

# **A Bibliometric Analysis on UNESCO Development Trends in Scientific Research**

Institute of Geographic Sciences and Natural Resources Research,  
Chinese Academy of Sciences

International Knowledge Centre for Engineering Sciences and  
Technology under the Auspices of UNESCO

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## **Abstract**

As one of the category 2 centres of UNESCO, the International Knowledge Centre for Engineering Science and Technology (IKCEST) is committed to providing knowledge services for engineering science and technology personnel from the developing countries. In order to accomplish this mission better, IKCEST intends to identify research interests, focus and trends of UNESCO in the field of science and technology through literature research. In this study, the Science Citation Index-Expanded (SCIE), Social Sciences Citation Index (SSCI), and Conference Proceedings Citation Index (CPCI) in Web of Science are used as data sources. The statistics shows that 4,416 academic papers are published by UNESCO from 2008 to 2017. This report describes UNESCO's academic research efforts subject research topics, international cooperation, and so on. Consequently, the number of academic papers published by UNESCO during this decade has been steadily increasing every year, and the proportion of highly cited papers are as high as 1.05% in total. The research papers cover 201 fields, focusing on natural science, social science, the humanities, management science, and their interdisciplines. This reflects the interdisciplinary research efforts of UNESCO. There are 42 subjects with the number of published papers of more than 1% of the total. The top 10 key research fields include "Water Resources", "Environmental Science", "Geoscience, Multidisciplinary", "Environmental Engineering", "Civil Engineering", "Chemical Engineering", "Biotechnology and Applied Microbiology", "Meteorology and Atmospheric Science", "Electrochemical", and "Ecology". The report also reveals key research topics of UNESCO from 2008 to 2017. In terms of international cooperation, the Netherlands, Spain, and China contribute the highest number of publications in the UNESCO cooperation network and occupy important positions and play critical roles. UNESCO's cooperation with Belgium, Canada, Benin, the United States, Japan, Germany, the Czech Republic, and other countries is slightly less frequent, but the quality of the cooperation output is high. UNESCO's cooperation with France, the Czech Republic, South Africa, Greece, etc., has witnessed a sharp increase in recent output.

# Contents

<b>Abstract .....</b>	<b>I</b>
<b>1. Introduction .....</b>	<b>1</b>
<b>2. Data sources, main research methods and software tools.....</b>	<b>1</b>
2.1 Data sources.....	2
2.2 Main research methods and software tools.....	2
2.2.1 Statistical analysis and data mining methods .....	2
2.2.2 Clustering analysis of frontier research topics .....	2
2.2.3 Analysis on scientific research cooperation.....	3
2.2.4 Software tools .....	3
<b>3. Results and analysis.....</b>	<b>3</b>
3.1. Analysis of UNESCO paper output .....	3
3.1.1 The number of paper output .....	3
3.1.2 Development trends in paper output.....	4
3.1.3 Composition and effect of "key research areas" .....	5
3.1.4 Journal Distribution of published papers.....	8
3.2 Disciplinary research topic .....	9
3.2.1 Key areas and research topics.....	9
3.2.2 UNESCO's hot topics in the field of natural science.....	12
3.2.3 UNESCO's research in specific areas .....	14
3.3 UNESCO's international cooperation in S&T .....	20
3.3.1 The distribution of "TOP 10 key areas" in major cooperative countries .....	20
3.3.2 National cooperative network.....	21
<b>4. Summary .....</b>	<b>23</b>

## **1. Introduction**

As one of the category 2 centres of UNESCO, IKCEST is committed to providing knowledge services for engineering science and technology personnel from the developing countries by integrating various types of digital resources on engineering science and technology, developing a common data service platform and collaborative service environment, and cooperating with other bodies. Founded to cater to domestic and foreign demand, including the demands of UNESCO, IKCEST (<http://ikcest.org>) has rapidly grown in terms of data resources construction and alliance, key generic technology research, and overall architecture and system platform construction (such as Disaster Risk Reduction Knowledge Service System (<http://drr.ikcest.org>)) based on the efforts of all bodies. Furthermore, IKCEST has cultivated a large number of engineering science and technology talents with good command of big data, who can provide professional knowledge services. In order to accomplish this mission better, IKCEST intends to identify research interests, focus and trends of UNESCO in the field of science and technology through literature research. We hope this study will help IKCEST better select corresponding areas and develop relevant knowledge services in the future.

## **2. Data sources, main research methods and software tools**

Bibliometrics is a subdiscipline of Library and Information Science that describes, evaluates, and predicts the status quo and development trends in science and technology through the analysis of the various features of the literature governing mathematics and statistics. In the current evaluation of science and technology, papers on science and technology form a system of scientific research and document the achievements in theoretical research by scientists and technicians. Such papers are often considered a major indicator of science and technology development<sup>[1,2]</sup>. Papers in databases and citation data are statistically significant in terms of rationality and reliability from a macro perspective concerning scientific activities<sup>[3]</sup>. This study primarily employs this method to analyse UNESCO science and technology field concerned.

## **2.1 Data sources**

Data used in this report are obtained from papers in the Scientific Citation Index-Expanded (SCIE), Social Sciences Citation Index (SSCI), and Conference Proceedings Citation Index (CPCI) in the Web of Science database. These papers are published between 2008 and 2017 and include articles, reviews, letters, and so on. To focus on research topics, the literature type is limited to articles when evaluating research topics of "key research areas."

## **2.2 Main research methods and software tools**

### **2.2.1 Statistical analysis and data mining methods**

This study adopts a scientific index system related to the output of scientific research papers, subject areas, research topics, and cooperative research relationship. The number of published papers, average growth rate of papers, composition of research fields (relative proportion) and related effects, and journal distribution of published papers are selected to show the contribution of institutions to global academic exchange and its evolving trends. The relative proportion of a research field refers to the proportion of the number of academic papers in a branch of a research institution to the total number of papers of the institution. The relative proportion of a research field can measure the scientific intensity of an institution in various fields.

