataset includes articles on the measurement, assessment and estimation of greenhouse gas emissions at the national and urban levels. It includes articles on national and urban emission sources, such as agricultural, industrial and urban sources, including transportation.

Carbon capture and storage

This dataset includes articles on carbon capture techniques, such as pre-, post- and oxyfuel combustion, direct air capture and carbon sequestration, which is the capture and storage of carbon through natural (biological, chemical and physical) processes that include photosynthesis, oceanic and geological capture. The publications refer to both natural sequestration and human attempts to enhance sequestration. This dataset is restricted to gaseous carbon; it excludes solid-state carbon, namely particulate matter.

Local impact of climate-related hazards and disasters

This dataset focuses on articles assessing climate hazards and climate-related disasters and the impact of these on small and vulnerable communities. Examples are coastal erosion, sea level rise, droughts, floods and extreme weather events.

New technologies to protect from climate-related hazards

This dataset focuses on any technology, innovation or tool that has the potential to mitigate the impact of climate change or climate-related disasters on communities. This includes publications on ways of building more resilient infrastructure, as well as those on better modelling tools to predict the risk of occurrence and consequences of catastrophic events, enabling better preparedness.

Local disaster risk reduction strategies

This dataset focuses on planning processes and techniques that help to reduce the risk faced by local and vulnerable communities with respect to climate change and related disasters, such as drought, flooding, extreme storms and wildfires. The publications included consider communities' strategies, preparation and mitigation efforts as well as their capacity to recover and be resilient.

Climate-ready crops

This dataset includes articles related to agriculture and crops that are tolerant of and resilient to salinity, flooding, drought and other climate-related stressors.

Topics relating to SDG14: Life below water

The data are presented in Table F7 of the statistical annex, which is available online, along with the full dataset.

Coastal eutrophication

This dataset includes all articles on coastal eutrophication, phosphorus removal and pollution, algal blooms, water nutrient dynamics and specific harmful algal species.

Floating plastic debris in the ocean

This dataset includes articles related to plastic debris and plastic pollution in the ocean. Search terms cover plastic and plastic types in aquatic environments, plastic consumption by marine wildlife, as well as the identification of plastics and byproducts in marine and coastal environments and food chains.

Ocean acidification

This dataset includes all articles on ocean acidification and seawater acidification, including those assessing the impact on species.

Sustainably manage marine tourism

This dataset includes articles on tourism management and the effects of tourism on oceanic or coastal zones. Articles often focus on the environmental impact but the socio-economic impact is also covered. Whenever there was a focus on sustainability, cruises, diving, recreational fishing and sea animal tourism (watching, swimming and diving) were all specifically included as search terms.

Sustainably manage fisheries and aquaculture

This dataset includes articles on fish farming and aquaculture, as well as commercial fishing as it relates to sustainable resource management. The dataset was constructed using key terms related to sustainable fisheries and aquaculture, as well as species and techniques commonly associated with these practices. When aquatic species names were used, this was done in conjunction with terms related to sustainability, to limit the dataset to the topic as much as possible.

Ecosystem-based approaches in marine environments

This dataset contains articles relating to management of coastal zones using an ecosystem-based approach, meaning the ecosystem and its interactions are considered as a whole in management processes. The dataset includes articles on concepts like integrated coastal zone management, which is closely linked to ecosystem-based approaches. When the dataset was verified, no articles focusing on ecosystems in international waters were found.

Topics relating to SDG15: Life on land

The data are presented in Table F8 of the statistical annex, which is available online, along with the full dataset.

Sustainable use of terrestrial ecosystems

This broad dataset includes all papers on the conservation, preservation, restoration and sustainable use of terrestrial ecosystems: forest, habitat, land, wildlife, pond, freshwater, drylands, etc. It includes research on species richness, biodiversity, etc. It also includes articles on ecosystem services.

Status of terrestrial biodiversity

This dataset includes articles on species with a defined conservation status, as well as more fundamental research needed to monitor, predict and protect those species. For example, articles on causes of species endangerment, such as habitat loss, are included.

Minimize poaching and trafficking of protected species

This dataset includes articles on the Convention on the International Trade of Endangered Species (CITES), wildlife trade, poaching, illegal fishing, illegal harvesting, wildlife forensics, etc.

Tackle invasive alien species

This dataset includes all articles related to biological invasions, alien species, invasive plants, etc. Basic research on invasive potential has also been included.

Use of ecosystem-based approaches in protected areas on land

This dataset includes articles on ecosystem-based management of public and private land. An effort was made to exclude marine and freshwater ecosystems, to avoid overlap with other selected topics.

Extent of water-related ecosystems

This dataset includes articles measuring the extent of water-related ecosystems (excluding oceans) such as wetlands, rivers, estuaries, lakes, aquifers, swamps, fens, peatlands, marshes, mangroves and artificial water bodies. It involves articles either measuring or improving delineation protocols of such systems, as well as estimating the water quantity

involved. Articles on disappearing systems are included, as well as articles on the inventory of water-based ecosystems. Some articles on ecosystems related to either the water quality or quantity found in ecosystems such as forests and mountains are also included when these are directly related to water.

Socio-ecological impact of terrestrial protected areas

This dataset covers conservation planning, reserve selection and reserve design, as well as the prioritization of protected areas and the future habitat suitability under climate change. The negative and positive impact of protected areas on humans, such as human–wildlife conflict or valuation of ecosystem services, are also targeted.