### **2.2.2 Clustering analysis of frontier research topics**

Based on the keyword co-occurrence method, this report uses VOSviewer to cluster research covered by highly cited papers. According to the dataset size, the method sets the co-occurrence threshold of keywords that are screened for clustering. Each cluster was named and interpreted according to expert opinions so as to identify and analyse the research frontier of the field. The co-occurrence method also analyses the performance of global countries and research institutions in the "frontier research field" based on the

Incite <sup>1</sup>database.

### **2.2.3 Analysis on scientific research cooperation**

Scientific research cooperation is the product of scientific research at a certain stage. It can satisfy the emerging needs of scientific development, complement each other's advantages, and improve research efficiency. In this paper, two indicators, the distribution of "TOP10 key areas" in major cooperative countries and national cooperative networks, are used to measure cooperative research capacity.

### **2.2.4 Software tools**

To ensure in-depth research and comprehensive data analysis, the following tools are used in this report: (1) TDA (2) VOSviewer (3) CiteSpace, etc.

## **3. Results and analysis**

### **3.1. Analysis of UNESCO paper outputs**

#### **3.1.1 The number of paper outputs**

From 2008 to 2017, a total of 4,416 papers with the affiliation of UNESCO have been published, which include 3152 SCI articles and 33 highly cited papers in the TOP 1%<sup>2</sup>. Highly-cited papers account for about 1.05%, which demonstrates immense development potential. Figure 1 shows that UNESCO's main cooperative research countries are distributed across five continents, mainly in Europe, including the Netherlands, France, Spain, Italy, Britain, Germany, and Belgium. Among these countries, the Netherlands published the greatest number of papers, up to 1,791 in the past decade. This is followed by France and Spain. Asian countries include China, India, Japan, etc. Countries like Australia, America, and South Africa are also included.

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<sup>1</sup> InCite database is based on the publication data of all literature types of the seven index databases in the core collection of Clarivate Web of Science™ that counts publications and performs indicator calculations. The citation index includes the most globally influential fields of natural science, social science, and the humanities and arts.

<sup>2</sup>By June 2018

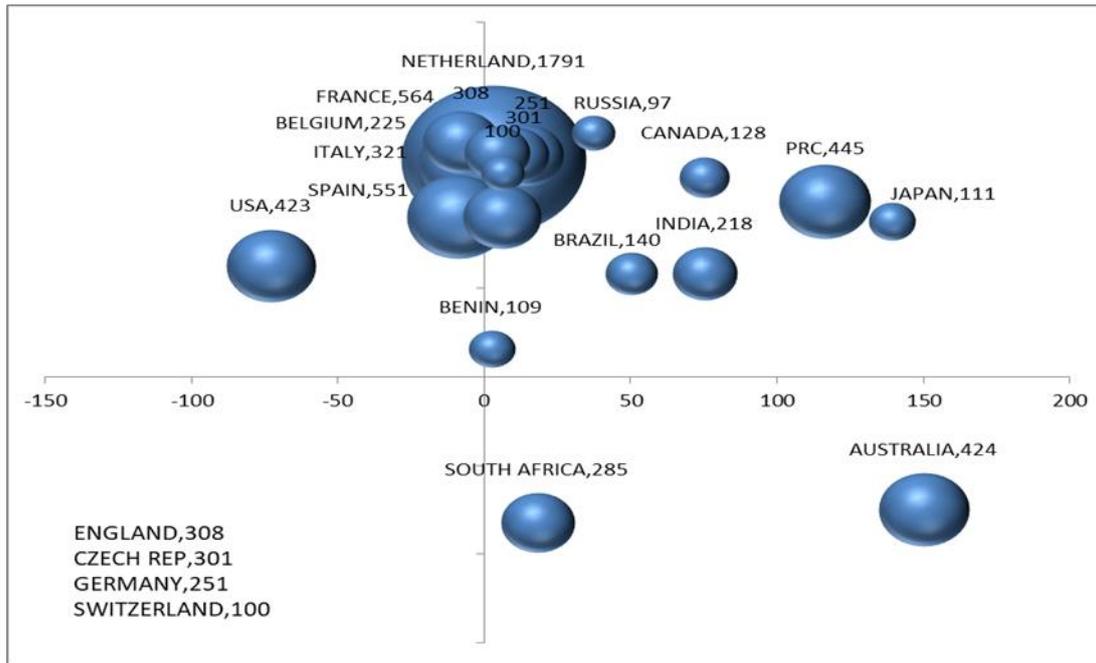


Figure 1. Country distribution of UNESCO scientific papers (only showing the top 20 countries)

### 3.1.2 Development trends in paper output

We plot the number of scientific papers produced by UNESCO between 2008 and 2017 on the Y-axis and the year on the X-axis, as shown in Figure 2. As can be observed from the chart, the output of UNESCO scientific papers appears exponential growth but approaching linear growth.

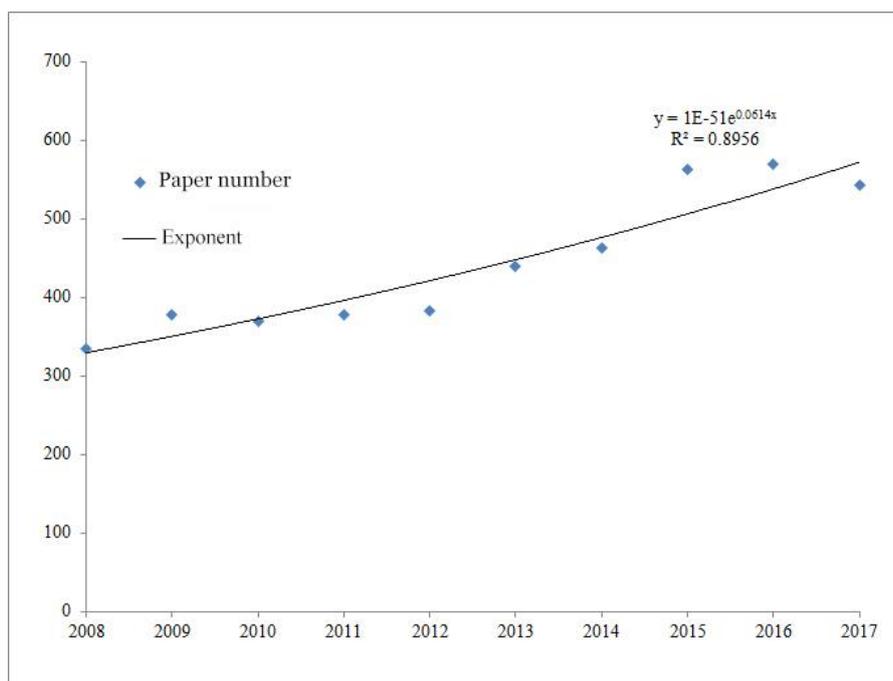


Figure 2. Total growth trend of UNESCO scientific papers

At this stage, the number of UNESCO SCI research papers also grows stably with an annual growth rate of 9.6 percent, as shown in Figure 3.

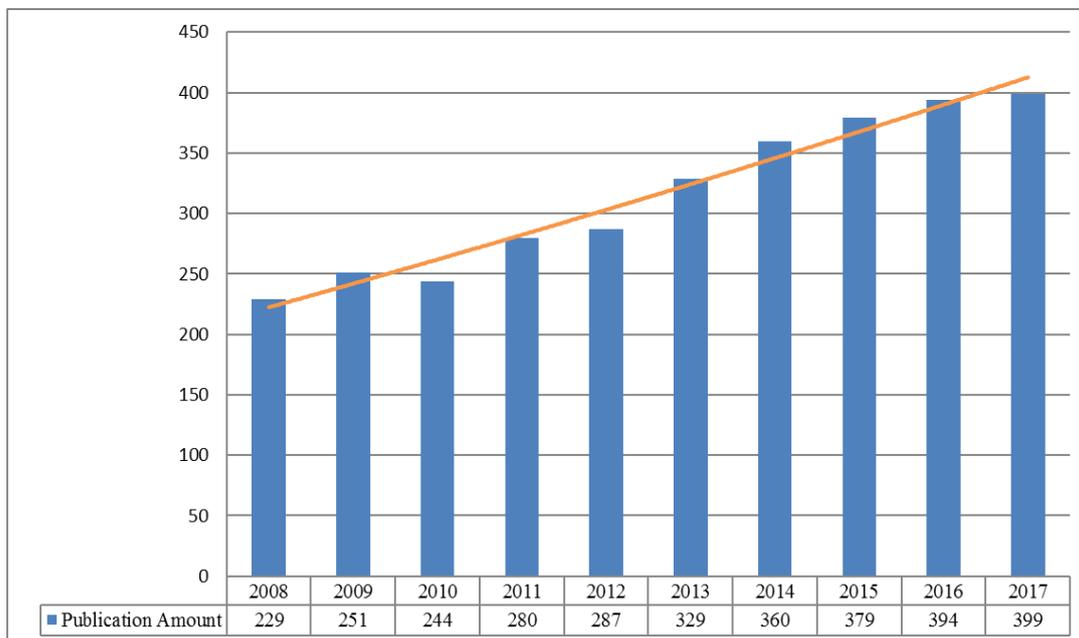


Figure 3. Growth trend of UNESCO SCI articles between 2008 and 2017

### 3.1.3 Composition and effect of "key research areas"

To focus on the object of analysis, this study uses the Web of Science discipline classification system<sup>3</sup> in the core collection database of Web of Science to subdivide the research fields of the SCI, SSCI, and CPCI papers published by UNESCO. Based on the Incite<sup>4</sup> database, the paper quantity, times cited, and the category normalized citation impact<sup>5</sup> were calculated. The number of papers published represents the productivity of scientific research, and the times cited demonstrates the overall effect of scientific research. The category normalized citation impact excludes the effect of the publication

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<sup>3</sup> WOS classifies and indexes periodicals according to 252 WOS categories. A journal can simultaneously belong to several WOS categories.

<sup>4</sup> InCites database is based on the publication data of all literature types of the seven index databases in the core collection of Clarivate Web of Science™ to count publications and perform indicator calculation. The citation index includes the most globally influential fields of natural science, social science, and the humanities and arts.

<sup>5</sup> The CNCI of a literature discipline is obtained by dividing its actual cited frequency by the expected cited frequency of the same literature type, the same publication year, and the literature in the same subject area. When a document is classified into more than one field, the average value of the ratio of actual citation times to expected citation times is used. The CNCI of a group of literatures, such as a person, an institution or a country, is the average value of each article in the group.

The Incite database retrieves 4,379 papers, all of which are analysed.

time and the speed of overall progress of the discipline, and so it can comprehensively reflect the academic level and influence of UNESCO in a specific research field.

UNESCO's research in the past decade has covered 201 areas. As shown in Table 1, the "key disciplines top 10" in the number of published papers between 2008 and 2017 include "Water Resources", "Environmental Science", "Environmental Engineering", "Chemical Engineering", "Biotechnology and Applied microbiology", and " Meteorology and Atmospheric Science", "Electrochemistry", and "Ecology". "Water Resources" is one of the most prolific fields of study in UNESCO with 1,135 publications, which is far higher than any other discipline. The citation rate of papers in various subjects is about 80%, with the highest being 90.6% and the lowest being 68.53%.

Table 1. The "key disciplines top 10"

Sequence number	Research field	Total volume	Citation frequency	Category normalized citation impact
1	Water resource	1135	81.32	1.36
2	Environmental Science	995	87.04	1.27
3	Geoscience, Multidisciplinary	419	84.73	1.44
4	Environment Engineering	326	87.42	1.50
5	Civil Engineering	275	76.73	1.32
6	Chemical Engineering	271	90.04	1.60
7	Biotechnology and Applied Microbiology	213	90.61	0.99
8	Meteorology and Atmospheric Science	152	86.84	1.39
9	Electrochemistry	143	68.53	0.58
10	Ecology	138	82.61	1.55

Figure 4 visualizes the scatterplot of the above 10 major publishing disciplines, including the number of published papers, times cited, and category normalized citation impact. The vertical axis represents the number of articles published by UNESCO in this field, the horizontal axis measures the times cited, and the size of the points indicates the degree of category normalized citation impact. The dotted line indicates average level.

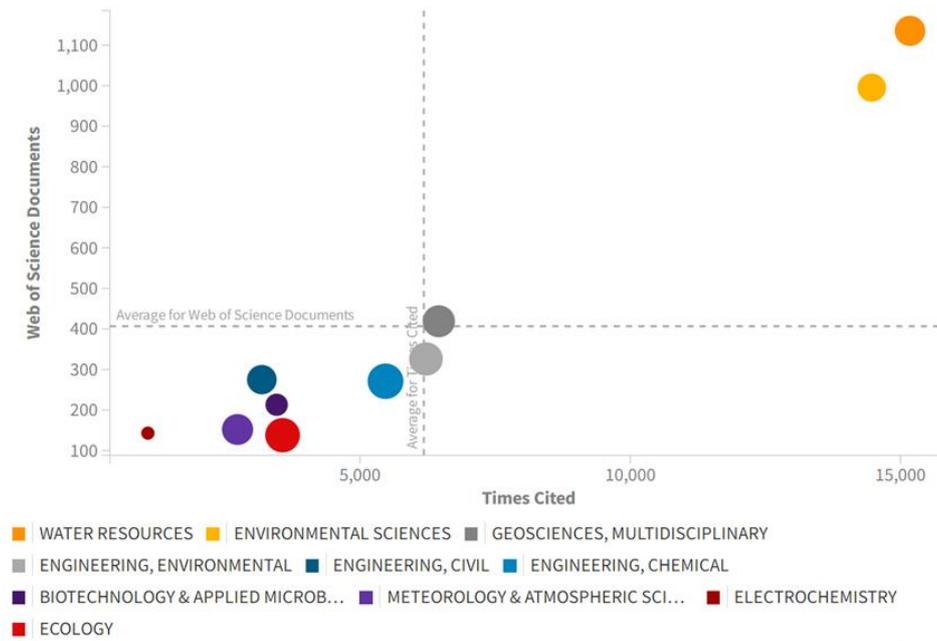


Figure 4. Impact distributions in UNESCO's science and technology key fields

The first quadrant: it can be observed that times cited and the number of papers in the discipline are above average levels. These disciplines include "Water Resources", "Geoscience, Multidisciplinary", and "Environmental Science". The number of papers and citation levels in the field of "water resources" are higher than in other fields. It also exhibits higher category normalized citation impact, which indicates that "Water Resources" is a dominant research field of UNESCO. The number of publications in the field of "Geoscience, Multidisciplinary" is higher than the other nine main fields of publications, and the field also exhibits relatively high category normalized citation impact. So "multidisciplinary geoscience" is also a dominant research field of UNESCO. The category normalized citation impact for the field of "Environmental Science" is lower than the average of the "key disciplines top 10", which suggests that UNESCO has a higher output in the field of "Environmental Science" but is less influential than in some other areas.

The second quadrant: there are no the "key disciplines top 10".

The third quadrant: the number of publications and times cited of the subject are below average levels of UNESCO in other major areas of publication. Subjects in the third quadrant include "Civil Engineering", "Chemical Engineering", "Biotechnology and

Applied Microbiology", "Meteorology and Atmospheric Science", "Electrochemistry", and "Ecology". Although the number of publications in "Civil Engineering", "Chemical Engineering", "Meteorology and Atmospheric Science", and "Ecology" is relatively small, the category normalized citation impact is higher than the average level of UNESCO in other major fields. In particular, "Ecology" has a very high category normalized citation impact, indicating that it is the second discipline (1.55) in academic effect in UNESCO, compared with other disciplines.

The fourth quadrant: the number of papers published in the discipline is lower than UNESCO's average in other major fields of publication, and the times cited is above the average. The only subject in the fourth quadrant is "Environmental Engineering", which indicates that UNESCO has relatively low output in this field. The average number of citations is close to the average level. However, UNESCO has a higher category normalized citation impact in this field and so it has stronger academic influence. The relatively low number of papers is mainly because of the slow progress in the discipline.

### 3.1.4 Journal distribution of published papers

UNESCO has published 4,416 papers (including reviews, etc.) in the past decade and those papers were published in 1,556 different journals. According to the number of papers and the journal's impact factor (JIF Percentile), we measured high-level UNESCO source journals. In this report, high-level journals are defined as those in the top 20 in terms of the number of articles and whose subject JIF Percentile value is more than 80%. It is estimated that UNESCO high-level journals include "Water Research", "Bioresource Technology", "Journal of Membrane Science" (Chemical Engineering), "Hydrology and Earth System Sciences", "Coastal Engineering", "Desalination", "Science of the Total Environment", "Hydrological Processes", and "Journal of Environmental Management", as shown in Table 2.

Table 2. Lists of high-level academic journals

Journal name	Total volume	Impact factor	JIF percentage
WATER RESEARCH	71	6.053	96.939

BIORESOURCE TECHNOLOGY	45	4.284	96.429
JOURNAL OF MEMBRANE SCIENCE	88	4.870	94.444
HYDROLOGY AND EARTH SYSTEM SCIENCES	96	3.895	93.883
COASTAL ENGINEERING	30	2.512	93.200
DESALINATION	49	4.575	92.222
SCIENCE OF THE TOTAL ENVIRONMENT	48	2.866	90.611
HYDROLOGICAL PROCESSES	37	2.669	88.068
JOURNAL OF ENVIRONMENTAL MANAGEMENT	37	3.713	83.188

### 3.2 Disciplinary research topic

#### 3.2.1 Key areas and research topics

Based on the above analysis, UNESCO has a good research foundation and strong influence in the field of "Water Resources". Among the TOP 10 high-level journals, 4 journals (WATER RESEARCH, HYDROLOGY AND EARTH SYSTEM SCIENCES, COASTAL ENGINEERING, and HYDROLOGICAL PROCESSES) are closely related to "Water Resources". In addition, UNESCO also illustrates outstanding academic effect in the field of "Ecology" with relatively high-category normalized citation impact. 4 of the TOP 10 published journals (BIORESOURCE TECHNOLOGY, HYDROLOGY AND EARTH SYSTEM SCIENCES, SCIENCE OF THE TOTAL ENVIRONMENT, and JOURNAL OF ENVIRONMENTAL MANAGEMENT) are closely related to ecological environment. The following provides an analysis of the research topics in the field of "Water Resources" and "Ecology".

#### (1) Hot topics of UNESCO research in the field of "water resources"

UNESCO has published 1,135 articles in the field of water resources. Five large clusters are obtained by clustering the most powerful keywords in these papers, and the research content can be narrowed down to five aspects (Table 3 and Figure 5).

Table 3. Hot topics in the field of "Water Resources"

Sequence number	Research topic	The number of core topics	Average cited frequency	Average time of occurrence (year)
1	Water purification technology	47	23	2012

2	Soil erosion caused by human-land relationship	40	16	2013
3	Ecosystem services and resource management	36	14	2012
4	Watershed hydrological modelling and prediction	36	20	2012
5	Water resources management and optimization design	8	19	2012

The main research topics in the field of "water purification technology" include drinking water purification and seawater desalination. The main research objects include drinking water, groundwater, surface water, and other wastewater. The major pollutants include phosphate, personal care products, various heavy metals and polycyclic aromatic hydrocarbons, and other organic pollutants. The main technologies adopted include reverse osmosis membrane, activated sludge process, various bioreactors, ultrafiltration and nanometre filtration.

The main research topics in the field of "soil erosion caused by human-land relationship" focus on the effects of land use pattern change on regional evapotranspiration. The research focuses on the evapotranspiration model, evapotranspiration path, and soil erosion model, such as forest water cycle. The research regions mainly include Ethiopia and northwest China.

The main research topics in the field of "ecosystem services and resource management" focus on ecosystem service function, agricultural production, climate protection, and challenges in the context of climate change. The main research areas include Africa, Australia, China, and India. The most concerned studies focus on African countries such as Kenya, Tanzania, and Southern Africa.

The main research point in the field of "watershed hydrological modelling " is the prediction of the probability of rainfall-induced flood by developing a watershed hydrological model.

Research on "water resources management and optimization design" and "hydrological modelling and prediction" interweaves with each other, but some of them focus on regional water resources accounting and strategic planning.





	management			
2	Study on water treatment related membrane technology	34	17	2013
3	Various sewage treatment technologies	30	14	2013
4	Pollution in Marine environments	22	15	2012
5	Detection of polycyclic aromatic hydrocarbons	16	12	2013
6	Model microbial design	14	16	2012

The main research issues related to the "modelling of water resources management" include water management issues associated with climate change, involving environmental policies, land use, and biodiversity conservation. An important research method involves establishing a water resource use and management model with an emphasis on simulation and prediction.

The main research questions in the field of "water treatment related membrane technology research" include seawater desalination and surface water purification. Important technologies include nano-membranes.

The main pollutants studied in the topic of "various sewage treatment technologies" include various heavy metals. The main treatment technologies include activated sludge process, biological adsorption process, and various bioreactors. The main area focuses on the purification of drinking water. UNESCO published 153 papers on sewage treatment research, mainly in the Netherlands (111), accounting for 72.6% of the total number of papers. 110 of these published papers were completed by IHE DELFT INSTITUTE FOR WATER EDUCATION in the Netherlands. Australia (29) accounts for 18.5% of the papers published, while China (16) accounts for 10.5% of the papers published. From the perspective of WoS categories, 86 papers are related to environmental science, 54 to water resources, and 50 to environmental engineering, which accounts for 56.2%, 35.2%, and 32.7% of the published papers, respectively.

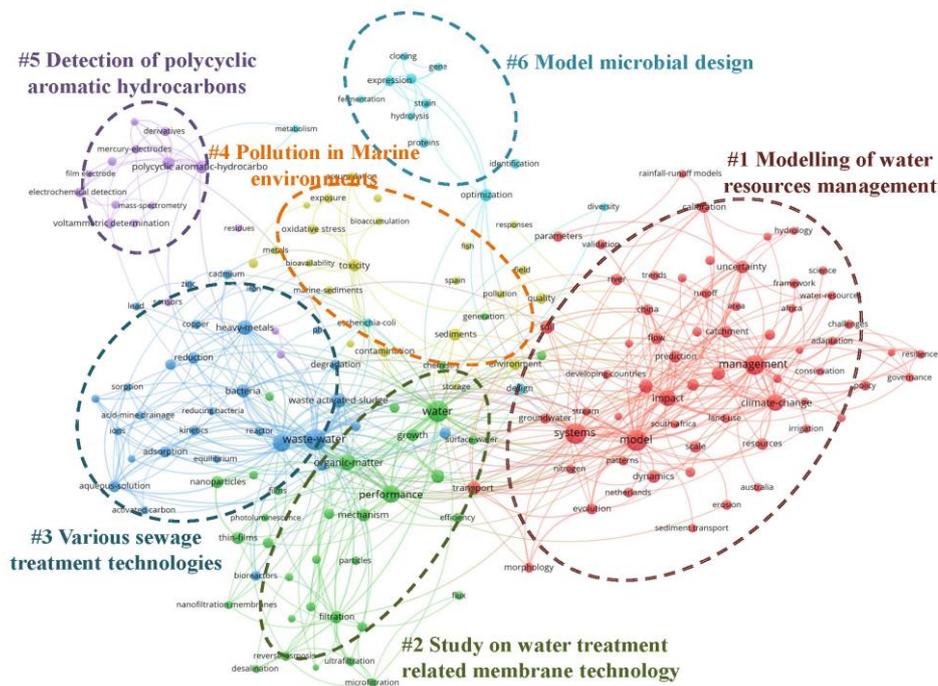


Figure 7. Layout of UNESCO's research on natural science between 2008 and 2017

The main research topics related to "Marine environmental pollution impacts pollution" focus on the hazards caused by Marine environmental pollution. The research subjects include pollutant deposition in Marine sediments and pollutant accumulation of fish.

The main research topic related to the "Detection of polycyclic aromatic hydrocarbons" includes the monitoring of polycyclic aromatic hydrocarbons in personal care products and medicines. Research on monitoring methods focuses on mass spectrometry and electrochemistry.

The main research topic related to "model microorganism design" includes the optimization of model microorganism, and the main research object is *Escherichia coli*.

### 3.2.3 UNESCO's research in specific areas

#### (1) Research on disaster prevention and mitigation

UNESCO published 623 papers in the field of disaster prevention and mitigation between 2008 and 2017, accounting for 14.1% of the total literature. Figure 8 demonstrates that the top 10 keywords in terms of node size are: "climate change", "model", "management", "uncertainty", "water", "flood risk", "impact", "simulation" and



Between 2008 and 2017, UNESCO published 227 research papers on Africa, with a total times cited of 2,780, indicating that the times cited per paper was 12.25. Figure 9 is drawn with the number of scientific papers as the Y-axis and the year as the X-axis. The number of research papers published between 2008 and 2012 keeps around 16, increased to 28 in 2013 and surged 42 in 2014, pushing African research to a climax. However, the output of papers declined in the 2015-2017 years. Why? Using CiteSpace as a tool, the author draws Fig. 10 and combs the UNESCO literature on African studies in the past decade. It is found that the studies mainly concentrate on four areas: ecosystem services and water resources management elements, climate change response, sprinkler irrigation system application research, food security research, taking sub Saharan, South Africa, Kenya and other regions as main research region,. Further enquiries are made on the keyword frequency annual changes of the main research topics. The result is shown in Figure 11. The annual changes in the number of papers on African are consistent with the annual changes in keyword frequency of ecosystem services and management. It is possible that the decrease in quantity of papers on Africa in recent years is mainly due to the decline of related hot topics<sup>[5]</sup>.



Figure 9. Annual changes in UNESCO's papers on Africa between 2008 and 2017



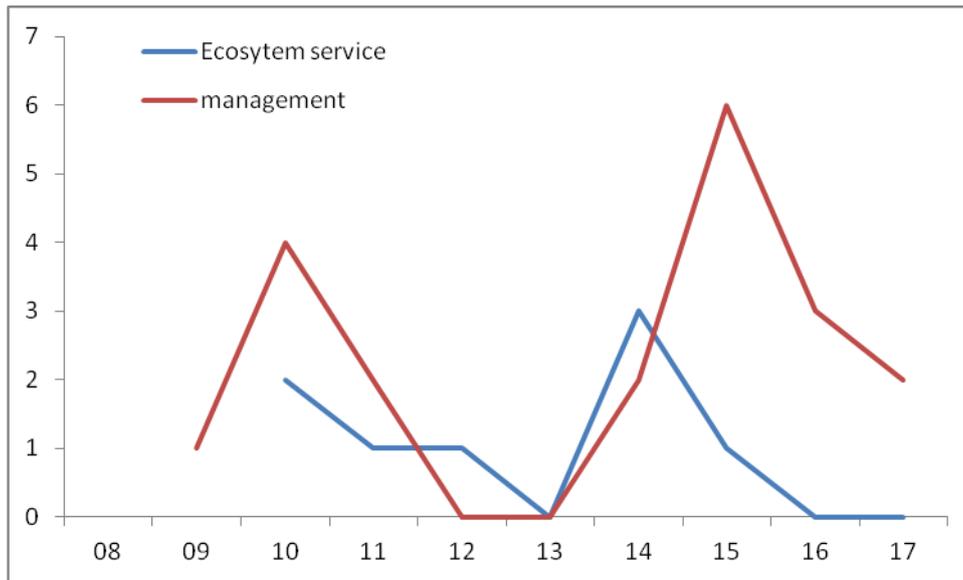


Figure 11. Keywords frequency distribution of UNESCO's ecosystem services and management research in the past 2008-2017

### (3) Research on women

From 2008 to 2017, UNESCO published 78 research papers on women. Figure 12 illustrates that in nearly a decade, studies on women primarily focus on diseases affecting women who were exposed to toxic and harmful substances for a prolonged periods (women, mercury, exposure, trace elements, hair, mental), gender studies (gender), adolescent research (adolescents) and women's cardiovascular disease risk factors (risk).

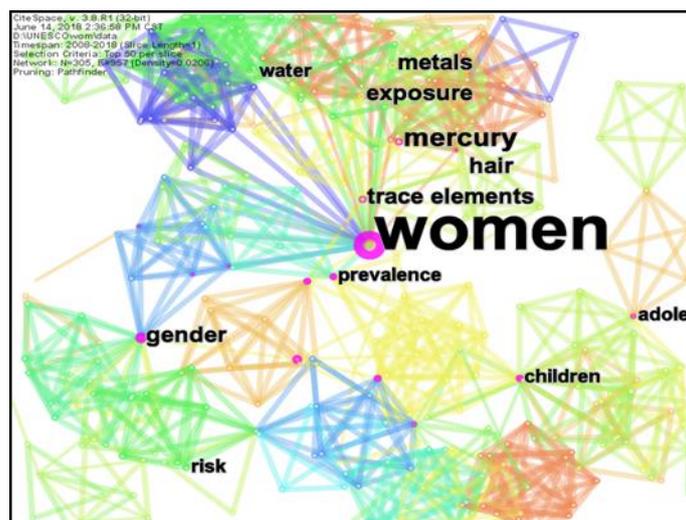


Figure 12. Map of keywords co-occurrence in women's studies between 2008 and 2017

### (4) Research on youth

Between 2008 and 2018, UNESCO published 19 research papers on youth. These papers mainly focused on youth education, rural youth development experiences, health-related issues such as AIDS among youth, and youth labour market research. Among these topics, youth education research accounts for more than one third of the total literature.

### (5) Cultural heritage conservation

From 2008 to 2017, there are 23 articles in the field of cultural heritage conservation of UNESCO. The co-occurrence relationship of keywords in the cultural heritage conservation is showed in Figure 13. The two most important nodes are “cultural heritage” and “conservation”, resulting by the research area of the cultural heritage conservation retrieval strategy of this report. The following nodes are “archaeology”, “climate change”, “vulnerability”, “synthetic aperture radar”, “recording”, “paintings”, etc. The keywords with more frequency can be clustered into two areas: Empirical and Theoretical . Empirical research include “archaeology”, “synthetic aperture radar” and “recording”, which is related to the research area such as the methods and techniques for the investigation and records of cultural heritage. Theoretical studies include “climate change”, “vulnerability” and “paintings”, which is related to the research area of cultural heritage conservation.



Figure 13. Visualization map of co-occurrence relationship of keywords in the cultural heritage

### 3.3 UNESCO's international cooperation in S&T

#### 3.3.1 The distribution of "TOP 10 key areas" in major cooperative countries

Considering the validity and simplicity of data, this report mainly selects the TOP 10 countries in the TOP 10 key areas to draw a map of a national distribution of key areas, as shown in Figure 14. From the perspective of discipline intensity, the Netherlands exhibits significant advantages in the fields of Water Resources, Environmental Sciences, Geoscience, Multidisciplinary, Environmental Engineering, and Civil Engineering. The UNESCO-IHE water institute, jointly established by UNESCO and the Dutch government, significantly contributes to this advantage because the institute assumes water conservancy, environment, and ecology as the main pillars, covering various aspects of natural science, engineering, and management. In addition, Environmental Science in Spain, Electrochemistry in the Czech Republic, and Chemical engineering in Australia are also strong. In comparison, China's research on Water Resources, Environmental Science, Geoscience, Multidisciplinary, and Chemical Engineering are at moderate levels, with Biodiversity and Applied microbiology taking precedence.

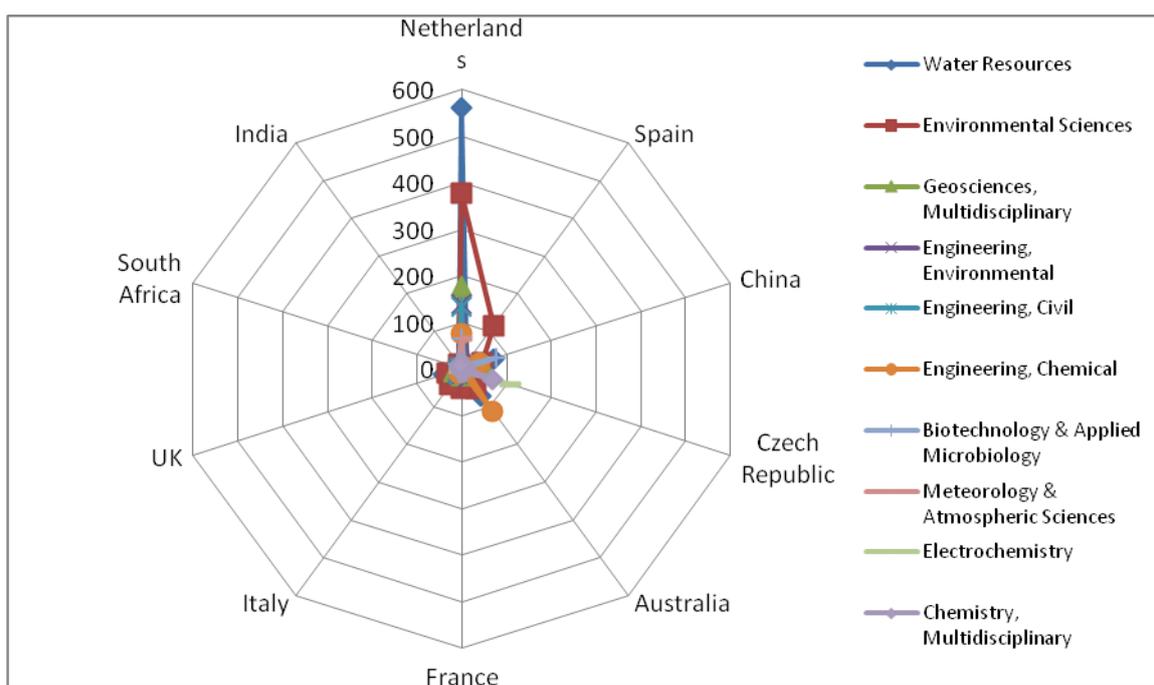


Figure 14. The distribution of UNESCO's TOP 10 key areas in major partner countries

### **3.3.2 National cooperative network**

To further demonstrate UNESCO's cooperation in the field of science and technology, the network map of UNESCO's cooperation in the field of science and technology research was mapped using the CiteSpace software system<sup>[4]</sup>, as shown in Figure 15. As shown in the figure, the nodes of Netherlands, Spain, China, France, Australia, the Czech Republic, Italy, the United States, and other countries in the graph are bigger (the frequency is more than 200), suggesting that these countries have published considerable literature through cooperation. However, among these countries, apart from China and Australia, connections among other countries are not evident, which illustrates that their cooperation is mainly between domestic institutions or scattered international cooperation, which is not very strong. However, the node of Netherlands stands out for its close scientific cooperation with Belgium, Ireland, Uganda, and other countries. In addition, the UK has frequent cooperation with several countries such as Benin, and China and Japan are closely linked. These countries are expected to cooperate with each other so that their scientific and technological research can gain rapid development under the guidance of UNESCO and gradually reduce the gap with traditional research powers.

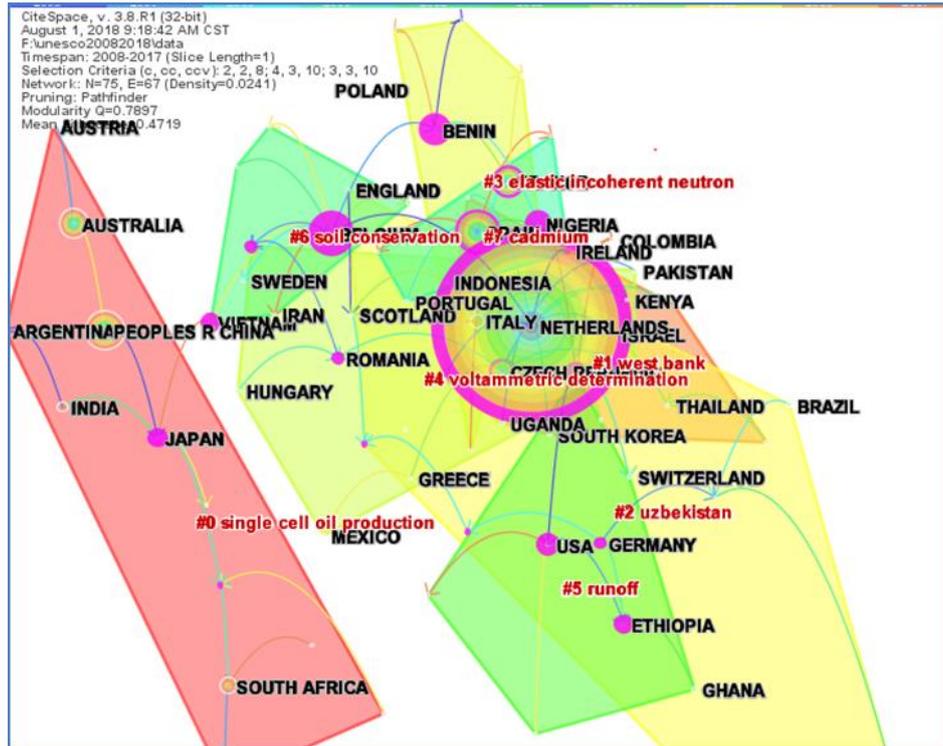


Figure 15. UNESCO network of national or regional cooperation in science and technology

According to the map, the nodes are statistically analysed using the CiteSpace software system, and the top 20 countries or regions are listed according to their cooperation frequency, as shown in Table 6. It can be observed that in addition to the 8 countries with high literature frequency and research function and status, the literature frequency of South Africa, Britain, Belgium, Canada, Benin, Japan, Germany, the Czech Republic, and other countries is slightly lower. However, these countries demonstrate a high degree of centrality, occupying an important position. Among them, France, the Czech Republic, South Africa, and Greece exhibit a high emergence rate and the Sigma value is greater than 1, which reflects the trend of the sudden rise in literature output with the cooperation of the four countries<sup>[6]</sup>.

Table 6. The frequency of UNESCO cooperation among countries or regions in science and technology

Frequency	Emergence rate	Degree of Centrality	Sigma	Country/region	First year of appearance(year)
1428		0.65	1	NETHERLANDS	2008
463		0.14	1	SPAIN	2008
380		0.10	1	PEOPLES R CHINA	2008
349	5.12	0.14	1.99	FRANCE	2008

304		0.05	1	AUSTRALIA	2008
267	6.94	0.19	3.35	CZECH REPUBLIC	2008
209		0.05	1	ITALY	2008
208		0.54	1	USA	2008
189	3.03	0.10	1.32	SOUTH AFRICA	2008
161		0	1	ENGLAND	2008
151		0.05	1	INDIA	2008
144		0.36	1	GERMANY	2008
128		1.25	1	BELGIUM	2008
100		0	1	BRAZIL	2008
85		0.85	1	BENIN	2008
69		0	1	RUSSIA	2008
64		0.63	1	CANADA	2008
63		0.49	1	JAPAN	2008
61		0	1	PORTUGAL	2008
57	3.92	0.05	1.21	GREECE	2008

#### 4. Summary

Based on bibliometric analysis, this report presents UNESCO's paper output trends, key research areas and research hotspots and frontiers, research power distribution of major countries and institutions, and insights into national cooperation networks in science and technology. The conclusions are as follows:

(1) UNESCO's research literature in science and technology is large in volume, fast in growth rate, high in cited papers, and profound in effect. However, there is regional imbalance as the most of research institutions distributed in Europe.

(2) UNESCO's "key research areas" include "Water Resources", "Environmental Science", "Geoscience, Multidisciplinary", "Environmental Engineering", "Civil Engineering", "Chemical Engineering", "Biotechnology and Applied microbiology", "Meteorology and Atmospheric Science", "Electrochemistry" and "Ecology". Among these, the number of papers and citation levels of "Water Resources" and "Geoscience, Multidisciplinary", with higher category normalized citation impact, are better than UNESCO's performance in other fields, which indicates that "Water Resources" and "Multidisciplinary Geoscience" are advantageous research fields of UNESCO. "Ecology" has a very high category normalized citation impact, which demonstrates that "Ecology"

has a prominent academic effect in UNESCO compared with other disciplines. Although there are many papers on environmental science, they are less influential.

(3) Key research topics of UNESCO in the field of natural science include water resource management modelling research, water treatment related membrane technology research, various sewage treatment technologies, marine environmental pollution, polycyclic aromatic hydrocarbon detection technology, and model microorganism design.

(4) The research topics of UNESCO in the field of water resources is drinking water purification technology, soil erosion caused by human-land relations, ecosystem services and resource management, watershed hydrological modelling and prediction, and water resource management and optimization design.

(5) The research topics of UNESCO in the field of ecology include forest ecosystem model, soil ecosystem phosphorus pollution removal, ecosystem adaptation research, and the impact of tropical rainforest land use on biological communities.

(6) Some UNESCO studies on water resources, environmental pollution, sewage treatment, marine management, biodiversity conservation, and sustainable development have been published in high-level journals (NATURE and SCIENCE), indicating that these fields have gained extensive and far-reaching attention.

(7) The frequency of cooperation papers between UNESCO and 8 countries, including the Netherlands, Spain, China, France, Australia, the Czech Republic, Italy, and the United States is over 200. The cooperation between China and Australia is close, while the cooperation among other countries is not significant as most of these countries cooperate with domestic or relatively scattered international institutions.

(8) In terms of the number of cooperation papers in key scientific and technological fields, the Netherlands has a great advantage in the fields of “Water Resources”, “Environmental Science”, “Geoscience, Multidisciplinary”, “Environmental Engineering” and “Civil Engineering”. Environmental Science in Spain, Electrochemistry in the Czech Republic, and “Chemical Engineering” in Australia are very competitive. In comparison, China’s research on “Water Resources”, “Environmental Science”,

“Geoscience, Multidisciplinary” and “Chemical Engineering” are at a medium level with “Biodiversity and Applied microbiology” having a certain advantage.

Overall, IKCEST continues to focus on SDGs as an objective, taking advantage of its strengths by prioritizing research on water resources, geoscience, ecology, environmental science, biological diversity, and applied microbiology. Breakthroughs in water resources, ecology, and geoscience research will strengthen the cooperation and support with UNESCO.

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